ICAIS

2009

16th International Conference on Aquatic Invasive Species

April 19 to 23, 2009

Fairmont Queen Elizabeth, Montreal, Quebec, Canada

Hosted by

Fisheries and Oceans Canada — Pêches et Océans Canada

NOAA — National Oceanic and Atmospheric Administration, U.S. Department of Commerce

Conference Co-Chairs

Christopher J. Wiley, Fisheries and Oceans Canada

David F. Reid, National Oceanic and Atmospheric Administration

Technical Program Committee

Christopher J. Wiley, Fisheries and Oceans Canada and Transport Canada, Co-Chair

David F. Reid, National Oceanic and Atmospheric Administration, Co-Chair

Abraham bij de Vaate, Waterfauna Hydrobiologisch Adviesbureau, Past Chair, Technical Program Committee, 2007

Kay H. Austin, International Joint Commission, United States Section

Beth Brownson, Ontario Ministry of Natural Resources

Renata Claudi, RNT Consulting Inc.

Alfred F. Cofrancesco, US Army Engineer Research & Development Center

Becky Cudmore, Fisheries and Oceans Canada

John Dettmers, Great Lakes Fishery Commission

Marc Gaden, Great Lakes Fishery Commission

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Nicholas Mandrak, Fisheries and Oceans Canada

Fred Nibling, Jr., US Bureau of Reclamation

Bivan Patnaik, US Coast Guard

Stephen Phillips, Pacific States Marine Fisheries Commission

Sanjeevi (Raju) Rajagopal, Radboud University Nijmegen

Glenn Rhett, US Army Engineer Research & Development Center

Anthony Ricciardi, Canadian Aquatic Invasive Species Network

Gerard van der Velde, Radboud University Nijmegen

Leonard Willett, US Bureau of Reclamation

Conference Administrator

Elizabeth Muckle-Jeffs
The Professional Edge
1027 Pembroke Street East, Suite 200
Pembroke, ON K8A 3M4 Canada
Toll Free (North America) 1-800-868-8776
International: 613-732-7068 Fax: 613-732-3386
E: elizabeth@theprofessionaledge.com Web: www.icais.org

Conference at a Glance

Sunday, April 19

12:00 PM to 6:00 PM
Conference Registration and PowerPoint Presentation Check-in

7:30 PM to 9:30 PM
Invited Reception for Authors of Presentations and Posters, Session Chairs and Technical Program Committee

Monday, April 20

8:30 AM to 12:00 PM
Plenary Session

12:00 PM to 1:30 PM
Luncheon (provided) with Luncheon Speakers

1:30 PM to 6:00 PM
Concurrent Sessions

6:00 PM to 8:00 PM
Poster Session and Networking Mixer

Tuesday, April 21

8:30 AM to 9:30 AM
Plenary Session

10:00 AM to 12:00 PM
Concurrent Sessions

12:00 PM to 1:30 PM
Luncheon (provided)

1:30 PM to 5:40 PM
Concurrent Sessions

Evening Free

Wednesday, April 22

8:30 AM to 9:30 AM
Plenary Session

10:00 AM to 12:00 PM
Concurrent Sessions

12:00 PM to 1:30 PM
Luncheon (provided)

1:30 PM to 6:00 PM
An afternoon at the Montreal Biodôme
Earth Day is Every Day, Spreading the News About Invasive Species
(no additional fee, but pre-registration is required)

1:30 PM to 5:20 PM
Concurrent Sessions

Evening Free

Thursday, April 23

8:30 AM to 9:30 AM
Plenary Session

10:00 AM to 12:00 PM
Concurrent Sessions

12:00 PM to 1:30 PM
Luncheon (provided)

1:30 PM to 3:10 PM
Concurrent Sessions

Conference concludes

Wednesday, April 22

1:30 pm to 6:00 pm

An afternoon at the Montreal Biodôme

Earth Day is Every Day, Spreading the News About Invasive Species

Earth Day is a prime time to capture the public's attention regarding invasive species topics. However, environmental education in general - and invasive species in particular - can and should be shared with varied audiences all year. What is your role in helping the public understand the pathways and potential effects of invasive species? How can you interact with the public more often?

Researchers, regulators, educators and others are needed to participate in a special roundtable session at the Montreal Biodôme. The afternoon opens with a behind-the-scenes tour of this research hub that is also a "free choice learning" center presenting science to audiences interested in environmental topics. This discussion-based ICAIS workshop will pose varied questions, such as:

What elements have made past partnerships for public outreach programming successful?

How can similar programs be implemented on a more frequent basis?

How can we resolve factors that have hindered some past efforts?

What can we expect as reasonable outcomes from programs that provide actions the public can take regarding invasive species?

In light of tight budgets in research, government and educational programs around the world, the need for outreach partnerships will only grow – as will the requirements to identify the social relevance, broader implications and behavior change associated with particular research projects.

This roundtable will start a discussion about maximizing the integration of invasive species topics into broader outreach efforts. We plan to continue the conversation through an online format. This session is being organized by the Aquatic Invaders Outreach Project Team, which includes members of the National Sea Grant Network and the Association of Zoos and Aquariums, with support from the National Oceanic and Atmospheric Administration. Special thanks to the Montreal Biodôme and members of the Canadian Association of Zoos and Aquariums.

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TUESDAY, APRIL 21

Monday, April 20 Morning

Plenary Session: Aquatic Invasive Species in a Changing World

Session Co-Chairs
Christopher J. Wiley, Fisheries and Oceans Canada
David F. Reid, National Oceanic and Atmospheric Administration

8:30 am
Welcoming Remarks
Wendy Watson-Wright, Assistant Deputy Minister, Science, Fisheries and Oceans Canada

9:00 am
Black Swans on the Pond:
The Future of Biological Pandemonium and Globalization
Andrew Nikiforuk, Journalist and Author

9:45 am
Questions and Discussion

10:00 am
Break

10:30 am
Can We Predict (and Prevent) Aquatic Invasions?
Hugh J. MacIsaac, Director, CAISN Network and University of Windsor, GLIER, Canada

11:00 am
Can We Predict the Impacts of Aquatic Invasions?
Anthony Ricciardi, McGill University, Redpath Museum, Canada

11:30 am
Aquatic Invasive Species: Closing the Science-Policy Gap
Wendy Watson-Wright, Fisheries and Oceans Canada

12:00 pm
Luncheon

12:30 pm
A Century of Cooperation Protecting Our Shared Waters
Rt. Hon. Herb Gray, P.C., C.C., Q.C.
Canadian Chair, International Joint Commission

12:45 pm
Sustainability - 50 Years and Counting
Richard Corfe, President and CEO, St. Lawrence Seaway Management Corporation, Canada

Concurrent Session A-1

Shipping: Great Lakes Management

Session Chair: CDR Tim Cummins
US Coast Guard

1:30 PM
Joint US/Canadian Ballast Water Inspection Program: A Binational Approach to Securing the Great Lakes and St. Lawrence River
Matt Edwards, US Coast Guard Marine Safety Detachment, USA

1:50 pm
Update on the Canadian Ballast Water Database
Sonya C. Santavy, Transport Canada, Ontario Region, Canada

2:10 pm
The Great Ships Initiative: Making Ballast Treatment in the Great Lakes a Reality
Allegra Cangelosi, Northeast-Midwest Institute, USA

2:30 pm
Timelines for Implementing Commercial Ballast Water Treatment Systems
Dale B. Bergeron, Minnesota Sea Grant College Program, USA

2:50 pm
Break

Concurrent Session B-1

Tunicates

Session Chair: Margaret (Peg) Brady
National Oceanic and Atmospheric Administration

1:30 pm
Modeling the Effectiveness of Searches for Invasive Tunicates in a Prince Edward Island Estuary
Lisa G. Kanary, University of New Brunswick, Canada

1:50 pm
Invasion Pathways of the Clubbed Tunicate *Styela clava* in the Northeastern Pacific
John A. Darling, US EPA, National Exposure Research Laboratory, USA

2:10 pm
Risk Analysis for the Introduction of Non-indigenous Ascidians
Martin H. Davis, Fawley Biofouling Services, UK

2:50 pm
Break

Concurrent Session C-1

Control

Session Chair: Leonard Pace
National Oceanic and Atmospheric Administration

1:30 pm
Integrated Approach to Protecting Industrial Assets from Macrofouling
Renata Claudi, RNT Consulting Inc., Canada

1:50 pm
New Challenges for the Chicago Sanitary and Ship Canal Dispersal Barrier
Philip B. Moy, University of Wisconsin Sea Grant, USA

2:10 pm
UV 101: The Basics of UV Disinfection
Ji An, Trojan Technologies, Canada

2:30 pm
UV Inactivation of Viral Hemorrhagic Septicemia Virus (VHSV IVb, Great Lakes Drum Isolate)
Linda Sealey, Trojan Technologies, Canada

2:50 pm
Break

Concurrent Session D-1

Education and Outreach

Session Chair: Rochelle Sturtevant
National Oceanic and Atmospheric Administration

1:30 pm
Please Don't Dump in Our Oceans: Innovative, Educational, Outreach Products Featuring Lionfish and *Caulerpa taxifolia* Created by Educators for Educators
Linda Walters, University of Central Florida, Department of Biology, USA

1:50 pm
***Aquatic Invaders:* Sea Grant/AZA Project Explains Pathways to Zoo and Aquarium Audiences**
Katie Mosher Patterson, North Carolina Sea Grant, USA

2:10 pm
Mandatory HACCP Training for Bait Harvesters: Ontario's Approach
Beth Brownson, Ontario Ministry of Natural Resources, Canada

2:30 pm
Boat Washing Stations — Palliative or Cure?
Douglas A. Jensen, University of Minnesota Sea Grant Program, USA

2:50 pm
Break

Monday, April 20 Afternoon

Concurrent Session A-2

Shipping: Canadian Research

Session Chair: Michael J. Dwyer
Transport Canada, Marine Safety

3:20 pm
Physical Factors Influencing the Dilution and Long Range Dispersion of Ballast Water Discharged in a Harbour
Mathew Wells, University of Toronto at Scarborough, Department of Physical and Environmental Sciences, Canada

3:40 pm
Invertebrates and Resting Stages in Sediment of Ballasted Ships Entering Canadian Ports
Elizabeta Briski, CAISN, University of Windsor, GLIER, Canada

4:00 pm
Non-indigenous Dinoflagellates (Motile and Cyst Forms) Introduced by Ship Transport to Canadian Aquatic Ecosystems
Oscar Casas-Monroy, CAISN, Université du Québec à Rimouski, Canada

4:20 pm
***Pseudo-nitzschia* Propagule Pressure in Ballast Water Arriving in Canadian Ports**
Georgia Klein, CAISN, Mount Allison University, Canada

4:40 pm
Does Genetic Structure of Diatom Populations Change During a Transoceanic Voyage?
Michael L. MacGillivary, CAISN, Mount Allison University, Canada

5:00 pm
Diatom Propagule Supply for Canadian Ports – Initial Results of a Two-year Survey
Irena Kaczmarska, Mount Allison University, Department of Biology, Canada

5:20 pm
Ballast Water Abundance and Composition of Heterotrophic Prokaryotes Discharged into Canadian Harbours
Bei Sun, CAISN, Memorial University of Newfoundland, Canada

5:40 pm
Bacterial Dynamics in Ballast Water During Trans-Pacific Voyages of Bulk Carriers
Jennica Seiden, CAISN, Memorial University of Newfoundland, Canada

Concurrent Session B-2

Tunicates

Session Chair: Lisa Jones
McGill University, Redpath Museum

3:20 pm
Monitoring for Tunicates in Nova Scotia
Benedikte Vercaemer, Fisheries and Oceans Canada, Bedford Institute of Oceanography, Canada

3:40 pm
First Occurrence of the Invasive Colonial Ascidian *Didemnum vexillum* to Utilize Eelgrass *Zostera marina* as Substrate
Mary R. Carman, Woods Hole Oceanographic Institution, Geology and Geophysics Department, USA

4:00 pm
Rapid Response to a New Marine Invader in Ireland – *Didemnum* spp.
John Kelly, EnviroCentre, Northern Ireland

4:20 pm
Successful Eradication of the Colonial Violet Tunicate, *Botrylloides violaceus*, in Belleoram Harbour, Fortune Bay, on the Southern Newfoundland Coast – Rapid Response and Mitigation Strategy
Cynthia H. McKenzie, Fisheries and Oceans Canada, Northwest Atlantic Fisheries Centre, Canada

4:40 pm
Development of a Portable Aquatic Laboratory for Mitigation Studies on Aquatic Invasive Tunicates
Garth Arsenault, University of Prince Edward Island, Atlantic Veterinary College, Canada

5:00 pm
New Mitigation Options Against *Ciona intestinalis*
Christine Paetzold, University of Prince Edward Island, Atlantic Veterinary College, Canada

5:20 pm
Field Trial to Optimize High-pressure Water Treatment for *Ciona intestinalis* on Mussel Aquaculture on Prince Edward Island
Aaron Ramsay, University of Prince Edward Island, Atlantic Veterinary College, Canada

5:40 pm
Washington State's Response to Invasive Tunicates in Puget Sound: Accomplishments, Lessons Learned and Next Steps
Kevin Anderson, Puget Sound Partnership, USA

Concurrent Session C-2

Control

Session Chair: Renata Claudi
RNT Consulting Inc.

3:20 pm
Ultraviolet for Golden Mussel Larvae Control and Microcystis Removal as Pilot Experiments
Cintia Pinheiro dos Santos, Federal University of Rio Grande do Sul, Centro de Ecologia, Brazil

3:40 pm
Invasive Fish Eradication Using Rotenone Derived Products in Water Bodies of Andalusia (Southern Spain)
Carlos Fernández-Delgado, University of Córdoba, Department of Zoology, Spain

4:00 pm
Better Biocide Delivery to Fouling Surfaces: Reaching the Interface from Within
Sanjeevi Rajagopal, Radboud University Nijmegen, Institute for Wetland and Water Research, The Netherlands

4:20 pm
Chronic Thermal Tolerance Limits of Quagga Mussels from Lake Mead (Arizona/Nevada) Relative to Zebra Mussels from Oklahoma, Kansas and New York
Robert F. McMahon, University of Texas at Arlington, USA

4:40 pm
Eradication of Introduced Signal Crayfish (*Pasifastacus leniusculus*) and Rudd (*Scardinius erythropthalmus*) Using the Pharmaceutical BETAMAX VET®
Helge Bardal, National Veterinary Institute, Section for Environmental and Biosecurity Measures, Norway

Concurrent Session D-2

Education and Outreach

Session Chair: Stephen Phillips
Pacific States Marine Fisheries Commission

3:20 pm
Stop Aquatic Hitchhikers!™ – A Successful Campaign Preventing the Spread of AIS
Douglas A. Jensen, University of Minnesota Sea Grant Program, USA

3:40 pm
Watercraft Inspection Training for Dreissenid Mussels in the Western United States
Stephen H. Phillips, Pacific States Marine Fisheries Commission, USA

4:00 pm
Using Interactive Web Technology to Educate and Inspire Community Action to Address Aquatic Invaders
Robin Goettel, Illinois-Indiana Sea Grant Program, USA

4:20 pm
Invasive Wetlands Plants Campaign and Outreach Tools
Hélène Godmaire, Great Lakes United, Union Saint-Laurent Grands Lacs, Canada

4:40 pm
Linking Science, Community, and Action Through Aquatic Invasive Species (AIS) Education: Outcomes of a Pilot Project and Why it Worked
Samuel Chan, Oregon State University, Sea Grant College Program and Extension Service, USA

5:00 pm
Understanding Citizens' Attitudes and Beliefs Regarding Behaviors that Prevent the Spread of Invasive Species: Applications for a Statewide Awareness Campaign
Samuel Chan, Oregon State University, Sea Grant College Program and Extension Service, USA

5:20 pm
Aquatic Invasive Species Watercraft Inspection Program in NW Ontario, Canada
Laurie Wesson, Fisheries and Oceans Canada, Canada

5:40 pm
Piloting a Volunteer AIS Boater Education Program: Michigan's Experience with Clean Boats, Clean Waters
Carol Y. Swinehart, Michigan Sea Grant College Program, USA

Monday, April 20, 6:00 pm to 8:00 pm

Poster Session

New York State Waterbird Mortality as a Result of Type E Botulism and Non-native Invasive Species
David Adams, New York State Department of Environmental Conservation, Office of Invasive Species Coordination, USA

Impact of the Zebra Mussel (*Dreissena polymorpha*) on Native Unionid Bivalves in European Ecosystems
Jean-Nicolas Beisel, Université Paul Verlaine – Metz, Laboratoire des Interactions Ecotoxicologie, Biodiversité, Ecosystèmes, France

Comparative Phylogeography of Two Invasive Colonial Tunicates Reveals Contrasting Invasion Histories in North America
Dan Bock, CAISN, University of Windsor, GLIER, Canada

Control of the Highly Invasive Curly Leaved Pondweed (*Lagarosiphon major)* in a Lake in the River Shannon Catchment, Ireland
Joe M Caffrey, Central Fisheries Board, Ireland

Use of Mitochondrial Cytochrome *c* Oxidase I (COI) Gene Sequences to Suggest Probable Source Populations of Non-indigenous Ascidians in Newfoundland
Ashley G. Callahan, Memorial University of Newfoundland, Ocean Sciences Centre, Canada

Prevention of Dispersion Strategy for Golden Mussels in Central Parts of South America
Claudia T. Callil, Federal University of Mato Grosso, Biosciences Institute, Brazil

Gametogenesis and Population Traces of Limnoperna fortunei (Dunker,1857) in a Brazilian Wetland
Claudia T. Callil, Federal University of Mato Grosso, Biosciences Institute, Brazil

Fragmentation and Dispersal of the Invasive Colonial Tunicate *Didemnum vexillum*
Mary Carman, Woods Hole Oceanographic Institution, Geology and Geophysics Department, USA

Shell Growth of *Limnoperna fortunei* in Two Localities Under Different Climate in the Plata Basin (Argentina)
Gustavo Darrigran, Grupo de Investigación sobre Moluscos Invasores Plagas, División Zoología Invertebrados, Argentina

Population Structure of the Invasive Hydrozoan *Cordylophora* in the Great Lakes
John A. Darling, US Environmental Protection Agency; National Exposure Research Laboratory, USA

Developing Robust, Risk-based Audit Protocols to Prevent the Accidental Introduction of Non-native Fishes in England and Wales
Gareth D. Davies, Bournemouth University, Centre for Conservation Ecology and Environmental Change, UK

Chinese Mitten Crabs in the St. Lawrence River and Estuary, Canada: Origin and Risk of Invasion
Yves de Lafontaine, Environment Canada, St. Lawrence Centre, Canada

Non-indigenous Species in Montreal Harbour, St. Lawrence River: Where Are They?
Yves de Lafontaine, Environment Canada, St. Lawrence Centre, Canada

Recruitment, Growth and Survival of the Exotic Brazilian Pepper (*Schinus terebinthifolius*) at Restored Mosquito Impoundments in Mosquito Lagoon, FL
Melinda Donnelly, University of Central Florida, Department of Biology, USA

Analyzing the Economic Benefits of Regulating Ships' Ballast Water Discharges
Lisa Drake, Science Applications International Corporation, USA

Re-evaluating Eradication of Nuisance Species: Invasion of the Tunicate, *Ciona intestinalis*
Paul Edwards, CAISN, McGill University, Canada

Do Round Gobies Benefit from Parasite Release: Comparison With the Parasite Fauna of Native Fish Species in the Great Lakes-St. Lawrence Basin
Andrée Gendron, Environment Canada, Centre Saint-Laurent, Canada

Genetic Tracks of the Invasion of *Limnoperna fortunei* in South America
Sara Ghabooli, CAISN, University of Windsor, GLIER, Canada

Could *Limnoperna Fortunei* Be Worse Than *Dreissena Polymorpha?* Population Density and Potential Impacts
Alexander Y. Karatayev, Buffalo State College, Great Lakes Center, USA

Feeding Activity of Suspended Mussels and Invasive Tunicates in Prince Edward Island: A Mesocosm Approach
Mayi Lecuona, CAISN, Université du Québec à Rimouski, Institut des sciences de la mer (ISMER), Canada

Aquatic Invasive Species Research in the Bay of Fundy (2006-08)
Murielle M. LeGresley, Fisheries and Oceans Canada, Canada

Structure of the Community of Invertebrates Associated with *Eichhornia crassipes* Mart. (Solms-Laubach) After the Introduction of *Limnoperna fortunei* (Dunker, 1857) (Bivalvia, Mytilidae) in the Upper Paraguay River, MT, Brazil
Sandra Francisca Marçal, Federal University of Mato Grosso, Brazil

Alien Fishes of Belarus: Diversity, Vectors of Introduction and Risk Assessment
Sergey E. Mastitsky, Buffalo State College, Great Lakes Center, USA

Evaluations of Phytoplankton Enumeration Experiment Workshop Samples Using Digital Signal Processor Based FlowCAM®
Bruce N. Nelson, Battenkill Technologies Inc., USA

An Evaluation of Viability Assays Using a Continuous Imaging Particle Analyzer (FlowCAM®) for Ballast Water Analysis and Regulatory Compliance
Harry Nelson, Fluid Imaging Technologies, USA

***Phyllodistomum folium*, a Fish Helminth Parasite Introduced by Zebra Mussels in the Ebro River, Spain**
Miguel A. Peribáñez, University of Zaragoza, Faculty of Veterinary Science, Department of Patología Animal, Spain

***Corbicula fluminea* (Muller, 1774) – Invasive Species in Romanian Waters**
Oana P. Popa, Grigore Antipa National Museum of Natural History, Romania

Detection of a Colonising, Aquatic, Non-indigenous Species
Samir A. Qureshi, CAISN, University of Windsor, GLIER, Canada

Do *Nodularia spumigena* Blooms Force Back *Neogobius melanostomus* (the Round Goby) Invasion in the Gulf of Gdańsk?
Mariusz Sapota, University of Gdańsk, Institute of Oceanography, Poland

Great Lakes Aquatic Non-indigenous Species Information System (GLANSIS)
Rochelle A. Sturtevant, NOAA National Center for Research on Aquatic Invasive Species, USA

The American Mud Crab *Rhithropanopeus harrisii* in the Southern Baltic Sea – Is There an Invasion?
Anna Szaniawska, University of Gdańsk, Institute of Oceanography, Poland

Investigation About Growth and Settling of *Limnoperna fortunei* in Artificial Substrate at Three Different Channels of Upper Paraná River Floodplain, Brazil
Alice Michiyo Takeda, Universidade Estadual de Maringá/DBI/Nupelia/National Council of Scientific and Technological Development, Brazil

Trends on the Publications of 100 Worst Invasive Species from 1965–2007
Rahel A.Tedla, CAISN, University of Windsor, GLIER, Canada

Use of NaCl Brine and Road Salt as a Ballast Water Treatment Technology for Transoceanic Vessels Entering the Great Lakes
Tony Wang, CAISN, University of Windsor, GLIER, Canada

Monday, April 20, 6:15 pm to 6:45 pm

Speed Poster Presentations

Session Chair: David F. Reid, National Oceanic and Atmospheric Administration

6:15 pm

Ships as Vectors for Freshwater Bryozoans

Rebekah Kipp, McGill University, Redpath Museum, Canada

6:20 pm

Assessing the Economic Impacts of Aquatic Invasive Species in the United Kingdom

Matthew P.J. Oreska, University of Cambridge, Department of Zoology, UK

6:25 pm

Numerical Modelling for the Economic Costs of Biological Invasion

Simone Delphim, National Laboratory for Scientific Computing - LNCC, Brazil

6:30 pm

Navigational Buoy Monitoring for Invasive Species in the St. Lawrence River and Lower Laurentian Great Lakes (2007-2009), with Addition of Molecular Biomonitoring for Epidemiology of Zoonotic Pathogens

David Bruce Conn, Berry College, School of Mathematical and Natural Sciences, USA

6:35 pm

Early Colonisation of the Zebra Mussel (*Dreissena polymorpha*) in Lough Neagh Northern Ireland: Ecological and Consequential Socio-economic Impacts for the Rural Eel Fishing Industry

Sarah McLean, Queens University Belfast, Northern Ireland

6:40 pm

Biology and Post-emergence Herbicidal Management of Water Hyacinth *(Eichhornia crassipes)* in the Water Bodies of Southern India

Chinnagounder Chinnusamy, Tamil Nadu Agricultural University, India

6:45 pm

Dinoflagellate Cysts as Indicators of Potential Introduction of Invasive Marine Species in East Coast Canadian Ports

Olivia Lacasse, Université du Québec à Rimouski, Institut des Sciences de la Mer de Rimouski, Canada

Tuesday, April 21 Morning

Plenary Session: Commercial Shipping in a Changing World

Session Chair: Rt. Hon. Herb Gray, P.C., C.C., Q.C.
International Joint Commission, Canadian Section

8:30 am
Does Increased Regulation Effectively Prevent New Introductions of AIS?
Ivan Lantz, Shipping Federation of Canada, Canada

9:00 am
Challenges and Solutions to Test the Performance of Ballast Water Treatment Systems Onboard Vessels According to the IMO Type Approval Guideline
Stephan Gollasch, GoConsult, Germany

9:30 am
Break

Concurrent Session A-3

Shipping: Policy

Session Chair: Bivan Patnaik
US Coast Guard

10:00 am
US Coast Guard's Proposed Ballast Water Discharge Standard Rulemaking
Bivan R. Patnaik, US Coast Guard, Environmental Standards Division, USA

10:20 am
US Coast Guard's Proposed Ballast Water Management System Approval Procedures
Richard A. Everett, US Coast Guard, Environmental Standards Division, USA

10:40 am
US Coast Guard's Ballast Water Management Program: Developing a US Administration Type Approval Process for Ballast Water Management Systems that Make Use of Biocides, Active Substances or Preparations
John C. Morris, US Coast Guard, Environmental Standards Division, USA

11:00 am
Invasive Species Threat to the Arctic
Farrah Chan, CAISN, University of Windsor, GLIER, Canada

11:20 am
Have the New Ballast Water Regulations and Inspection Program Reduced the Risk of NIS Introductions for the Laurentian Great Lakes?
Matthew G. Deneau, Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences, Canada

11:40 am
The US Environmental Protection Agency's Vessel General Permit
William Bolen, US Environmental Protection Agency, USA

12:00 pm
Luncheon

Concurrent Session B-3

Dreissena

Session Chair: Felix Martinez
National Oceanic and Atmospheric Administration

10:00 am
Changes in Behaviour of *Dreissena polymorpha* (Bivalvia) Induced by Potential Fish Predators of Various Species and Size
Jarosław Kobak, Nicolaus Copernicus University, Institute of General and Molecular Biology, Poland

10:20 am
Do Life History Traits Mediate Exotic Species Replacement? A Case Study of Zebra and Quagga Mussels
Lisa A. Jones, McGill University, Redpath Museum, Canada

10:40 am
Distribution and Ecology of Zebra Mussels *(Dreissena polymorpha)* in the Newly Formed Cardiff Bay
Muriel Alix, Faye Cardiff University, School of Biosciences, Wales

11:00 am
Does Size Matter? A Quantitative Assessment of Human Waterborne Pathogens in Zebra Mussel (*Dreissena polymorpha*) Size Ranges Found in an Irish "at Risk" Lake
Frances Lucy, Institute of Technology, Sligo, Ireland

11:20 am
Recent Dramatic Changes in the Offshore Benthic Community of Lake Michigan
Thomas F. Nalepa, NOAA, Great Lakes Environmental Research Laboratory, USA

11:40 am
Recent Dramatic Dreissenid-Induced Changes in Offshore Pelagic Food Webs of the Great Lakes: Mechanisms and Global Implications
Henry A. Vanderploeg, NOAA, Great Lakes Environmental Research Laboratory, USA

12:00 pm
Luncheon

Concurrent Session C-3

Control

Session Chair: Tony Van Oostrom
Ontario Power Generation

10:00 am
Chlorine Minimization for Biofouling Control in Industrial Cooling Water Systems: Comparison of Different Modes of Chlorination
Sanjeevi Rajagopal, Radboud University Nijmegen, Institute for Wetland and Water Research, The Netherlands

10:20 am
The Use of Potassium Chloride to Control Zebra Mussels in an Open Body of Water
Dan Butts, ASI Group Ltd., Canada

10:40 am
***Pseudomonas fluorescens* Strain CL145A as a Zebra and Quagga Mussel Control Agent**
Daniel P. Molloy, New York State Museum, Division of Research and Collections, USA

11:00 am
Commercialization of a *Pseudomonas fluorescens* strain for Controlling Zebra and Quagga Mussels
Pamela Marrone, Marrone Organic Innovations, Inc., USA

11:20 am
BioBullets: Effective Control of Zebra and Quagga Mussels in Industrial Settings and the Open Environment
David C. Aldridge, University of Cambridge, Department of Zoology, UK

12:00 pm
Luncheon

Concurrent Session D-3

Monitoring and Rapid Response

Session Chair: Margaret (Peg) Brady
National Oceanic and Atmospheric Administration

10:00 am
Application of Citizen Science and Search Theory to Optimally Detect Species at Low Density: A Case Study of Monitoring the Asian Shore Crab (*Hemigrapsus sanguineus*)
David G. Delaney, McGill University, Department of Biology and School of Environment, Canada

10:20 am
A Habitat-Based Probabilistic Sampling Approach for Invasive Species in a Columbia River Reservoir
Timothy D. Counihan, US Geological Survey, Western Fisheries Research Center, USA

10:40 am
Risk-Based Surveillance for the Management of Invasive Species
Christopher L. Jerde, University of Notre Dame, Department of Biological Sciences, USA

11:00 am
Influence of Pest Population Size at Time of Detection on the Efficacy of Ensuing Management Measures
Oliver Floerl, National Institute of Water and Atmospheric Research, New Zealand

11:20 am
New Method to Detect and Identify Invasive Bivalves Using a Continuous Imaging Particle Analyzer (FLOWCAM®)
Harry Nelson, Fluid Imaging Technologies, USA

11:40 am
The Application of Multiple Gene PCR to Single Cell Diatoms from Fixed Ballast Water Samples
Imke Lang, CAISN, Mount Allison University, Canada

12:00 pm
Luncheon

Tuesday, April 21 Afternoon

Concurrent Session A-4

Shipping: Policy Support

Session Chair: Christopher J. Wiley
Fisheries and Oceans Canada

1:30 pm
US Coast Guard Experience with Implementation of a Prototype Ballast Water Management Equipment Evaluation Program
Brian Moore, US Coast Guard, Environmental Standards Division, USA

1:50 pm
Testing and Evaluation of Experimental Shipboard Ballast Water Treatment Systems for STEP: Experience and Lessons Learned
Michael G. Dyer, US Department of Transportation, Volpe National Transportation Systems Center, USA

2:10 pm
The European Union in the Dawn of Ballast Water Management Approaches
Matej David, University of Ljubljana, Faculty of Maritime Studies and Transport, Slovenia

2:30 pm
Aquatic Biosecurity: Bug Hunts in an Environment of Uncertainty
Marty Deveney, SARDI, Australia

2:50 pm
Break

Concurrent Session B-4

Dreissena

Session Chair: Frances Lucy
Institute of Technology Sligo

1:30 pm
The Effect of Temperature on Zebra Mussel (*Dreissena polymorpha*) Densities in Two Oklahoma Reservoirs
Chad J. Boeckman, Oklahoma State University, Ecotoxicology and Water Quality Research Laboratory, USA

1:50 pm
Laboratory Spawning and Mortality of Quagga Mussel (*Dreissena bugensis*) Embryos and Larvae from the Newly Established Population in the Southwestern United States
Kevin B. Johnson, Florida Institute of Technology, Department of Marine and Environmental Systems, USA

2:10 pm
When is an Invasive Species Not Invasive? Contrasting Filter-Feeding Mussels in Coastal Ecosystems and Freshwater Lakes
Kevin B. Johnson, Florida Institute of Technology, Department of Marine and Environmental Systems, USA

2:30 pm
Interactions Between Pollution and Parasitism in Zebra Mussels (*Dreissena polymorpha*)
Laëtitia Minguez, Université Paul Verlaine – Metz, Laboratoire des Interactions, Ecotoxicologie, Biodiversité, Ecosystèmes, France

2:50 pm
Break

Concurrent Session C-4

Fish

Session Chair: Nicholas Mandrak
Fisheries and Oceans Canada

1:30 pm
Stock-Recruit Model: An Underused Tool to Manage Aquatic Invasive Fishes
Michael Hoff, US Fish and Wildlife Service, Fisheries Division, USA

1:50 pm
Population Increment of Native and Alien Fish Species in The Dutch Rivers Rhine and Meuse: Competition and Relations with Environmental Variables
Martijn Dorenbosch, Radboud University Nijmegen, Institute for Wetland and Water Research, The Netherlands

2:10 pm
Some Life-history Patterns of Non-native Monkey Goby *Neogobius fluviatilis* (Pallas, 1814) from the River Ipel' (Slovakia)
Mária Čápová-Placha, Comenius University, Department of Ecology, Slovakia

2:30 pm
Observations of the Ecology of the Goby *Rhinogobius brunneus*, a Recent Introduction to the Columbia River
Christopher Walker, US Geological Survey, Western Fisheries Research Center, USA

2:50 pm
Break

Concurrent Session D-4

Monitoring and Rapid Response

Session Chair: Ann Garrett
National Oceanic and Atmospheric Administration

1:30 pm
Binational Aquatic Invasive Species Rapid Response Policy Framework – An Update on International Joint Commission Activities
Mark J. Burrows, International Joint Commission, Great Lakes Regional Officei, Canada

1:50 pm
Rapid Detection of Invasive Species in Ballast Water Using Molecular Methods
Andrew R. Mahon, University of Notre Dame, Center for Aquatic Conservation, USA

2:10 pm
Development of a Standardized PCR Method for Dreissenid Mussel Monitoring
John S. Wood, Pisces Molecular, LLC, USA

2:30 pm
Aquatic Invasive Species Monitoring in Alaska
Lisa Ka'aihue, Prince William Sound Regional Citizens' Advisory Council, USA

2:50 pm
Break

Tuesday, April 21 Afternoon

Concurrent Session A-5

Shipping: US Research

Session Chair: David F. Reid
National Oceanic and Atmospheric Administration

3:20 pm
Determining the Viability of Organisms in Size Classes Defined by the IMO Convention and the US Environmental Technology Verification Program
Lisa A. Drake, Science Applications International Corporation, USA

3:40 pm
Validation of Biological Methods for Full Scale Treatment Testing
Scott C. Riley, Science Applications International Corporation, USA

4:00 pm
Pilot Environmental Technology Verification (ETV) Test Report of the Severn Trent DeNora BalPure™ Ballast Water Treatment System
Jonathan Grant, Battenkill Technologies Inc., USA

4:20 pm
Concentrating High Densities of Ambient Plankton for Use in Ballast Water Treatment Testing
Mia Steinberg, US Naval Research Laboratory, USA

4:40 pm
Overview of the Naval Research Laboratory's Phytoplankton Enumeration Experiment Workshop
Bruce N. Nelson, Battenkill Technologies Inc., USA

5:00 pm
Determination of Accuracy and Precision in Plankton Enumeration Methods in Ballast Water Treatment System Testing
Edward J. Lemieux, US Naval Research Laboratory, USA

5:20 pm
Computation Fluid Dynamics Characterization of Inline Sampling for Ballast Water Discharges
Edward J. Lemieux, US Naval Research Laboratory, USA

Concurrent Session B-5

Golden Mussel

Session Chair: Thomas Nalepa
National Oceanic and Atmospheric Administration

3:20 pm
Effect of Invasive Bivalves *Dreissena polymorpha* and *Limnoperna fortunei* on Benthic Communities
Lyubov E. Burlakova, Buffalo State College, Great Lakes Center, USA

3:40 pm
Effects of the Presence and Density of Conspecifics on Settling Juveniles of the Invasive Bivalve *Limnoperna fortunei*
Paula Sardiña, Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina

4:00 pm
Colonization Pattern and Population Density of the Invasive Bivalve *Limnoperna fortunei* in a Reservoir in Central Argentina
Alexander Karatayev, Buffalo State College, Great Lakes Center, USA

4:20 pm
Potential Distribution of Golden Mussel (*Limnoperna fortunei*) in North America Based on Environmental Limits Observed in a Tropical Wetland of Brazil
Márcia Divina de Oliveira, Embrapa Pantanal, Brazil

Concurrent Session C-5

Fish

Session Chair: Sharon Gross
US Geological Survey

3:20 pm
Sex Ratio as One of the Major Factors Promoting the Invasion of the Round Goby (*Neogobius melanostomus*) in the Gulf of Gdańsk
Mariusz R. Sapota, University of Gdańsk, Institute of Oceanography, Department of Marine Biology and Ecology, Poland

3:40 pm
Status of the Non-native Gobiids in Fish Communities and Food Webs of the Lower Vistula River (Central Poland) 3-5 Years After Their Appearance
Tomasz Kakareko, Nicolaus Copernicus University, Institute of Ecology and Environmental Protection, Poland

4:00 pm
Present Status of the North American *Umbra pygmaea* (Eastern Mudminnow) in Flanders (Belgium) and in Europe
Hugo Verreycken, Research Institute for Nature and Forest, Belgium

4:20 pm
Impacts of Introduced Aquatic Alien Species in European Aquaculture Initiatives
Stephan Gollasch, GoConsult, Germany

4:40 pm
Life History Traits of Invasive Topmouth Gudgeon (*Pseudorasbora parva*) from Europe
Eva Záhorská, Comenius University, Department of Ecology, Slovakia

5:00 pm
How Will Climate Change Factors, Such as Increased Temperature and River Discharge, Affect the Growth, Reproduction and Dispersal of Non-native Freshwater Fishes in UK Waters?
Gordon H. Copp, Centre for Environment, Fisheries and Aquaculture Science, UK

5:20 pm
Do Native Predators Feed on Exotic Preys? An Answer for Round Goby in a Multi-Species Assemblage of Piscivorous Fish (St. Lawrence River, Canada)
Yorick Reyjol, Ministère des Ressources Naturelles et de la Faune du Québec, Canada

Concurrent Session D-5

Monitoring and Rapid Response

Session Chair: Beth Brownson
Ontario Ministry of Natural Resources

3:20 pm
Volunteer Based Early Detection and Rapid Response; Examples of Successful Partnerships Addressing Non-native Finfish in the Tropical Western Atlantic
Lad Akins, Reef Environmental Education Foundation, USA

3:40 pm
Standardizing Sampling Techniques for *Potamopyrgus antipodarum* (New Zealand Mudsnail) to Establish Early Detection and Monitoring Programs
Jill M. Hardiman, US Geological Survey, Western Fisheries Research Center, USA

4:00 pm
The Adirondack Park: A Region of Opportunities for Successful Aquatic Invasive Species Spread Prevention and Management
Hilary A. Smith, The Nature Conservancy-Adirondack Chapter, USA

4:20 pm
Developing and Implementing a Citizen Volunteer Lake Water Quality Monitoring Program on 20 Northwestern Montana Lakes for Early Aquatic Nuisance Species (ANS) Detection
John L. Wachsmuth, Montana Fish, Wildlife & Parks, USA

4:40 pm
Biological Synopsis of Selected Phytoplankton New to the Bay of Fundy
Jennifer L. Martin, Fisheries and Oceans Canada, Biological Station, Canada

5:00 pm
Green Marine and its Environmental Program
David Bolduc, Green Marine, Canada

Plenary Session: Risk Analysis in a Changing World

Session Chair: Pierre Trépanier
International Joint Commission, Canadian Section

8:30 am
Frameworks and Tools for Risk Analysis of Non-indigenous Species
David M. Lodge, University of Notre Dame, Center for Aquatic Conservation, USA

9:00 am
Practical Applications of Risk Assessments in an Aquatic Invasive Species Program
Becky Cudmore, Fisheries and Oceans Canada, Centre of Expertise for Aquatic Risk Assessment, Canada

9:30 am
Break

Concurrent Session A-6

Shipping: Great Lakes Research

Session Chair: LCDR Matt Edwards
US Coast Guard

10:00 am
The Role of Domestic Shipping as a Vector for Introduction and Spread of Aquatic Non-indigenous Species in the Great Lakes
Sarah Bailey, Fisheries and Oceans Canada, Canada

10:20 am
Brine as an Alternative Treatment of Water Ballast Tanks for Non-compliant Ships Wishing to Enter the St. Lawrence Seaway
Philip T. Jenkins, Philip T Jenkins & Associates Ltd., Canada

10:40 am
Brine Treatment for Limiting Spread of Non-indigenous Species via Ballast Water
Johanna Bradie, CAISN, University of Windsor, GLIER, Canada

11:00 am
Great Lakes Shipping, Trade and AIS: A Report from the US Transportation Research Board
Hugh MacIsaac, National Academy of Sciences, Canada

12:00 pm
Luncheon

Concurrent Session B-6

Risk Analysis

Session Chair: David M. Lodge
University of Notre Dame, Center for Aquatic Conservation

10:00 am
South Australian *Caulerpa taxifolia* Invasions: Are They Inconsequential?
Marty Deveney, SARDI, Australia

10:20 am
Patterns of Invasion in Western Europe: Can We Predict Which Aquatic Invaders to Expect in Britain and Ireland?
Philine S.E. zu Ermgassen, University of Cambridge, Department of Zoology, UK

10:40 am
Statewide Risk Analysis for the Spread of Zebra and Quagga Mussels in Colorado, USA
Jonathan M. Bossenbroek, University of Toledo, Lake Erie Center and Department of Environmental Sciences, USA

11:00 am
Hung Out to Dry: Fitness Loss Due to Desiccation of Eurasian Watermilfoil (*Myriophyllum spicatum*) and Implications for Efficient Risk Management
Matthew A. Barnes, University of Notre Dame, Department of Biological Sciences, USA

11:20 am
Investigating Patterns of Risk Activity Within an Invasion Pathway
Andrew Drake, CAISN, University of Toronto, Canada

11:40 am
Predicting the Secondary Spread of *Bythotrephes longimanus* (Spiny Waterflea) in the 2EB Watershed in Ontario
Erin L. Gertzen, CAISN, McGill University, Canada

12:00 pm
Luncheon

Concurrent Session C-6

Invasion Biology

Session Chair: Mark Burrows
International Joint Commission, Canadian Section

10:00 am
An Alternative Hypothesis for Invasional Meltdown: General Facilitation by *Dreissena*
Kristen M. DeVanna, University of Toledo, Lake Erie Center, USA

10:20 am
Alien Invasive Species at the Romanian Black Sea Coast – Present and Perspectives
Marius Skolka, University "Ovidius"of Constantaza, Romania

10:40 am
Genetic Structure of Native and Introduced Populations of the Charru Mussel *Mytella charruana*
Eric Hoffman, University of Central Florida, Department of Biology, USA

11:00 am
Invasion Genetics of the Round Goby (*Apollonia melanostoma* = *Neogobius melanostomus*): Founding Sources, Spatial Patterns, and Temporal Changes
Carol A. Stepien, University of Toledo, Lake Erie Center, USA

11:20 am
Biological Invasions in Aquatic Ecosystems of the Lake Baikal Basin
Dimitriy V. Matafonov, Institute of General and Experimental Biology, Russia

11:40 am
Introduction of Aquatic Organisms to Thailand Via Aquarium Trade
Suchana Chavanich, Chulalongkorn University, Faculty of Science, Department of Marine Science, Thailand

12:00 pm
Luncheon

Concurrent Session D-6

Western Dreissena

Session Chair: Abraham bij de Vaate
Waterfauna Hydrobiologisch Adviesbureau

10:00 am
U.S. Bureau of Reclamation Response to the Western Dreissenid Invasion
Fred L. Nibling Jr., U.S. Bureau of Reclamation, USA

10:20 am
The Quagga Mussel: Dealing with an Invasive Species
Leonard Willett, US Bureau of Reclamation, Lower Colorado Dams Office, USA

10:40 am
Response of Southern Nevada Water Authority to the Quagga Mussel Invasion of Lake Mead
Peggy Roefer, Southern Nevada Water Authority, USA

11:00 am
Salt River Project and the Threat of Dreissenid Invasion in the Southwest
Lesly Swanson, Salt River Project Environmental Services, USA

11:20 am
Exercise Those Mussels: Building Dreissenid Response Readiness Through Mock Drills
Paul Heimowitz, US Fish and Wildlife Service, Region 1, USA

11:40 am
Quagga and Zebra Mussels: Are They a Major Cause of the Botulism E Epidemic? Could it Happen Out West?
Daniel P. Molloy, Division of Research and Collections, New York State Museum, USA

12:00 pm
Luncheon

Wednesday, April 22 Afternoon

Concurrent Session A-7

Shipping: Testing Technologies

Session Chair: Richard A. Everett
US Coast Guard

1:30 pm
The Wilh. Wilhelmsen Group Ballast Water Treatment Initiative
Iver Iversen, Wilhelmsen Ships Equipment, Norway

1:50 pm
Continuous Treatment (UV or UV Advanced Oxidation Plus Filtration) of Ballast Water in Closed-loop Processing Proves Viable
Linda Sealey, Trojan Technologies, Canada

2:10 pm
Methods for Measuring the Impact of UVC Treatments on Marine Phytoplankton
Benjamin F.N. Beall, University of Western Ontario, Department of Biology, Canada

2:30 pm
Differences in the Responses of Marine Phytoplankton to Monochromatic and Polychromatic UVC
André Morson, University of Western Ontario, Department of Biology, Canada

2:50 pm
Break

Concurrent Session B-7

Risk Analysis

Session Chair: Becky Cudmore
Fisheries and Oceans Canada

1:30 pm
Predation as a Component of the Risk of Establishment by Rusty Crayfish in Lakes
Darren C.J. Yeo, University of Notre Dame, Department of Biological Sciences, USA

1:50 pm
Predicting Future Great Lakes Invaders: Global Datasets of Shipping Traffic and Environmental Conditions Identify High-risk Shipping Routes
Reuben P. Keller, University of Notre Dame, Center for Aquatic Conservation, USA

2:10 pm
GlobalFish: An Environmental Matching Tool for Freshwater Organisms
Nicholas E. Mandrak, Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences, Canada

2:30 pm
A Comparison and Evaluation of Qualitative Approaches to the Assessment of Risk from Invasive Species
Marten A. Koops, Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences, Canada

2:50 pm
Break

Concurrent Session C-7

Invasion Biology

Session Chair: John Dettmers
Great Lakes Fishery Commission

1:30 pm
Effects of an Invasive Catfish on Aquatic Macroinvertebrates
Craig Duxbury, Walt Disney Imagineering, Research and Development, USA

1:50 pm
The Role of *Balanus improvisus* in the Present Macrobenthic Communities in the Gulf of Gdańsk, Southern Baltic
Anna Dziubińska, University of Gdańsk, Institute of Oceanography, Poland

2:10 pm
Vectors of Introduction, Spread and Potential Impacts of Exotic Freshwater Gastropods in Southern US
Alexander Y. Karatayev, Buffalo State College, Great Lakes Center, USA

2:30 pm
Is the Chinese Mitten Crab *Eriocheir sinensis* Threatening the Baltic Coastal Ecosystem?
Monika Normant, University of Gdańsk, Institute of Oceanography, Poland

2:50 pm
Break

Concurrent Session D-7

Crustaceans

Session Chair: Gerard van de Velde
Radboud University Nijmegen

1:30 pm
Factors Affecting the Dominance of an Invasive Amphipod *(Echinogammarus ischnus)* in the St. Lawrence River: Interactions with Other Introduced Species
Åsa M. Kestrup, CAISN, McGill University, Canada

1:50 pm
Derivation of 'Functional Responses' as a Predictive Tool in Invasion Biology: Comparison of Invader *vs* Native Functional Responses and the Effects of Parasitism
Jaimie T.A. Dick, Queen's University Belfast, Medical and Biological Centre, Northern Ireland

2:10 pm
Plasticity of Sexual Reproductive Size in Amphipods as a Strong Survival Mechanism During Invasions. A Case Study in a Dutch Lake
Dirk Platvoet, University of Amsterdam, Zoological Museum, The Netherlands

2:30 pm
Interference Competition Between Invasive and Native Gammaridean Amphipods, a Matter of Shelter or Intraguild Predation?
Gerard van der Velde, Radboud University Nijmegen, Institute for Water and Wetland Research, The Netherlands

2:50 pm
Break

Wednesday, April 22 Afternoon

Concurrent Session A-8

Shipping: Testing Technologies

Session Chair: Richard A. Everett
US Coast Guard

3:20 pm
Testing and Verification of Ballast Water Management Systems
Tor Gunnar Jantsch, Norwegian Institute for Water Research, Norway

3:40 pm
Shipboard Trials of a Ballast Water Treatment System for US and IMO Approval – A Case Study
David A. Wright, University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, USA

4:00 pm
Land-based and Shipboard Testing of the SEDNA®-System According to the IMO Guidelines
Matthias Voigt, Hamann AG, Germany

4:20 pm
Chlorine Dioxide as a Treatment for Ballast Water to Control Invasive Species: Shipboard Testing
Lucie Maranda, University of Rhode Island, Graduate School of Oceanography, USA

4:40 pm
Bacterial Response Following Chlorine Dioxide Treatment of Ballast Water
Annie Cox, University of Rhode Island, Graduate School of Oceanography, USA

5:00 pm
Testing Ballast Water Treatments on Microorganisms at the Great Ships Initiative Land-based Facility
Euan D. Reavie, University of Minnesota-Duluth, USA

Concurrent Session B-8

Risk Analysis

Session Chair: Becky Cudmore
Fisheries and Oceans Canada

3:20 pm
Development of the Canadian 'GloBallast' System
Matthyw Thomas, BMT Fleet Technology Ltd., Canada

3:40 pm
Ireland's Most Unwanted – Risk Assessment and Prioritisation of Invasive Species for Management
John Kelly, EnviroCentre, Northern Ireland

4:00 pm
Developing Risk-based Mitigation and Remediation Procedures for Non-native Freshwater Fishes: A Case Study of *Pseudorasbora parva* in the UK
Gareth D. Davies, Bournemouth University, Centre for Conservation Ecology and Environmental Change, UK

4:20 pm
Marine Biosecurity Risk Evaluation to Protect High-Value Areas of New Zealand
Marnie L. Campbell, Australian Maritime College, National Centre for Marine Conservation and Resource Sustainability, Australia

Concurrent Session C-8

Invasion Biology

Session Chair: Sarah Bailey
Fisheries and Oceans Canada

3:20 pm
Otters, Crabs and Louisiana Crayfish in Ewaso Ng'iro River: Victory of the Natives?
Mordecai O. Ogada, Kenya Wildlife Trust, Kenya

3:40 pm
Larval Settlement Substrate Preferences of *Balanus amphitrite* (the Striped Barnacle), a Long-Established Invader on Florida's East Coast
Holly Sweat, Florida Institute of Technology, Department of Marine and Environmental Systems, USA

4:00 pm
Community-level Effects of Co-occurring Native and Exotic Ecosystem Engineers
Jessica M. Ward, McGill University, Redpath Museum, Canada

4:20 pm
The Ecology of Invasive Hydroids on Man-made Structures in Port Phillip Bay, Australia
Isla Fitridge, University of Melbourne, Department of Zoology, Australia

4:40 pm
Aquatic Invaders as a Vector of Spread of Parasites and Their Potential Effect on Invaded Ecosystems
Sergey E. Mastitsky, Buffalo State College, Great Lakes Center, USA

5:00 pm
Pathway to Invasion: From Artificial Structure to Rocky Reef
Katherine A. Dafforn, University of New South Wales, School of Biological, Earth and Environmental Sciences, Australia

Concurrent Session D-8

Crustaceans

Session Chair: Gerard van de Velde
Radboud University Nijmegen

3:20 pm
Application of a Lower Food Web Productivity Model to Investigate Ecosystem Level Changes Resulting from Aquatic Invasive Species in Lake Michigan
David H. Miller, US EPA, Mid-Continent Ecology Division, Large Lakes Research Station, USA

3:40 pm
Resting Egg Bank and Yearly Recruitment Potential of the Fishhook Waterflea (*Cercopagis pengoi*) in Different Areas of the Baltic Sea
Tarja Katajisto, Tvärminne Zoological Station, Finland

4:00 pm
A Biochemical Approach to Understand the Invasion Success of an Exotic Amphipod
Sophie Sroda, Université Paul Verlaine – Metz, Laboratoire des Interactions Ecotoxicologie, Biodiversité, Ecosystèmes, France

4:20 pm
The Swimming Performance in Native and Exotic Amphipods as a Part of Their Anti-predator Strategy
Vincent Médoc, Université Paul Verlaine – Metz, Laboratoire des Interactions Ecotoxicologie, Biodiversité, Ecosystèmes, France

Thursday, April 23 Morning

Plenary Session: Emerging Issues in a Changing World

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

8:30 am
Invasive Species in the Tropics: The Same Old Mistakes in a Changing World
Mordecai Ogada, Kenya Wildlife Trust, Kenya

9:00 am
Ballast Water Management Moving Towards a New Phase
Dandu Pughiuc, International Maritime Organization, UK

9:30 am
Break

Concurrent Session A-9

Shipping: Hull Fouling

Session Chair: Francisco Sylvester
CAISN, University of Windsor, GLIER

10:00 am
Implementing Biofouling Controls on International Shipping: The Current State of the 'Art'
John F. Polglaze, URS, Australia

10:20 am
TBT Ban – A Golden Opportunity for Alien Hitchhikers?
Sanjeevi Rajagopal, Radboud University Nijmegen, , Institute for Wetland and Water Research, The Netherlands

10:40 am
IMProtector: a Novel In-water Treatment System for Vessel Biofouling
Ashley D.M. Coutts, Aquenal Pty Ltd., Australia

11:00 am
Evaluation of the Efficacy of Hull Cleaning Methods for NIS Vector Control
Chris Woods, National Institute of Water and Atmospheric Research, New Zealand

11:20 am
Hull Fouling as a Vector for Introduction of Non-indigenous Species
Francisco Sylvester, CAISN, University of Windsor, GLIER, Canada

12:00 pm
Luncheon

Concurrent Session B-9

Risk Analysis in a Changing World

Session Chair: Cynthia Kolar
US Geological Survey

10:00 am
Testing the Effects of Multiple Anthropogenic Stressors on the Spread of Invasive Species: Climate Change, Urbanization and Water Hyacinth
Juliet C. Simpson, Brown University, Department of Ecology and Evolutionary Biology, USA

10:20 am
Effects of Global Warming and Thermal Pollution on Native and Exotic Fish Species in the Rhine
Rob S.E.W. Leuven, Radboud University Nijmegen, Institute for Wetland and Water Research, The Netherlands

10:40 am
Trinational Risk Assessment Guidelines for Alien Invasive Species: Test Cases for the Snakehead (Channidae) and Armored Catfishes (Loricariidae) in North American Waters
Roberto Mendoza, Universidad Autónoma de Nuevo León (UANL), Faculty of Biological Sciences, Mexico

12:00 pm
Luncheon

Concurrent Session C-9

Plants

Session Chair: Alfred F. Cofrancesco
US Army Engineer Research and Development Center

10:00 am
The Transformation of Aquatic Invasive Species into Environmental and Economic Activities at the Niger River Basin Initiative
Sylvie Trudel, Great Lakes United, Union Saint-Laurent Grands Lacs, Canada

10:20 am
Source Populations and Reproductive Mode of Invasive *Cabomba caroliniana* in Canada
Andrée M. McCracken, University of Guelph, Department of Integrative Biology, Canada

10:40 am
The Use of Life Cycle Traits in the Management of the Invasive Species *Lagarosiphon major* in Lough Corrib, Ireland
Stephanie Evers, Central Fisheries Board, Swords Business Campus, Ireland

11:00 am
Invasive Aquatic Plants: Growing Solutions in Indiana
Patrice M. Charlebois, Illinois-Indiana Sea Grant/Illinois Natural History Survey, USA

11:20 am
Status of the Water Chestnut *(Trapa natans)* Eradication Program in Quebec, Canada
Isabelle Simard, Ministère du Développement durable, de l'Environnement et des Parcs, Canada

11: 40 am
Potential for Weed Biocontrol in Ireland: *Azolla filiculoides* Control by *Stenopelmus rufinasus*
Jan-Robert Baars, University College Dublin, School of Biology and Environmental Science, Ireland

12:00 pm
Luncheon

Concurrent Session D-9

Bullfrogs

Session Chair: Stan A. Orchard
BullfrogControl.com Inc.

10:00 am
Introduction and Session Overview
Stan A. Orchard, BullfrogControl.com Inc., Canada

10:20 am
A Practical and Effective Approach to Bullfrog Control and Eradication
Stan A. Orchard, BullfrogControl.com Inc., Canada

10:40 am
Mechanisms Behind the Successful Invasion of Bullfrogs (*Rana catesbeiana*) in the Northwest United States
Tiffany S. Garcia, Oregon State University, Fisheries and Wildlife Department, USA

11:00 am
The American Bullfrog as Predator and Cannibal: What are the Benefits of Eating Your Own Species?
Kevin Jancowski, BullfrogControl.com Inc., Canada

11:20 am
Bullfrog Eradication Efforts in Scotia Canyon, Huachuca Mountains, Arizona, USA
Thomas R. Jones, Arizona Game and Fish Department, USA

12:00 pm
Luncheon

Thursday, April 23 Afternoon

Concurrent Session A-10

VHS in the Great Lakes

Session Chair: Dale Bergeron
University of Minnesota

1:30 pm
History and Current Affairs of VHS Virus
Gael Kurath,U.S. Geological Survey, Western Fisheries Research Center, USA

1:50 pm
Development of Improved Detection Methodologies for Viral Hemorrhagic Septicemia Virus (VHSV) and their Use in the Surveillance of the Great Lakes Region of Canada
Kyle Garver, Fisheries Oceans Canada, Pacific Biological Station, Canada

2:10 pm
Persistence of VHSV-GL in the Absence of Clinical Disease
James W. Casey, Cornell University, Department of Microbiology and Immunology, USA

2:30 pm
U.S. Federal Efforts to Address VHSV and Other Aquatic Animal Pathogens
P. Gary Egrie, U.S. Department of Agriculture, Animal and Plant Health Inspection Service, USA

2:50 pm
Response of Great Lakes States to the Presence of the VHS Virus in the Region
Philip B. Moy, University of Wisconsin Sea Grant Institute, USA

3:10 pm
Fisheries Management Responses to the Detection of VHS (Viral Hemorrhagic Septicaemia) in Ontario
Brenda Koenig, Ontario Ministry of Natural Resources, Canada

Concurrent Session B-10

Lionfish

Session Chair: Raju Rajagopal
University of Radboud, Nijmegen

1:30 pm
Reproductive Biology and Ecology of the Invasive Lionfishes *Pterois miles* and *Pterois volitans*
James A. Morris, Jr., NOAA National Ocean Service, National Centers for Coastal Ocean Science, USA

1:50 pm
Predicting the Impact of Invasive Lionfish (*Pterois volitans* and *P. miles)* on Native Reef Fish Populations in the Caribbean
Stephanie J. Green, Simon Fraser University, Department of Biological Sciences, Canada

2:10 pm
Dietary Habits and Feeding Ecology of Invasive Lionfish in the Tropical Western Atlantic
Lad Akins, Reef Environmental Education Foundation, USA

2:30 pm
Bioenergetics and Trophic Impacts of Invasive Lionfish (*Pterois miles* and *Pterois volitans)*
James A. Morris, Jr., National Oceanic and Atmospheric Administration, National Ocean Service, USA

Concurrent Session C-10

Plants

Session Chair: Alfred F. Cofrancesco
US Army Engineer Research and Development Center

1:30 pm
Spread and Distribution of *Hydrilla verticillata* in North America: Where Will it Stop!
Alfred F. Cofrancesco, US Army Engineer Research and Development Center, USA

1:50 pm
Effects of Temperature, pH and Conductivity on Giant Salvinia (*Salvinia molesta*) Growth
Chetta Owens, US Army Engineer Research and Development Center, USA

2:10 pm
Integrating Herbicides with *Mycoleptodiscus terrestris* to Control Hydrilla
Linda S. Nelson, US Army Engineer Research and Development Center, USA

2:30 pm
Addressing the Invasive Risks Associated with the Importation of Plants for Planting and Status of Aquatic Federal Noxious Weeds
Christa Speekmann, US Department of Agriculture, Animal and Plant Health Inspection Service, USA

2:50 pm
Fungal Pathogen – Biocontol Agent for Reproductive Ecology of Invasive Alien *Potamogeton pectinatus* L. in Freshwater Ecosystems of the Kashmir Himalaya, India
Zafar Reshi, University of Kashmir, Department of Botany, India

Concurrent Session D-10

Bullfrogs

Session Chair: Stan A. Orchard
BullfrogControl.com Inc.

1:30 pm
Bullfrog Session continues
An open discussion, followed by a focused discussion, on issues of common concern and possibilities for future co-operation, collaborations and collective actions.

Can We Predict (and Prevent) Aquatic Invasions?

Hugh J. MacIsaac
Director, CAISN Network and University of Windsor, Great Lakes Institute for Environmental Research
401 Sunset Avenue, Windsor, ON, N9B 3P4 Canada

Aquatic invasive species (AIS) are a major ecological and economic problem globally. A central problem for environmental managers is predicting where invasions will occur, which species might invade, and how to effectively reduce the invasion threat to minimize potential problems. Canada and many other countries have developed multi-tiered approaches that seek to prevent AIS from colonizing, and thereafter selectively managing the most harmful AIS when opportunities to do so exist. This presentation will highlight some vector-based and environmental suitability approaches that are useful to identify which habitats are at greatest risk. It will utilize experiences on the Great Lakes where collaboration between USA and Canadian universities, governments, and industry has resulted in policy changes that dramatically reduce the risk of AIS invasions via ships' ballast water.

NOTES

Can We Predict the Impacts of Aquatic Invasions?

Anthony Ricciardi
McGill University, Redpath Museum
859 Sherbrooke West, Montreal, Quebec H3A 2K6 Canada

Non-indigenous species are being discovered in aquatic ecosystems at increasing rates worldwide. Most of these invasions appear to have relatively minor ecological and economic consequences, but some cause dramatic impacts – including habitat degradation, disruption of water supply systems, fishery collapse, and native species loss. Managers lack risk assessment tools for prioritizing invasion threats, because there are few predictive models that enable us to recognize which species will cause the greatest damage. A major impediment to the development of such models is the context dependence of impact. Impacts vary across time and space (e.g., an invader may cause the loss of native species from a particular area, while co-existing with the same species in other areas), largely due to the influence of local environmental variables. Furthermore, interactions with other invaders or other stressors can produce synergistic effects that are difficult to forecast (e.g., avian botulism in the lower Great Lakes).

Nevertheless, the growing number of case studies worldwide is beginning to reveal intriguing patterns that may have applied value. The most severe ecological impacts are caused by aquatic invaders that have one or more of the following qualities: 1) They have high rates of reproduction compared to less disruptive invaders; 2) They are functionally distinct from resident native species; 3) They are (often) top predators or suspension feeders; 4) They can alter the availability of critical resources such as light, nutrients, or habitat space; 5) They have been introduced to a new biogeographic region; and 6) They have a history of similar impacts in other invaded regions. The impact history of an invader, if sufficiently documented, can be used to construct predictive models for that species, as has been demonstrated with the zebra mussel and common carp.

NOTES

Aquatic Invasive Species: Closing the Science-Policy Gap

Wendy Watson-Wright
Assistant Deputy Minister, Science Sector, Fisheries and Oceans Canada
200 Kent Street, Ottawa ON K1A 0E6 Canada

In the context of expanding global urbanization, industrialization, and international trade, combined with added stresses of environmental degradation and climate change, the problems and perils of aquatic species invasions the world over continue to defy definitive solution. Certainly few topics are more complex or fraught with more possible missteps for the scientist, the policy maker and the politician than the issue of risk assessment and human behaviour. A lack of a common language among the three can make the decision-making process even more problematic.

The scientists can tell the policy makers about the empirical evidence – about the arrival of new invasive species, about their concerns on the warming of ocean currents, and on the latest risk assessment observations. The policy makers can inform the debate on the human vectors of AIS entry, on the impact of global shipping, on progress on implementing the Ballast Water Convention, on issues surrounding the aquarium trade, or live bait, or aquaculture, to name but a few of the variables involved. And the politicians are left with the challenge of encouraging and sometimes legislating best behaviours to a multitude of stakeholders holding differing and often conflicting agendas.

The presenter discusses the challenges involved in closing the science-policy gap that is often the hallmark of the divergent priorities of AIS stakeholders. With specific references to the Canadian experience, Dr. Watson-Wright will focus on how policy makers and scientists can best work together to speak with a shared language of understanding and how collectively they are in a position to help the politicians connect the dots between what we know and what we don't know. The politicians in turn can begin to make reasoned and reasonable decisions based on our current understanding of the dangers that Aquatic Invasive Species continue to present to native oceans, lakes and waterways.

NOTES

A Century of Cooperation Protecting Our Shared Waters

Rt. Hon. Herb Gray, P.C., C.C., Q.C.
Canadian Chair, International Joint Commission
234 Laurier Ave West 22nd Floor, Ottawa, ON K1P 6K6

2009 is the 100th anniversary of the Boundary Waters Treaty that created the International Joint Commission. The Treaty sets principles to guide the United States and Canada in managing the waters they share. Learn how the two countries overcome their differences in pursuit of the common good, and about the IJC's efforts to use the Treaty and the Great Lakes Water Quality Agreement to address the issue of Aquatic Invasive Species in those boundary waters.

NOTES

Sustainability – 50 Years and Counting

Richard Corfe
St. Lawrence Seaway Management Corporation
202 Pitt Street, Cornwall, ON K6J 3P7 Canada

Since its inception in 1959, over 2.4 billion tonnes of cargo valued in excess of $350 billion has been transported via the Seaway. In March, the Seaway will be marking its 50^{th} anniversary with a special opening ceremony at the St. Lambert Lock, as the navigation season gets underway.

The St. Lawrence Seaway Management Corporation is dedicated to ensuring that the Seaway operates as a sustainable transportation artery, based upon the three "pillars" of sustainability:

Environmental – We work diligently in overseeing transits into our waters, such that our carriers, through sound ballast water management practices, move cargoes in a manner that does not bring about future introductions of aquatic nuisance species.

Economic – We adapt new work practices and procedures, and leverage technology, to further refine our operations. The end result is a transportation system that moves tonnage cost effectively, reinforcing our clients' economic competitiveness.

Social – We continue to advocate the advantages of moving cargo via the Seaway Great Lakes System, recognizing that marine transportation is the most energy efficient mode, having a very advantageous greenhouse gas footprint. Every tonne of cargo moved over our waters, which we refer to as Highway H_2O, eases the pressure on our congested land based arteries. As a consequence, we foresee that moving more cargo via the marine mode brings about fewer traffic tie-ups, increased safety, and improved air quality, all contributing to our quality of life.

Sustainability and Aquatic Invasive Species

At the heart of the sustainability issue, we must address Aquatic Invasive Species and its impact upon the Seaway and Great Lakes.

The St. Lawrence Seaway Management Corporation and our U.S. counterpart, the Saint Lawrence Seaway Development Corporation, recognize that as stewards of the St. Lawrence Seaway we operate within a shared resource. Understanding and minimizing the impact of marine transportation on the environment is very important to us. Since we hold the key to the door of the Great Lakes, we are responsible for ensuring that our efforts set the standards in this field.

NOTES

Joint US/Canadian Ballast Water Inspection Program: A Binational Approach to Securing the Great Lakes and St. Lawrence River

LCDR Matt Edwards
US Coast Guard Marine Safety Detachment
180 Andrews Street, PO Box 728, Massena, NY 13662 USA

The United States and Canada share the waters of the Great Lakes and St. Lawrence River as well as the concerns of keeping aquatic invasive species at bay. A US/Canadian joint ballast water working group was formed in January 2006 to efficiently and effectively prevent the introduction of additional species into the world's largest fresh water resource. The United States Coast Guard, Transport Canada, St. Lawrence Seaway Development Corporation and St. Lawrence Seaway Management Corporation routinely share information, inspection works loads and develop shared protective measures to meet both nations' program goals. This evolving relationship has enabled the two nations to complete the daunting task of inspecting the ballast water and residuals for all vessels entering the St. Lawrence Seaway that have operated outside the Canadian EEZ.

For a St. Lawrence Seaway or Great Lakes bound vessel, the ballast water exam program begins 96 hours prior to a vessel entering eastern Canadian waters. A vessel submits a ballast water reporting form, designed to meet all agencies' criteria, to the Eastern Canadian Regulatory System (ECAREG). Transport Canada reviews this form for compliance with ballast water requirements. This provides an opportunity to alert the vessel to a deficiency in ballast water management practices and time for corrective action. Another ballast water reporting form is submitted to the US Coast Guard 24 hours prior to the vessel's arrival in Montreal. This form is again reviewed for compliance with applicable ballast water requirements.

For vessels bound for the Great Lakes or St. Lawrence Seaway, inspectors from one of the four agencies board the vessel and verify the ballast water reporting form data and the vessel's management practices. Any deficiencies found during this exam are transmitted to the other three agencies so that a joint enforcement or ballast water management practice may be implemented. The teamwork and information sharing among the inspectors and agencies has been vital to implementing a protective strategy for the Great Lakes and St. Lawrence Seaway.

NOTES

Update on the Canadian Ballast Water Database

Sonya C. Santavy
Transport Canada, Ontario Region
100 Front Street South, Sarnia, ON N7T 2M4 Canada

In 2006, Transport Canada Marine Safety and Fisheries and Oceans Canada Science launched a new battle against aquatic invasive species: the Canadian Ballast Water Database.

Over 20,000 ballast water reporting forms have been entered in the ballast water database since 2006, with an aim to provide information on ballast water entering Canadian waters. The data on the ballast water reporting forms has improved greatly since the development of the database, with more complete information being provided. However, there remain forms submitted with incomplete data, and an inconsistency in forms being used across regions. In addition, data input has been insufficient to keep up to date with actual ship arrivals. The development of online submission will address these issues to ensure a complete and national database.

Scientists are using the data to estimate propogule pressure of invasive species to Canadian ports. Accurate and comprehensive data will provide a superior investigative tool as research continues.

The Joint Boarding Enforcement program is successfully ensuring that no unmanaged ballast enters Canadian waters. All tanks are recorded and salinity testing is carried out to verify exchange or flushing has taken place. These efforts validate the data submitted by the ballast water reporting forms.

The National Canadian Ballast Water Database has not been without its challenges. The GloBallast Risk Assessment and GIS mapping have yet to be implemented, and the online submission option remains in progress. However, improvements have been made and the reality of a national database providing credible data for scientific analysis and regulatory enforcement is at hand.

Transport Canada and Fisheries and Oceans Canada remain committed to tracking vessels and ballast water management options and are optimistic that the proactive and preventative measures taken have significantly reduced the threat of ballast water discharges to the freshwaters of the Great Lakes and to Canadian ports in all areas of the country.

NOTES

The Great Ships Initiative: Making Ballast Treatment in the Great Lakes a Reality

Allegra Cangelosi *and Nicole Mays*
Northeast-Midwest Institute
50 F Street, NW, Suite 950, Washington, DC 20001 USA

Mary Balcer, Matt TenEyck, Thomas Markee and Heidi Saillard
University of Wisconsin-Superior
PO Box 2000, Superior, WI 54880 USA

Donald Reid
Consultant
200 Grandview Road, Nepean, ON K2H 8B1 Canada

Euan Reavie
University of Minnesota-Duluth
1900 East Camp Street, Ely, MN 55731 USA

Chad Scott
AMI Engineers
1 East 1st Street, Suite 403, Duluth, MN 55802 USA

The Great Ships Initiative (GSI) is a collaborative effort to end the problem of ship-mediated invasive species in the Great Lakes-St. Lawrence Seaway System through independent research and demonstration of environmental technology, financial incentives and consistent basin-wide harbor monitoring. Launched in 2006, the GSI's first priority is to incubate/evaluate operational and biological performance of prospective ballast water treatment systems at three testing scales: bench, land-based, and shipboard. GSI established a state-of-the-art Research, Development Testing and Evaluation land-based testing facility in Duluth/Superior Harbor of Lake Superior. Laboratory space within the University of Wisconsin-Superior and University of Minnesota-Duluth is utilized for bench-scale tests and analyses. Developers of ballast water treatment systems apply for GSI research services online, and research services are awarded based on an objective review process. GSI testing protocols are consistent with IMO requirements, and will be consistent with applicable domestic regulatory requirements. Infrastructure and protocol validation tests were conducted in 2007 at both the bench-scale and land-based scale. In 2008 GSI undertook treatment testing at the bench-scale on eight different treatment prospects (as of August 2008), and land-based treatment testing of an individual prospect. Intercalibration with other test facilities is a priority for GSI, and it is actively participating in intercalibration studies and collaborative calls for proposals. Methods and findings from land-based and bench-scale experiments will be presented here. GSI testing will allow meritorious ballast treatment systems to progress as rapidly as possible to an approval-ready and market-ready condition.

NOTES

Timelines for Implementing Commercial Ballast Water Treatment Systems

Dale B. Bergeron
Minnesota Sea Grant College Program
2305 East Fifth Street, Duluth, MN 55812-1445 USA

Since the 19th Century, commercial ships have been dependant on the use of ballast water for stability, safety and profitability; it is an essential element of modern global trade and our world-economy. However, ballast water poses the most important environmental issue for maritime trade in the 21st Century: the unwanted movement of aquatic organisms.

There is a desire to implement solutions expeditiously. However, the time required to move policy into implementation has not been widely considered. Once policy is determined, it will still be several years before effective, safe, tested, economically viable, and certified, ballast water treatment systems are commercially available. Ballast water treatment system certification will require multiple interests to consider efficacy, environmental impact, vessel integrity, human safety, and economic practicality. Systems will need to be designed for use on a variety of vessel types and address the needs of both new-build and retrofits. After full vetting and certification, a ballast water treatment system will need to move from prototype to final product, and then through the normal business cycle of financing, manufacturing, production, sales, distribution, installation, and support. In addition, crews will need to be trained in usage, maintenance and compliance reporting. All of these steps involve further subsets of specific activities, and each has a time demand of its own. Treatment-system installation throughout the fleet will be complex and time consuming. To fully install ballast water treatment systems on the world fleet is projected to take at least a decade, once final regulations are adopted.

The challenge of creating and installing viable ballast water treatment systems demands a multi-disciplinary and multi-organizational approach. The specific cascade of events and time considerations for bringing ballast water treatment systems to market is largely unavoidable. However, specific investments may help accelerate the process.

NOTES

Modeling the Effectiveness of Searches for Invasive Tunicates in a Prince Edward Island Estuary

Lisa G. Kanary *and James Watmough*
University of New Brunswick, Department of Mathematics and Statistics
Fredericton, NB, E3B 5A3 Canada

Andrea Locke
Fisheries and Oceans Canada
PO Box 5030, Moncton, NB, E1C 9B6 Canada

Visual searches are a common method of detecting invasive species in coastal waters, but the effectiveness of the search has rarely been evaluated. An experiment using "decoy" artificial tunicates was conducted in Hillsborough Bay, Prince Edward Island, to determine 1) the probability of detecting presence of tunicates (and the error probability of non-detection when tunicates are present), and 2) what proportion of a known number of "tunicates" are detected. Searches were conducted on blue mussel *Mytilus edulis* (blue mussel) aquaculture sites using underwater examination of mussel socks by divers, and by above-water visual examination of mussel socks, as well as a land-based along-shore search focused on floating docks and other hard substrates. Modeling was conducted to examine the effects of tunicate density, distribution, search time and search effectiveness/methodology with the goal of achieving maximum results with minimum effort and cost.

NOTES

Invasion Pathways of the Clubbed Tunicate *Styela clava* in the Northeastern Pacific

John A. Darling
U.S. Environmental Protection Agency, National Exposure Research Laboratory
26 West Martin Luther King Drive, Cincinnati, OH, 45208 USA

Recognizing the patterns by which established invasive populations expand their ranges is crucial to understanding the risks posed by those species. Recently there has been growing appreciation for the value of genetic analysis in inferring these patterns when faced with limited direct knowledge of invasion history. Here we describe the use of population genetic methods to reconstruct the expansion of the clubbed tunicate *Styela clava* in the northeastern Pacific. *S. clava* has become a common component of fouling communities from Northern Mexico to British Columbia, and has proven a costly nuisance species where found in high densities. Mitochondrial cytochrome c oxidase subunit I (COI) sequences and multilocus genotype data from12 polymorphic nuclear microsatellite loci were generated for a total of 419 individual tunicates from thirteen populations. Levels of genetic diversity range broadly, with some populations showing indications of strong founder effects. Significant genetic structure is observed across the introduced range, and patterns of genetic relatedness suggest connectivity between geographically disparate populations, indicating that human-mediated long distance dispersal events are likely contributing to the post-establishment expansion of this species. I discuss the utility of these results for assessing the most likely vectors and pathways of introduction for *S. clava*, and argue for the integration of genetic data into modeling efforts designed to predict future spread of this and other invasive species.

NOTES

Risk Analysis for the Introduction of Non-indigenous Ascidians

Martin H. Davis *and Mary E. Davis*
Fawley Biofouling Services
45 Megson Drive, Lee-on-the-Solent, Hampshire PO13 8BA UK

Traditionally, risk is defined as the product of the probability of an event and its consequence. Risk analysis, a precursor to risk assessment, identifies the key risk factors and provides an indication of where effort can be most effectively applied to reduce the overall risk.

Three phases contribute to the probability that a non-indigenous ascidian will be successfully introduced into a new area: entry, establishment and spread. The entry probability of an invasive organism may be estimated by determining the potential vectors linking source populations with the area of concern, the likelihood that the organism is associated with a vector at the source, and the probability that the organism can survive being transported to the new habitat. The probability of establishment may be assessed by determining how likely the organism is to transfer from the vector to a habitat suitable for it to survive, the availability of receptor habitats in the target area, and the probable effect of competition and predation. Arrival and establishment may be considered as stochastic events. Successful establishment depends on the number of organisms arriving exceeding a viable minimum determined by demographic stochasticity. In addition, the receiving habitat must be suitable, a function of environmental stochasticity, with an available area exceeding the minimum area necessary to contain the founder population. The probability of spread will depend upon the reproductive strategy of the organism, the duration of its life cycle, its adaptability, and whether its spread is by natural means or involves human assistance.

The consequences of the introduction of a non-indigenous ascidian are more difficult to identify but, once identified, are generally quantifiable in economic terms. An indication of the economic consequence for the receiving habitat can be obtained by assessing the financial effect caused by the organism within its existing geographic range. It is more difficult to attribute an economic value for the likely environmental, social and other effects caused by the organism in the receiving habitat.

This paper reviews the risk analysis for the introduction of a solitary (*Styela clava*) and colonial (*Didemnun* sp.) non-indigenous ascidian into the UK. It identifies the stages in the invasion process where intervention will have greatest benefit and examines suitable control methods.

NOTES

Integrated Approach to Protecting Industrial Assets from Macrofouling

Renata Claudi
RNT Consulting Inc.
823 County Road 35, Picton, ON K0K 2T0 Canada

Many different industries have to cope with a variety of macrofouling organisms. Each industry has both generic and unique problems when dealing with macrofouling. To address these problems, an integrated assessment approach can be taken. The assessment is generally a three-step process.

The first step is to assess the risk of the macrofouler flourishing, long term, in the source body of water based on chemical, physical, hydrological, operational, and biological parameters. Even when the macrofouler is already present, review of the environmental conditions of the specific water source can provide valuable insights for control strategies.

Second step of the review process should focus on a detailed assessment of the facility in question. This involves physical inspection of all elements in direct contact with the raw water source and assessment of the impact that macrofouling has on the various components and their operation. Part of this step is consultation with staff of the facility on specific operational cycles of the various components.

The third step is the formulation of a monitoring and control strategy. The control strategy has to address the specific components at risk of fouling, the operational preference of the staff and comply with the requirements of the environmental or industry regulator.

The presentation will go through the three-step process using a case study and focus on macrofouling control options and their application.

NOTES

New Challenges for the Chicago Sanitary and Ship Canal Dispersal Barrier

Philip B. Moy
University of Wisconsin Sea Grant Institute
705 Viebahn Street, Manitowoc, WI 54220 USA

Since 2002 the electric barrier in the Chicago Sanitary and Ship Canal has been providing protection from the dispersal of aquatic organisms into and out of the Great Lakes. The original barrier, constructed in 2001 has been operating for over six years and is at the end of its service life. A new more powerful and longer lasting barrier is partially constructed and will eventually replace the original barrier. However that greater size and power has brought with it increased concerns about human safety and vessel operation. Long term operation of the barrier will likely require periodic shut-downs which in turn will require removal of potentially invasive organisms from the inter-barrier portions of the canal. Clearly, the project faces significant challenges in the future. As we move toward a new era in the life of the project we will need to urgently seek and apply additional technologies to deter organisms from passing through that section of the Canal and must evaluate means to permanently separate the Lake Michigan and Mississippi River drainage basins.

NOTES

UV 101: The Basics of UV Disinfection

Ji An
Trojan Technologies
3020 Gore Road, London, ON N5V 4T7 Canada

UV disinfection is a treatment technology that has gained mainstream acceptance for treating municipal water and waste water. It is also proving to be amenable to treating hatchery waters and ballast waters, making it a powerful tool against the spread of aquatic invasive species.

To design a UV system for a given application, there are two main steps: determining the dose required to achieve the disinfection target; determining the amount of equipment required to achieve the design dose in a given application. Separating the process into these two steps helps to bring clarity to the types of information required, and understanding why UV will or will not be an economical choice for a given application.

UV inactivates viruses and bacteria by photochemically dimerizing genetic material and preventing replication. UV has also been shown to be very effective against larger pathogens like the protozoans *Cryptosporidium* and *Giardia*. Understanding of UV effectiveness on these larger organisms came with the realization that vital stain methods were too conservative for measuring inactivation, and that infectivity studies were the more meaningful approach. To prevent infection, one may only need to prevent replication as opposed to killing a pathogen. We have continued to study UV effectiveness for various organisms to help bring understanding of UV dose requirements to new applications like those for fighting aquatic invasives. Various papers at this conference will show our work on VHSV, Whirling Disease parasites, and marine phytoplankton, highlighting the theme of finding the correct metrics for measuring effectiveness.

With the proper UV dose requirement in hand, the determination of the amount of UV equipment is the next step in system design. Calculations of UV reactor dose delivery are often too simplified to properly express performance of today's reactors, especially in challenging conditions. In the municipal water treatment industries, bioassay testing has been embraced as the preferred method for actually measuring UV reactor performance. More complex models based on computational fluid dynamics have been developed and shown to be more accurate than older simplified models when compared to measured bioassay performance.

This paper will give an overview of UV disinfection, including the advancements and state of the art in the science, the equipment, the methods and the new applications.

NOTES

Please Don't Dump in Our Oceans: Innovative, Educational, Outreach Products Featuring Lionfish and *Caulerpa taxifolia* Created by Educators for Educators

Linda Walters
University of Central Florida, Department of Biology
4000 Central Florida Blvd., Orlando, FL 32816 USA

S. Zaleskie
University of Southern California Sea Grant Program
3616 Trousdale Parkway, AHF 209, Los Angeles, CA 90089-0373 USA

Although scientists will never be able to quantify the number of times unwanted aquarium organisms are released into aquatic ecosystems, all agree that this potential source of invasive species is a serious threat to global biodiversity. Scientific evidence suggests that invasions of the green macroalga *Caulerpa taxifolia* and the Indo-Pacific red lionfish *Pterois volitans* were the result of aquarium releases. Scientists also realize that outreach to those who own or maintain aquaria is the best way to reduce the likelihood of future invasions. With funding from the US Fish and Wildlife Service/U.S. National *Caulerpa* Management Plan, over the past three years we created outreach products for adult aquarium hobbyists to modify behaviors and reduce the likelihood that they will release unwanted aquarium flora and fauna into coastal waters. These products include: an animated public service announcement and DVD, a photographic key based on morphological characteristics of species in the genus *Caulerpa* that are commonly used by aquarium hobbyists, and a brochure on the alternatives to release. We are currently developing a complimentary photographic key for customs agents on organisms outside the genus *Caulerpa* that are frequently confused with *Caulerpa taxifolia.* To build upon our outreach campaign, we contacted pre-K through 12th grade educators and found they were very interested in helping us spread our "don't release" message, but they needed products specifically tailored for their classrooms. In July 2008, we ran a 6-day educator's workshop in the Florida Keys where a group of exceptionally talented pre-K through high school educators worked together to develop materials that would be effective in their classrooms. This workshop included lectures by experts in the field; running laboratory experiments on vegetative propagation in the genus *Caulerpa*; snorkeling in seagrass beds, mangroves and coral habitats to better understand local biodiversity; and brain-storming/writing time. One of the most helpful aspects of the workshop was the group critique session for each product. These were very positive and fruitful events that helped focus the message of the materials to the targeted age groups. By the end of the workshop, we had drafts of: 1) pre-school through 2nd grade story book plus associated lesson plans, 2) 3rd – 5th grade story book and lesson plans, and 3) middle and high school lesson plans with reading passages and accompanying questions that meet National, Florida and California standards for science and literacy comprehension. Post-workshop, all products were tested in a large number of classrooms by an independent evaluator to ensure our educational materials were effective and our "don't release" message was understood and remembered by all teachers and all children. Our workshop was very successful and could serve as a model for how to create effective educational products that can be successfully utilized by pre-K through 12th grade educators. We will provide copies of all of our completed products.

NOTES

Aquatic Invaders*:* Sea Grant/AZA Project Explains Pathways to Zoo and Aquarium Audiences

Katie Mosher Patterson
North Carolina Sea Grant, North Carolina State University,
NCSU Box 8605, Raleigh, NC 27695 USA

Steve Olson
Association of Zoos and Aquariums
Silver Spring, MD USA

Alan Power
University of Georgia, Marine Extension Service
20 Ocean Science Circle, Savannah, GA 31411 USA

Peggy Sloan
North Carolina Aquarium at Fort Fisher
900 Loggerhead Rd., Kure Beach, NC 28449 USA

Visitors to zoos and aquariums are taking home more than photos and souvenirs. They now have tips to avoid spreading invasive species. The *Aquatic Invaders* informal education program helps audiences to see that ecosystems can't afford to let invaders take precious habitat and food from native species. The 20-minute program focuses on pathways by which invaders spread — and answers questions such as: What harm can a little goldfish do? How should I get rid of leftover fishing bait? Why clean my boat hull between outings?

Funded by the U.S. National Oceanic and Atmospheric Administration's National Sea Grant College Program, the *Aquatic Invaders* outreach project drew upon expertise in Sea Grant programs and the Association of Zoos and Aquariums — which tallies more than 140 million visitors annually to 210 member institutions. AZA members vary, from the Shedd Aquarium in Chicago to the Roger Williams Park Zoo in Rhode Island. Even the popular Biodome de Montreal is AZA certified. Each site can tailor a "storyline" highlighting relevant species, pathways and waterways.

"This is a great partnership to bring critical and useful information to our audiences who are eager to be environmentally aware in their actions," notes Steve Olson, AZA government affairs director. Derek Chan, age 11, of Fayetteville, NC, saw the program at the NC Aquarium at Fort Fisher. "I liked that we had a chance to participate. We got to see how the ecosystem works," says Chan, who was with a school group. The audience of all ages also included many families.

Often individuals who do not know better unintentionally introduce invasive species — including red lionfish, zebra mussels and numerous aquatic plants. Now, AZA audiences can begin to identify invasive species and, more importantly, to avoid releasing invaders into new ecosystems. The program's story shares a consistent message regarding specific pathways, including home aquaria, water gardens and fishing/boating. The project team worked with many partners to develop a program to complement, not duplicate, other NOAA-supported AIS outreach, such as *Nab the Aquatic Invaders*, *Habitattitude* and *Stop Aquatic Hitchhikers.*

The *Aquatic Invaders* project was introduced to ICAIS via a poster in 2007. For the 2009 meeting, we hope to present a live, but shortened version of the innovative program, with its colorful two-layer banner as a centerpiece and the lively "Biodiversity Song" on CD from Billy B. Conference attendees would participate in the roles of AZA site visitors. We also will share responses from our project evaluation and encourage partnerships among university/agency researchers and "free choice" learning sites. *Aquatic Invaders* is the cover story for North Carolina Sea Grant's current *Coastwatch* magazine.

NOTES

Mandatory HACCP Training for Bait Harvesters: Ontario's Approach

Beth Brownson
Ontario Ministry of Natural Resources
2nd Floor North, 300 Water Street, Peterborough, ON K9J 8M5 Canada

Hazard Analysis and Critical Control Point training in Ontario is based on the successful program developed by Sea Grant in the U.S., however several modifications have been made to adapt the program to fit Ontario needs. Training is conducted for the commercial bait industry by the Ontario Ministry of Natural Resources (OMNR) with support from the Bait Association of Ontario, the Ontario Federation of Anglers and Hunters, and the Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem. After an initial attempt to have bait harvesters and dealers attend training sessions on a voluntary basis, a mandatory program was imposed beginning in 2006. Due to the large number of licenced bait harvesters and dealers in the province, training is occurring over a four-year period targeting completion in 2009. In order to obtain their licence, harvesters are required to attend a training session and complete a HACCP plan specific to their operation that is approved by OMNR staff. Dealers must complete an approved plan as well, but receive a self-learning package, rather than attend a training session. Ontario's approach will be discussed including planned efforts to monitor effectiveness.

NOTES

Boat Washing Stations — Palliative or Cure?

Douglas A. Jensen
University of Minnesota Sea Grant Program
2305 East Fifth Street, Duluth, MN 55812-1445 USA

Boat washing stations are often considered by lake associations and management authorities to prevent and slow the spread of aquatic invasive species (AIS) by recreational watercraft users. Over the last decade, several portable and permanent stations have been tried in the US and Canada's Great Lakes region. In all cases, each was discontinued after a few years. Examination of the pros and cons reveal that they were discontinued because of incomplete effectiveness, lack of use, limited public acceptance, expense (capital, maintenance), limited space, user safety and liability. While boat washing stations may be effective in certain situations (e.g., marinas) and applications (e.g., water festivals), this assessment suggests that boat washing stations in reality have limited potential as a management tool. Furthermore, if boat washing stations are used, they should be used to augment a strategic public education campaign, like *Stop Aquatic Hitchhikers!™*. Boater education programs emphasizing self-inspection and removal of AIS are a more effective method of controlling AIS than boat washing stations. This presentation will highlight the pros and cons to help you to decide if boat washing stations are palliative or a cure to prevent and slow the spread of AIS by watercraft users.

NOTES

Physical Factors Influencing the Dilution and Long Range Dispersion of Ballast Water Discharged in a Harbour

Mathew Wells
University of Toronto at Scarborough, Department of Physical and Environmental Sciences
1265 Military Trail, Toronto, ON M1C 1A4 Canada

Barry Ruddick, Chris Taggart and Matthew Hatcher
Dalhousie University, Department of Oceanography
Halifax, NS B3H 4J1 Canada

Sarah Bailey
Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences
867 Lakeshore Road, Box 5050, Burlington, ON L7R 4A6 Canada
and
University of Windsor, Great Lakes Institute for Environmental Research
401 Sunset Avenue, Windsor, ON N9B 3P4 Canada

Gary Sprules
University of Toronto at Mississauga, Department of Biology
Mississauga, ON L5L 1C6 Canada

The International Maritime Organization has proposed ballast water discharge standards for viable organisms and indicator microbes. Theoretically, as the number of organisms (propagules) in ballast water decreases, the probability of long-term population establishment also decreases due to density-dependent demographics and environmental stochasticity. One limitation for estimating the efficacy of the proposed standards is an understanding of the rates of physical dilution and dispersal of ballast water post discharge. Here we report preliminary results from an experiment designed to obtain a) dilution rate of ballast water post discharge; b) residence time of ballast water in the harbour; and c) probability of transport of propagules over distances up to 6 km. Ballast water from two ships was tagged with rhodamine WT dye and microscopic magnetically-attractive tracer particles and discharged at the Port of Goderich, Ontario under normal operational conditions. Fluorometric tracking of dye, intercalibrated with simultaneously conducted net tows to collect tracer particles were used to estimate initial dilution rates and harbour residence time. Long distance tracking of particles was achieved via autonomous moored magnetic particle collectors. Initial results will be presented and an expanded program in 2009 will be outlined.

NOTES

Invertebrates and Resting Stages in Sediment of Ballasted Ships Entering Canadian Ports

Elizabeta Briski, *Melania Cristescu and Hugh MacIsaac*
CAISN, University of Windsor, Great Lakes Institute for Environmental Research
401 Sunset Avenue, Windsor, ON, N9B 3P4 Canada

Sarah Bailey
Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences
867 Lakeshore Road, Box 5050, Burlington, ON, L7R 4A6 Canada

The introduction of non-indigenous species (NIS) is a potent agent of biodiversity change. Ballast water and hull fouling are recognized as the most important vectors for NIS introductions to marine habitats globally. Currently, we have little information of the relative strength of these mechanisms for delivering NIS to ports in eastern and western Canada and to the Great Lakes.

Here, as part of the CAISN initiative, we opportunistically sampled ballast on board ships. Three categories of ships were sampled in eastern and western Canada: transoceanic ships carrying exchanged ballast water, ships from the USA carrying exchanged ballast water, and ships from the USA carrying unexchanged ballast water. Transoceanic ships carrying exchanged ballast water were also sampled on the Great Lakes.

In all cases, we collected and identified invertebrates and their diapausing stages to explore the relative risk of invasion by each shipping transit category to each region. Diapausing eggs and active invertebrates were separated from sediment and counted. Cladoceran, copepod, and rotifer taxa were then identified using mitochondrial 16s and cytochrome oxidase 1 (CO_1) sequences. Results from laboratory-based hatching experiments were used to infer viability of diapausing eggs. The number of eggs hatched will be used to estimate the number of viable propagules, which then will be multiplied by the amount of sediment to estimate the total number of propagules per ship. We then test the hypothesis that propagule pressure is directly related to invasion rates in different regions of the country.

NOTES

Non-indigenous Dinoflagellates (Motile and Cyst Forms) Introduced by Ship Transport to Canadian Aquatic Ecosystems

***Oscar Casas-Monroy**, Suzanne Roy and André Rochon*
CAISN, Université du Québec à Rimouski, Institut des Sciences de la Mer de Rimouski
310, allée des Ursulines, Rimouski, QC G5L 3A1 Canada

Ballast water has been identified as a major vector of introduction of aquatic invasive species (AIS) into new areas of North America. In order to reduce the abundance and diversity of AIS, ships now have to exchange their ballast water in mid-ocean, before reaching coastal regions. However, these non-indigenous species invasions continue, even with mandatory guidelines (form June 2006 for Canada) for the control of ballast water management. The present study focuses on dinoflagellates, a group of phytoplankton with numerous toxic or harmful species and with life stages both in the plankton (vegetative cells) and in the benthos (resting cysts). The major objectives are to: 1) Identify dinoflagellate species from ballast water and sediments carried by ships visiting the Canadian West and East coast and the Great Lakes; 2) Compare propagule pressure among transoceanic ships, USA-exchanged and USA-unexchanged ballast water; and 3) Compare the risk associated with the transport of non-indigenous species in ballast water and ballast sediment. During the summer of 2007 and 2008, 160 ballast water samples were collected from Bulk Carrier ships visiting Vancouver (West coast), Port-Cartier, Sept-Îles, Halifax (East coast), Hamilton and Toledo (Great Lakes) harbors. Preliminary results show that non-indigenous dinoflagellate species were present in ballast water (e.g., *Dinophysis caudata, D. tripos, D. dens, Ceratium* cf. *gibberum*, cf *Akashiwo sanguinea*). Some of these species are harmful or toxic (e.g., *Dinophysis caudata, D. acuminata* cf *Akashiwo sanguinea* and *Alexandrium* sp.). In ballast sediment, five non-indigenous species were found: cf. *Echinidinium transparantum, Gymnodium* cf *catenatum, Lingulodinium machaerophorum, Spiniferites bentori* and *Trinovantedinium applanatum* even though all ships examined had done ballast water exchange. Half of the non-indigenous species were found in both transoceanic and USA-exchanged ships arriving to the West coast. However, comparing these classes of ships to the East coast, occurrence of NIS was highest in the latter (60%). Further analyses will allow us to assess their potential for establishment in these coastal regions.

NOTES

Pseudo-nitzschia Propagule Pressure in Ballast Water Arriving in Canadian Ports

Georgia Klein *and Irena Kaczmarska*
CAISN, Mount Allison University, Department of Biology
63B York Street, Sackville, NB, E4L 1G7 Canada

James M. Ehrman
Mount Allison University, Digital Microscopy Facility
63B York Street, Sackville, NB, E4L 1G7 Canada

In addition to the invasive potential of micro-organisms discharged by ballast water, added concern may be the introduction of harmful organisms including toxigenic diatoms. Dinoflagellates and diatoms are one of the most often reported micro algae found in ships' ballast waters.

Pseudo-nitzschia Peragallo is a marine diatom genus widespread in all oceans of the world. The majority of the species are thought to be cosmopolitan. Numerous studies on members of this genus have increased since its various species are known for their ability to produce domoic acid (DA), the accumulation of this toxin in shellfish presenting a severe health problem for humans (amnesic shellfish poisoning), and other higher invertebrates, e.g., sea lions. For accurate assessment, not only cell counts are needed but also correct species identification which currently require the use of scanning electron microscopy (SEM). As part of the Canadian Aquatic Invasive species Network (CAISN), 67 ballast water samples from vessels arriving in ports at the East Coast (EC,24), West Coast (WC,30) and Great Lakes (GL,13) have been investigated using light microscopy and SEM. Epifluorescence served as an indicator for the viability of the cells at the time of fixation. Three classifications of ship types applied to our study: 1) ships undergoing ballast water treatment in form of trans-oceanic exchange (TOE); 2) intra-coastal exchange (ICE) which is required when travelling up the US-American WC from a port south of Cape Blanco; or 3) ballast water was discharged into ports by vessels commuting between US-American and Canadian ports but without undergoing exchange (ICU). In 63% of the samples 16 members of the genus *Pseudo-nitzschia* were found. Of these, only 6 species are reported as being non-toxic, so far.

With over 25,000 cells/L, ICE vessels arriving at the EC carry the highest density of viable propagules. At the WC, ICU vessels exceed the TOE threefold with viable propagules being discharged into the receiving port of Vancouver, BC. Of the identified *Pseudo-nitzschia* species some should be cause of concern, e.g., *P. turgidula* was found in 11 ships with the mean of 824 cells/L. This is a significant finding as *P. turgidula* has not yet been reported among the *Pseudo-nitzschia* species occurring at the East Coast and was isolated and identified as toxic from a harmful bloom in New Zealand. WC samples in general showed a higher diversity with 13 species present compared to 9 species occurring in EC samples. Only 2 of 13 samples from the GL contained in total 3 *Pseudo-nitzschia* species, 2 of which are toxigenic. In conclusion, Pseudo-nitzschia species are arriving frequently in ballast water in Canadian ports. Furthermore, several species show high densities indicating a considerable propagule pressure on the receiving coasts.

NOTES

Does Genetic Structure of Diatom Populations Change During a Transoceanic Voyage?

Michael L. MacGillivary *and Irena Kaczmarska*
CAISN, Mount Allison University, Department of Biology
63B York Street, Sackville, NB, E4L 1G7 Canada

With recent increases worldwide in the number and size of ocean-going vessels there is a greater potential for alien species to be transported and dispersed worldwide as these ships travel from port to port. These species, under the appropriate, yet poorly understood conditions, may become invasive and cause widespread damage to local ecosystems as has been the case with the European green crab, *Carcinus maenas* L., on the Atlantic and more recently the Pacific coasts of North America. Macroscopic organisms such as these are more readily noted when invasive, whereas microbiota such as diatoms are often overlooked. However, with ballast tanks of some transoceanic ships harbouring as many as 3×10^8 viable cells of dozens of diatom species, it is logical to assume that some alien species have already been established in Canadian waters. Often, microscopic invaders to marine environments have only been noticed after reaching a "nuisance state" and causing significant economic or health problems. The presumed cosmopolitan nature of many diatoms morpho-species hampers the task of detecting non-indigenous arrivals, which may be morphologically cryptic. This study aims to detect changes in the genetic structure of populations of diatoms in ballast tank water over the duration of one transoceanic voyage. We hypothesize the change in genetic composition will be non-random, and that we will identify taxonomic and geographic source(s) of the arriving inoculums. Samples taken daily, over a 21 day transoceanic voyage, will be examined to select a few of the most common ballast water species (i.e. *Ditylum brightwellii* (West) Grunow). Then 10 individual cells or colonies per sample will be isolated and subjected to a single cell PCR protocol to amplify the ITS region of the nuclear ribosomal RNA. Haplotypic and nucleotide diversity will be estimated within and between each sample day. The most prevalent and/or persistent haplotypes of these species will then be compared to those now present in Canadian receiving port(s) to see whether these haplotypes are already present in these waters. Since diatoms are one of the largest contributors to carbon fixation (25%) on earth, they form the base of most aquatic food webs and thus are of great ecological importance. Invasion of diatom species may interfere with the viability of native species and may have a large ecological impact. Also, some diatom species cause harmful algal blooms that may decimate other ecologically important biota, or may have an adverse affect on the aquaculture industry and human health (i.e. certain *Pseudo-nitzschia* species cause amnesic shellfish poisoning). The conclusions drawn from this study may provide information as to which haplotypes are non-native and may be potential invaders and may serve notice that invasive microscopic organisms such as diatoms may be a threat to marine ecosystems in Canada.

NOTES

Diatom Propagule Supply for Canadian Ports – Initial Results of a Two-year Survey

Irena Kaczmarska, *Georgia Klein and Imke Lang*
Mount Allison University, Department of Biology
63B York Street, Sackville, NB E4L 1G7 Canada

James M. Ehrman
Mount Allison University, Digital Microscopy Facility
63B York Street, Sackville, NB E4L 1G7 Canada

Jennifer L. Martin
Fisheries and Oceans Canada, Biological Station
531 Brandy Cove Road, St. Andrews, NB E5B 2L9 Canada

The rate of new biological invasions increased exponentially in the past three decades throughout the World Ocean, across habitats, but most conspicuously across taxonomic groups comprised of macroscopic and well studied organisms. Evidence exists suggesting that shipping plays the major role in such dispersal. Ballast tank waters carried by cargo ships are quickly translocated over great distances, allowing source region biota taken up with ballast to arrive alive and in great numbers to receiving ports. Among such arrivals diatoms, photo-autotrophic protists are one of the most taxonomically diverse and numerous microorganisms, making the numbers of diatom individuals translocated (propagule supply) worldwide astronomical. Yet the number of diatoms species known to be invaders is minuscule. The following hypotheses attempt to reconcile this discrepancy: 1) reported taxonomic resolution of the arriving diatom propagules is insufficient to recognize non-indigenous species; 2) our knowledge of indigenous Canadian diatom florae is insufficient to allow detection of alien species, or 3) only cosmopolitan diatoms survive in ballast waters.

We tested these hypotheses on a data-set consisting of 110+ ballast water samples collected over two seasons at several ports from three regions of Canada; West coast (WC), East coast (EC) and Great Lakes (GL). Three categories of vessels were targeted; those undergoing either trans-oceanic ballast exchange (TOE) or intra-coastal ballast exchange (ICE) and those carrying un-exchanged ballast (ICU). We identified diatom species or to lowest practical taxonomic level. We related sample diatom species composition and densities to measured ballast water parameters (temperature, salinity, pH), type of vessel, specific coast of Canada, ballast source and location of exchange and length of transit.

After the first year of study we already identified 150+ species of diatoms in incoming ballast waters, 17 of which are not yet reported from Canadian coasts. Propagule size varied greatly, from a few cells up to 800,000 cells L^{-1}. Many species arrive at our ports repeatedly, indicating a consistent rate of propagule supply. Thus far we have detected no obvious relationship between the propagule composition and supply and the type of vessel, ballast water origin or measured properties of ballast waters. Our results thus far suggest that both diatom propagule quantity and the rate of delivery at examined Canadian ports are considerable and sufficient for alien species establishment.

Many diatom species are believed to be cosmopolitan. However, the rapid increase in number of discovered (semi)cryptic species among diatoms suggests that at least some of the species presumed to be cosmopolitan may represent species complexes. Therefore we are in the process of applying molecular genetics to verify species-specific affinity of selected "cosmopolitan" diatoms and to identify taxonomic and geographic source(s) of the arriving inocula.

NOTES

Ballast Water Abundance and Composition of Heterotrophic Prokaryotes Discharged into Canadian Harbours

Bei Sun, *Candice Way and Richard B. Rivkin*
CAISN, Memorial University of Newfoundland, Ocean Sciences Centre
St. John's, NL A1C 5S7 Canada

During a study carried out from March to November 2007, and May to October 2008 we assessed the potential introduction and risk of ballast water-introduced bacteria to the Canadian coastal environment. We measured bacterial abundances, size and community structures along the West and East coasts of Canada and on the Great Lakes.

Our study showed that bacterial abundances in port water samples, which ranging from 3.44×10^{8} cell L^{-1} to 1.01×10^{10} cell L^{-1}, was three- or four-fold higher than that in ballast water samples ranging, which from 8.69×10^{7} cell L^{-1} to 2.60×10^{9} cell L^{-1}. Cell volumes of all 2007 samples, ranging from $0.051\mu m^{-3}$ to $0.162\mu m^{-3}$ (n=72), were about two-fold larger than these of 2008 samples, ranging from $0.039\mu m^{-3}$ to $0.088\mu m^{-3}$ (n=99). , Community structure as determined by Fluoresecence *In Situ* Hybridization (FISH) during 2007, showed that for the domains *Eubacteria* and *Archaea* percentages of the prokaryotic communities were higher in all port samples (66.3%) than in all ballast water samples (46.4%, P=0.006). *Cytophaga-Flavobacteria* and *alpha-proteobacteria* account for more than half of detected *Eubacteria* for all both port water samples and ballast water samples. The potential pathogens, *Vibrio spp.* and *E. Coli* were under detection in our study with FISH, but it could not exclude the possibility that their existence in low abundances.

Although bacterial abundances in ballast waters were lower than in receiving harbors, the distinct ballast water bacterial community structures in ballast waters from port water samples implies potential environmental risks from ballast water-distributed bacteria to Canadian harbours.

NOTES

Bacterial Dynamics in Ballast Water During Trans-Pacific Voyages of Bulk Carriers

Jennica Seiden, *Candice Way and Richard B. Rivkin*
CAISN, Memorial University of Newfoundland, Ocean Science Centre
St. John's, NL, A1C 5S7 Canada

Abstract: To assess bacterial dynamics in ballast water during trans-Pacific voyages of bulk carriers, water samples were collected during two voyages (July-August 2007 and September-October 2007) from ballast tanks of a ship that originated in Hakata, Japan, and terminated on the West Coast of Canada approximately 3 weeks later. Here, we (i) characterize the population response (growth, loss, and community structure) of heterotrophic microbes in ballast water during oceanic transit, (ii) assess the environmental factors (temperature, dissolved oxygen concentration, and salinity) that regulate the changes in bacterial processes, and (iii) assess the efficacy of mid-ocean exchange (MOE) as a method for reducing the number of bacteria entering Canadian waters and thus potential ecological changes.

During the July-August voyage, bacterial abundances in the unexchanged tanks increased from ~4.6×10^8 to 1.8×10^9 cells/L (day 9), while in MOE tanks, abundances increased from ~8.6×10^8 to 2.2×10^9 cells/L (day 9) before MOE (day 12). In both cases, this increase was followed by a decline. The average net growth rates for unexchanged and MOE tanks were 0.22 d^{-1} (0.02 to 0.92 d^{-1}) and 0.10 d^{-1} (0.02 to 0.21 d^{-1}), respectively. Bacterial cell volumes in the unexchanged tanks generally increased and were significantly ($p = 0.05$) larger at the end of the voyage. In the MOE tanks, bacterial cell volumes decreased until exchange occurred, when they significantly ($p = 0.05$) increased and then decreased. During the September-October voyage, bacterial abundances showed different growth patterns compared with the summer voyage. There was an overall decline in all tanks (unexchanged tanks, ~2.9×10^9 to 1.1×10^9 cells/L; MOE tanks, ~2.8×10^9 to 1.2×10^9 cells/L). However, for both voyages no significant differences were found between the final bacterial abundances of the unexchanged tanks and MOE tanks, suggesting MOE does not significantly reduce the number of bacteria in the tanks.

Bacterial abundances showed a significant and positive relationship with temperature and an inverse relationship with dissolved oxygen concentrations ($p < 0.001$; ANCOVA; for both variables) during the July-August voyage. However, during the September-October voyage, no significant relationships were observed. The preliminary observations of the July-August voyage suggest that a supplemental strategy (to MOE) for controlling the introduction of heterotrophic microbes into Canadian coastal waters could be to maintain ballast tanks at lower temperatures and higher dissolved oxygen concentrations. This would need to be assessed further. The varied responses between cruises could be due temporal and spatial differences and thus possible differences in bacterial assemblages (ballast water was taken up in different harbours). Community structure will be characterized to provide further insight into these varied responses and relationships.

NOTES

Monitoring for Tunicates in Nova Scotia

***Benedikte Vercaemer**, Jean-Marc Nicolas, Dawn Sephton and JoAnne Keays*
Fisheries and Oceans Canada, Bedford Institute of Oceanography
1 Challenger Drive, Dartmouth, NS B2Y 4A2 Canada

In the past decade, the shellfish culture industry in Atlantic Canada has been severely impacted by invasions of fouling tunicates. A surveillance program was initiated by Fisheries and Oceans Canada (DFO) in 2006 under the Aquatic Invasive Species program to monitor five species of concern: *Ciona intestinalis* (vase tunicate), *Botrylloides violaceus* (violet tunicate), *Botryllus schlosseri* (golden star tunicate), *Styela clava* (clubbed tunicate) and *Didemnum vexillum.* Collection plates have been deployed every year at geo-referenced sites along the coast of mainland Nova Scotia and Cape Breton and retrieved after 8-10 and 16-20 weeks. Monitoring sites were selected based on the presence of the following risk factors for tunicate introduction or establishment: shellfish processing/aquaculture in area, port with international traffic, marina with US traffic, fishing harbour, high risk ports with herring or US caught lobster processing. On the South Shore of Nova Scotia, *Ciona intestinalis* is the most problematic species for mussel farms and monitoring recruitment on a weekly/bi-weekly basis can help management and mitigation practices. Results from the past few years will be presented. To complement this targeted surveillance, posters, brochures and ID Watch Cards were produced in an effort to promote community based monitoring (general surveillance) and circulated to members of the general public, lease holders and fishermen. Numerous presentations have been made to various stakeholders and a toll-free AIS tunicates reporting line and e-mail address were also established.

NOTES

First Occurrence of the Invasive Colonial Ascidian *Didemnum vexillum* to Utilize Eelgrass *Zostera marina* as Substrate

Mary R. Carman
Woods Hole Oceanographic Institution, Biology Department
360 Woods Hole Road, Woods Hole, MA 02543 USA

The invasive colonial ascidian *Didemnum vexillum* Kott, 2002 has adapted to utilizing eelgrass *Zostera marina* (Linnaeus, 1753) as substrate in Atlantic coastal waters at Massachusetts. Usually associated with artificial and rocky substrates, we found *D. vexillum* attached to *Z. marina* at Lake Tashmoo, Martha's Vineyard, Massachusetts in 2008. Several non-endemic species of ascidians including *D. vexillum* were introduced to New England in the 1980s and are now common in subtidal communities and at shellfish aquaculture sites, marinas and harbors. The bay scallop *Argopecten irradians irradians* (Lamarck, 1819), a cultured shellfish that is also placed out as part of shellfish restoration efforts on the Vineyard, is a valuable coastal resource on the Vineyard and elsewhere in New England. Eelgrass serves as a habitat for bay scallops and juvenile fish and threats to it are of concern by coastal managers and the fishing industry. We surveyed Lake Tashmoo, a protected marine pond with shellfish aquaculture operations and restored bay scallops. We found the invasive colonial ascidians *D. vexillum*, *Botrylloides violaceus* Okra, 1927, *Botryllus schlosseri* (Pallas, 1774), *Diplosoma listerianum* (Milne-Edwards, 1841) and the native solitary ascidian *Molgula manhattensis* (Dekay, 1843) growing on eelgrass in patches scattered throughout the mid pond area, encompassing about one fourth of the pond. These ascidians, including *D. vexillum*, were attached to the stalk and blade of live in situ eelgrass and to floating pieces of eelgrass. Rafting of ascidians on floating eelgrass blades or pieces of the plant is a recognized dispersal mechanism for some ascidians and should now be considered as a dispersal mechanism for *D. vexillum* too. *Botrylloides violaceus, B. schlosseri, D. listerianum* and *M. manhattensis* have been previously recorded as attached to eelgrass, but *D. vexillum* has not been previously recorded attached to eelgrass. Perhaps because of lack of available space, *D. vexillum* has spread to utilize eelgrass as habitable space. Other eelgrass sites in North American Atlantic and Pacific waters should be examined for epibiotic ascidians and the impact of *D. vexillum* and other invasive species of ascidians on eelgrass should be assessed.

NOTES

Rapid Response to a New Marine Invader in Ireland – *Didemnum* spp.

***John Kelly**, Caitriona M. Maguire and Peter Cosgrove*
EnviroCentre
10 Upper Crescent, Belfast, BT7 1NT, Northern Ireland

Christine A. Maggs
Queens University Belfast, School of Biological Sciences
97 Lisburn Road, Belfast, BT9 7BL, Northern Ireland

The colonial tunicate *Didemnum* spp. was first recorded in October 2005 at one site on the east coast of Ireland and at a second location in June 2006. It was found extensively overgrowing fouling organisms on the hulls of pleasure craft and other submerged surfaces in two marinas. Distinction between *Didemnum* species is difficult; however the tunicate colonies formed pendulous growths, which had not been observed in Ireland before. Similar growth forms have been recorded in North America, New Zealand, France and the Netherlands. The absence of *Didemnum* at other marina sites or observations of this growth form before suggested it was a recent arrival to Ireland.

At the same time as *Didemnum* was recorded in 2006, a risk assessment framework for potential and established invasive species was being developed and applied in Ireland. Although the status of the Irish form had not yet been established as non-native, a precautionary approach was taken and it was included in the risk assessments while awaiting clarification of status. The potential for this species to impact on the shellfish aquaculture industry and overgrow sessile marine organisms and impact marine habitats of conservation value were considered sufficient threats to 'shoot first and ask questions later'.

Given its relatively restricted distribution and potential for rapid spread resulting in impacts on areas of nature conservation value and the shellfish industry, *Didemnum* scored highly in the risk assessment and was selected for the preparation of a management plan. A working group made up of key stakeholders including scientists, Government Departments and agencies, environmental managers, marine conservation groups and the aquaculture industry were involved in the development of the management plan during 2007. Given the limited resources available for implementation of the plan, this stakeholder approach ensured the involvement of key organisations enabling a baseline distribution survey to be undertaken and inspection of aquaculture installations for the presence of *Didemnum*. Containment of further spread was a priority so action undertaken included a public awareness campaign and development of Codes of Practice for marina operators, the aquaculture industry and recreational water users which aimed to prevent further spread of *Didemnum* and other aquatic invasive species.

While these actions were ongoing the status of *Didemnum* as a non-native species was confirmed so the precautionary approach was justified in this case. The implementation of the management plan is now being led by stakeholder groups and supported by the Invasive Species in Ireland project. This paper will present progress to date and lessons learnt in developing a rapid response to a new marine invader in Ireland.

NOTES

Successful Eradication of the Colonial Violet Tunicate, *Botrylloides violaceus,* in Belleoram Harbour, Fortune Bay, on the Southern Newfoundland Coast – Rapid Response and Mitigation Strategy

Cynthia H. McKenzie *and Geoff Perry*
Fisheries and Oceans Canada, Northwest Atlantic Fisheries Centre
PO Box 5667, St. John's, NL A1C 5X1

In October 2007, during an aquatic invasive species (AIS) dive survey on the southern coast of Newfoundland, the colonial Violet tunicate, *Botrylloides violaceus,* was detected on a small area of the government wharf and attached to three vessels in Belleoram Harbour, Fortune Bay. The AIS dive survey was part of the 2007 Rapid Assessment Survey being conducted Province -wide focusing on high traffic ports and areas of interest, in particular Placentia Bay and Coast of Bays on the south coast of Newfoundland. These AIS surveys were a collaborative effort between Fisheries and Oceans Science (AIS Monitoring Program), Policy and Oceans Branches, the Ocean Sciences Centre (OSC), Memorial University and the Provincial Department of Fisheries and Aquaculture (DFA). Several follow up surveys were conducted in the surrounding areas and no additional colonies were found. No *B. violaceus* was detected at any other location during the Newfoundland survey in 2007.

Belleoram is a very active, multi-use harbour and an important area for commercial fishing, finfish and shellfish aquaculture. Following the discovery of *B. violaceus*, concern was expressed by several industries based in the area regarding the risk to aquaculture and the potential spread and rapid growth of this AIS colonial tunicate. In November at the Newfoundland AIS Workshop held in St. John's, several mitigation measures were discussed with attending federal and provincial participants as well as industry and environmental stakeholders. Recommendations arising from the workshop included a rapid response mitigation plan for *B. violaceus* in Belleoram to prevent the spread of this new AIS in Newfoundland waters.

The early detection, the relatively confined extent of the infestation, the time of year, the location of the colonies on a government wharf and the willingness to respond made eradication or suppression a possibility with a reasonable chance for success. A mitigation plan was developed by Fisheries and Oceans Canada in consultation with OSC, DFA, Environment Canada and the Newfoundland Aquaculture Industry Association.

The mitigation was implemented on March 10-17th, 2008. Methods of tunicate removal were modified from New Zealand treatment trials for *Didemnum vexillum* infestations. Fisheries and Oceans, Small Craft Harbours requested harbour maintenance at the Belleoram government wharf and commercial divers were contracted for site clean-up. The mitigation had three areas of focus with priority on the manual removal of the AIS colonies. The vessels were wrapped in plastic sheets (7 days) with a freshwater layer introduced between the hulls and plastic. The wharf pilings and cross-beams were wrapped in plastic wrap and remained in place until June. Rocks and other material were manually removed by the divers were allowed to air dry/freeze. Finally the seafloor of the infested area was vacuumed using an underwater hose and tanker truck.

The success of the mitigation was confirmed when a follow up dive survey was conducted June 17, 2008 and no *B. violaceus* was found in the eradication area. Another dive survey is scheduled for late September 2008 to determine introduction and re-growth during the summer months.

NOTES

Development of a Portable Aquatic Laboratory for Mitigation Studies on Aquatic Invasive Tunicates

Garth Arsenault *and Jeff Davidson*
University of Prince Edward Island, Atlantic Veterinary College
550 University Avenue, Charlottetown, PE C1A 4P3 Canada

Thomas Landry
Fisheries and Oceans Canada
343 University Avenue, Moncton NB, E1C 9B6 Canada

A constraint for aquatic invasive species researchers studying mitigation strategies in Atlantic Canada has been the lack of a flow through salt water system. Salt water recirculation systems have limited application in treatment trials due to space limitations and the requirement for regular feeding and extensive monitoring and maintenance of the system to ensure acceptable water quality. During the summer of 2008, a portable aquatic laboratory (PAL) was designed and setup on a marine wharf in eastern PEI to enable close observation of the effects of new treatments on tunicates. The adjacent estuary is heavily infested with *Ciona intestinalis* (Vase tunicate) and provides a source of research animals. Research is conducted in the PAL using thirty small (20 L) and five large (200 L) tanks that are supplied with flow-through seawater pumped from the adjacent harbour. Animals are thus exposed to natural food sources and favourable water quality, eliminating the need to provide food or artificial seawater. Remote surveillance of the laboratory is possible through a network camera permanently connected to the Internet. The PAL will provide researchers with an efficient means to evaluate the efficacy of new mitigation treatments or to study the biology of exotic species in a controlled environment using the estuarine water from which the study animals are collected. This presentation will outline the development and use of the PAL.

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New Mitigation Options Against *Ciona intestinalis*

***Christine Paetzold**, Jeff Davidson and Aaron Ramsay*
University of Prince Edward Island, Atlantic Veterinary College
550 University Avenue, Charlottetown, PE C1A 4P3 Canada

Over the past decade, the fouling of mussels and aquaculture gear by invasive tunicates has decreased the profitability of the mussel industry in PEI. Tunicates settle in such abundance on mussel gear and crop that regular maintenance requires more time, manpower and cost due to the increased weight of the gear. In addition, mussel growth and meat yields can be negatively impacted on leases heavily infested with tunicates resulting in longer time to reach market size. Lastly, either chemical or mechanical treatments are necessary to remove the tunicates from mussel gear throughout the season and prior to harvest, adding more expenses to a mussel farming operation.

Currently, the most detrimental tunicate around PEI is the vase tunicate, *Ciona intestinalis.* Consisting mostly of water, *C. intestinalis* adds considerable weight to the mussel lines. Previously, a variety of *C. intestinalis* mitigation treatments were tested and high-pressure water proved to be most effective. Our current focus is on developing a more practical and efficient mitigation method. New treatments under consideration include the biocide Virkon Aquatic®, electrochlorination (hypochlorous acid), ultrasound, laser and water siltation. In addition, the cellulose-degrading enzyme cellulase was tested since tunicates contain a cellulose-like compound in the tissue surrounding their internal organs. Treatment trials were conducted in the laboratory at the Atlantic Veterinary College and in a portable aquatic laboratory (PAL), which is a flow-through system using estuarine water. The goal of these trials was to develop a treatment that is safe, effective, affordable and efficient, both from an economic and environmental perspective. This presentation presents the results of the work carried out in the summer and fall of 2008 discussing the effectiveness of each treatment as a tunicate mitigation option.

NOTES

Field Trial to Optimize High-pressure Water Treatment for *Ciona intestinalis* on Mussel Aquaculture on Prince Edward Island

Aaron Ramsay, *Christine Paetzold and Jeff Davidson*
University of Prince Edward Island, Atlantic Veterinary College
550 University Avenue, Charlottetown, PE C1A 4P3 Canada

Over the past decade, four exotic tunicates (*Styela clava*, *Ciona intestinalis*, *Botrylloides violaceus* and *Botryllus schlosseri*) have been detected in Prince Edward Island (PEI), Canada. *Styela clava*, was the first exotic tunicate to arrive in 1997, rapidly establishing, spreading, invading, and eventually becoming a nuisance in several estuaries. The mussel industry adapted by modifying some of their growing practices and increasing the effort to produce a market-size mussel. In the fall of 2004, the vase tunicate *C. intestinalis* was detected. The abundance of *C. intestinalis* rapidly increased post-incursion, eventually replacing *S. clava* as the foremost nuisance species on mussel farms. Over the past couple of years, new tools and strategies were developed to mitigate the impact of *C. intestinalis*, however this species is proving itself to be much more prolific than *S. clava*. High-pressure water delivery systems designed to remove the tunicates from the product and gear have shown to be the best treatment to date, however the optimal timing of treatment application and the number of repeated applications remain undetermined. This mitigation technique requires a considerable amount of effort and re-establishment by *C. intestinalis* is rapid. A large field trial has been designed to address this issue and is currently in progress. Three sites along the eastern coast of PEI have been chosen for this study. Data on the population development of *C. intestinalis* and water quality are also being collected in parallel with the field trial. Treatments will be applied throughout the summer and fall field season, with sampling occurring in November, April and at the time of mussel harvest. Based on indicators such as reduction of tunicate fouling and mussel productivity an optimal treatment will be recommended to the mussel industry.

NOTES

Washington State's Response to Invasive Tunicates in Puget Sound: Accomplishments, Lessons Learned and Next Steps

Kevin Anderson
Puget Sound Partnership
PO Box 40900, Olympia, WA, 98504-0900 USA

In 2006, the state of Washington began an official response to infestations of nonnative invasive tunicates in Puget Sound. The tunicates are *Styela clava* (club tunicates), *Ciona savignyi* (transparent tunicate), and *Didemnum vexillum* (colonial tunicate). Based experiences with similar infestations around the world and the potential for significant environmental and economic damage to the region, the state responded as quickly as possible to these newly discovered infestations. Club tunicates infested four marinas in Puget Sound, *Ciona savignyi* were found growing in extremely large numbers over commercially important giant geoduck clam (*Panopea abrupta*) beds, while *Didemnum* was discovered at several marinas, and important underwater parks and critical habitat areas.

In 2006, the Governor and the legislature appropriated $250,000 from emergency and supplemental state funds to respond to this problem. Since then, the legislature authorized an additional $500,000 for the 2007-2008 fiscal period to finish work started in 2006. We anticipate another $500,000 or more for the 2009-2011fiscal period to collect better scientific information and improve the state's ability to effectively respond to invasive tunicates. Future efforts will focus on research to fully evaluate the environmental consequences of the invasion, improving monitoring to track the rate of spread, eradicating invasive tunicates at specific locations, and managing all vectors that spread these animals.

The Puget Sound Partnership, the agency that sets the environmental agenda to restore and recovery Puget Sound, created an oversight committee to coordinate and oversee the work of multiple state agencies involved in the response. The state caucus group, working with an advisory committee, drafted a management plan that identified short and longer-term strategies for responding to these invaders.

The initial focus of the state's response strategy in 2007 and 2007 was to stop club tunicates from spreading to other locations in Puget Sound (outside the four infested marinas). Fouled hulls of recreational boats spread this organism during summer voyages away from their home marinas. The state hired commercial diver companies to survey the infested marinas and remove club tunicates from boat hulls before the start of the recreational boating season.

Other elements of the response strategy focused on (a) enhancing the state's ability to detect new invasions, (b) conducting education and outreach to the boating public, marina operators and natural resource managers about the issue, and (c) carrying out surveys to determine the spread and distribution of invasive tunicates in Puget Sound. The state also (d) monitored the effectiveness of eradication efforts, (e) developed and tested methods and procedures to cost effectively kill and remove invasive tunicates, and (f) documented costs for mobilizing the response and carrying out containment and control work.

The author will discuss lessons learned from the initial response efforts including accomplishments, challenges and key next steps.

NOTES

UV Inactivation of Viral Hemorrhagic Septicemia Virus (VHSV IVb, Great Lakes Drum Isolate)

Linda Sealey
Trojan Technologies
3020 Gore Road, London, ON N5V 4T7 Canada

Paul Huber and John Lumsden
University of Guelph
50 Stone Road East, Guelph, ON N1G 2W1 Canada

Viral hemorrhagic septicemia virus (VHSV) is a rhabdovirus of the Norvirhabdoviridae. A major feature of VHSV is the broad range of species affected both in fresh and marine water, with a total of at least 48 species recorded to date. VHSV was newly identified in the Great lakes associated with a mortality event in freshwater drum (Lumsden et al. 2007) and subsequently from multiple mortality events in numerous species (Elsayed et al. 2006; Groocock et al. 2007). It is highly probable that VHSV entered the Great Lakes via ballast water, pointing to the need for ballast water treatment. All strains of VHSV are reportable diseases under the World Organization for Animal Health (OIE) and as such the presence of the agent has substantial implications for fish culture, both for protecting facilities and receiving waters from VHSV in feed and discharge water, and for ensuring disease-free stocks to prevent the unintended spread of VHSV.

UV disinfection is a treatment technology that has great utility in hatcheries and aquaculture facilities as it is non-chemical, and is highly effective on a wide spectrum of pathogens from virus to bacteria to protozoans. We investigated the UV dose-response requirements for VHSV, using a Great Lakes isolate. Epithelioma papulosum cyprini (EPC) cell line (ATCC, CRL-2872) was used for the propagation of VHSV IVb Great Lakes drum isolate (B042-05, Lumsden et al. 2007). Freshly prepared stocks of VHSV IVb were made into working stocks of about 10^6 pfu/mL. Aliquots of the working stocks were exposed to UV light to establish a dose-response curve, along with appropriate controls. UV irradiations were done using a monochromatic (254 nm) collimated beam apparatus and UV dose accuracy was ensured by using a NIST-traceable calibrated radiometer. Plaque assays were used to quantify infectious virus.

VHSV IVb proved to be very susceptible to UV. In our first experiments, the lowest treatment of 5 mJ/cm^2 inactivated all of the VHSV (> 6 logs). Later low dose experiments defined the inactivation kinetics to be 0.61 mJ/cm^2/log reduction. These UV dose requirements are very low and thus UV is both amenable and economical as a treatment technology for fish culturing facilities and for ballast water. In contrast, municipal water and water reuse requirements typically range between 20 and 100 mJ/cm^2 to provide protection against a spectrum of pathogens. Despite the low dose requirements for VHSV, a wise approach would be to implement treatment at a higher dose as a barrier against multiple pathogens that may have higher UV resistance.

NOTES

Ultraviolet for Golden Mussel Larvae Control and Microcystis Removal as Pilot Experiments

***Cintia Pinheiro dos Santos**, Vanessa Gazulha, Maria Tereza Raya Rodriguez, Maria Cristina Dreher Mansur, Luiz Fernando Cybis, Pedro Costa, Manuel Luiz Leite Zurita, Marinei Vilar Nehrke and José Paulo Martins*
Federal University of Rio Grande do Sul – UFRGS
Av. Bento Gonçalves, 9500, Setor 4, Prédio 43422, Sala 102, Porto Alegre - 91.540- 000, RS, Brazil

Limnoperna fortunei (Mytilidae), the so-called golden mussel, is an invasive freshwater bivalve native from south-eastern Asia. It was observed in South America for the first time in Argentina (1991) and southern Brazil (1998). After seven years it has spread from Guaíba Lake upward Jacuí River, Brazil, causing both severe impact in the environment and biofouling in thermal electric power plants. In Guaíba Lake, cyanobacteria blooms have also been frequently observed during the summer increasing in frequency and density each year. Cyanotoxins production by blooms can be a problem leading to animal and human intoxications, and complications in water treatment. The aim of this study was to remove golden mussel larvae by UV light exposure in order to mitigate the biofouling impacts inside cooling systems of power plants. Additional experiments using cyanobacteria *Microcystis aeruginosa* were made in order to evaluate the effect of UV treatment for larvae control on the *M. aeruginosa* cellular lise and microcystin releasing. UV radiation pilot tests were carried out at an experimental station built in laboratory from November 2007 to April 2008. Larvae were sampled from Guaíba Lake and filtered using 30-μm plankton net. Golden mussel larvae and *M. aeruginosa* were exposed to two 75 w UV Nat7501 reactors in four different water flows: 1400, 2000, 2400, 3000 $m^3.h^{-1}$. Initial concentration of larvae and *M. aeruginosa* were 50 $ind.mL^{-1}$ and 10^4 $cells.mL^{-1}$, respectively. To assess the UV exposition effects on larvae the following variables were observed at the laboratory: larvae concentration, exposition time to UV radiation under different water flows, and water types (deionized and raw water). *M. aeruginosa* experiments were made in deionized water. After exposure, the water containing larvae was re-filtered, concentrated in 100 ml, and observed under microscope. Letability criteria were: lack of movements, opening and closing of valves, and crystalline style rotation. Larvae mortality was significantly high in all water flows tested ($p<0,001$). *M. aeruginosa* cell lising and microcystin releasing were very low in all water flows tested ($p>0,001$). The best results (100 % mortality) were obtained after 7-min exposure under UV radiation treatment in a 1400 $m^3.h^{-1}$ water flow. The experiments for larvae control by ultraviolet radiation exposition did not promote *M. aeruginosa* cell lise and microcystin releasing in the tested conditions.

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NOTES

Invasive Fish Eradication Using Rotenone Derived Products in Water Bodies of Andalusia (Southern Spain)

Carlos Fernández-Delgado
University of Córdoba, Department of Zoology
Campus Universitario de Rabanales, Edificio Charles Darwin: 3a pta, Cordoba E-14071 Spain

Rafael Arenas González
Consejeria de Medio Ambiente
Junta de Andalucia, 7a planta, Cordoba E- 14071 Spain

Gunnar Persson
InterAgro AB, Sweden

Andalusia, in southern Spain, endures the hottest and driest summers in the country, and most probably in Europe. In this context, most of its natural wetland areas are non-permanent. Nevertheless, some have water throughout the year, constituting essential shelters for biota, especially during the summer drought. In fact, these wetlands are the last refuge for several endangered duck species, such as the White-headed Duck (*Oxyura leucocephala*), the Red-crested Pochard (*Netta rufina*) or the Tufted Duck (*Aythya fuligula*). One of the worst disturbances in these rare habitats is the presence of exotic fish species, introduced in these water bodies mainly for mosquito control (mosquitofish, *Gambusia affinis*), and sport fisheries (largemouth-bass, *Micropterus salmoides*; carp, *Cyprinus carpio*).

As a pioneer management experience in the country, the Andalusian Environmental Agency (regional government), along with the University of Córdoba, is developing a program to eradicate fish species from these wetlands using chemical methods. These habitats are very appropriate for this kind of treatment: they are endorheic and closed systems, isolated from other water bodies. To date we have treated 4 lagoons where we have eliminated over 50 tons of fishes, of which carp represented over 99 %. One of the treated lagoons was home to the sand smelt *Atherina boyeri,* a native fish species. Previous to the treatment, we captured a representative number of specimens (≈ 4000) that were kept in captivity for one year. Once the lagoon recovered appropriate conditions for the species, it was restocked with these specimens. The species is reproducing again in the lagoon.

Both the methodology developed to spread the liquid, and the product used, derived from rotenone (CFT Legumine®), revealed very efficient. Monitoring programs showed that fish eradication was 100% effective. After one year of treatment, habitat conditions improved considerably: the anoxic area decreased; transparency increased, aquatic vegetation, which was almost non-existent before the treatment, covered most of the lagoons´ bottom; and the invertebrate community increased from one to 16 species. The existing low quality bird community, dominated by piscivorous species, rapidly changed after treatment to another, more interesting, dominated by diving species. The endangered duck species have returned to the lagoons again.

NOTES

Better Biocide Delivery to Fouling Surfaces: Reaching the Interface from Within

Sanjeevi Rajagopal *and Gerard van der Velde*
Radboud University Nijmegen, Institute for Wetland and Water Research
Heyendaalseweg 135, 6525 AJ Nijmegen, The Netherlands

Vayalam Purath Venugopalan
BARC Facilities, Water and Steam Chemistry Division
Kalpakkam 603 102, India

The green mussel *Perna viridis* (L.), the brown mussel *Perna perna* (L.), and the black striped mussel, *Mytilopsis sallei* (Recluz) are the important invasive fouling species occurred in industrial cooling water systems. Injectable biocides are mainly used to control biofouling in water treatment systems, heat exchangers and industrial cooling towers. Unlike paints, they are injected into the bulk water, from where they diffuse to the bulk water material interface (which is the actual site of biofilm/biofouling formation), building up a concentration sufficiently strong enough to deter biological attachment. One major deficiency of this method (as compared to an antifouling paint) is that a large portion of the added biocide is wasted to "treat" the bulk water, because biofouling essentially is an interfacial problem. This method, therefore, entails a larger biocide inventory than what is required, had the treatment been truly "interfacial" and results in unnecessary kill of organisms in the bulk water. A logical method would be to deliver the right concentration of biocide at the interface (within the viscous sublayer) so that an effective concentration is maintained at the actual site of fouling, while the bulk water concentration remains largely negligible.

The present study attempts to use porous surfaces to serve as a biocide (e.g., chlorine) delivery vehicle. Ceramic surfaces represent a relatively new class of porous materials that can be produced from a variety of starting materials and processed in different ways to yield products with a broad range of physical-chemical characteristics as well as a large range of applications. The robust character of ceramic membranes enables them to withstand broad pH and temperature ranges, elevated pressures, organic solvents and chemical and heat sterilization. In addition, pore size can be controlled in these materials. Ceramic based delivery vehicles have been successfully used for application of sparingly soluble biocides such as ozone. We used porous surfaces (from commercial sources) for delivery of chlorine and study their usefulness for application in biofouling control in industrial cooling water systems. Our results indicates that about 45-60% of chlorine can be saved by using porous surfaces in comparison with existing continuous chlorination for controlling mussel fouling in industrial cooling water systems. Biocide concentrations in discharged water will also be correspondingly reduced. Though the method looks promising, more work is required on the effectiveness of the method on a variety of fouling organisms before it can be adopted for power plant biofouling control.

NOTES

Chronic Thermal Tolerance Limits of Quagga Mussels from Lake Mead (Arizona/Nevada) Relative to Zebra Mussels from Oklahoma, Kansas and New York

Robert F. McMahon and John Morse
University of Texas at Arlington
Box 19494, Department of Biology, Arlington, TX 76019 USA

The invasive quagga mussel, *Dreissena rostriformis bugensis*, was discovered in Lake Mead (Arizona/Nevada) during January 2007. Zebra mussels, *Dreissena polymorpha*, were discovered during 2003 at Lake Oologah, Oklahoma. These populations experience average late summer surface water temperatures of approximately 29°C, close to both species' previously estimated incipient upper thermal limits.

Chronic upper thermal tolerance limits were determined for quagga mussels from Lake Mead (Arizona/Nevada) and zebra mussels from Lake Oologah (Oklahoma) and Hedges Lake (New York). Mussels were acclimated to 20°C for two weeks prior to experimentation. Subsamples (n = 20) from each group were exposed for 28 days to constant temperatures ranging in 1°C increments from 20°C-33°C (quagga mussels) or 26-34°C (zebra mussels) during which sample mortality was assessed daily. Median survival times at a lethal temperature of 29°C for Lake Mead quagga mussels were 480 h ± 10 h, and, for zebra mussels from Hedges Lake and Lake Oologah, 483 h ± 14 h and 355 h ± 10 h, respectively. The reduced survivorship of Lake Oologah zebra mussels at 29°C may have been due to poor physical condition associated with massive summer mortalities. In contrast, recent (2008) studies of chronic thermal tolerance in a healthy population of zebra mussels from Lake Winfield, Kansas, indicated that their thermal tolerance was greater than that of mussels from Hedges Lake, New York, indicative of selection for increased thermal tolerance.

Thermal tolerance data for quagga mussels from Lake Mead suggested that this population will not thrive in shallow surface waters during the summer but could survive at deeper, cooler depths. The potential development of increased thermal tolerance among southwestern zebra and quagga mussel populations may result in their US distributions extending into southern waters previously considered too warm for successful colonization. It may also require increased treatment temperatures or application times for successful thermal remediation of mussel fouling in southern and southwestern raw-water facilities.

NOTES

Eradication of Introduced Signal Crayfish (*Pasifastacus leniusculus*) and Rudd (*Scardinius erythropthalmus*) Using the Pharmaceutical BETAMAX VET®

Roar Sandodden and ***Helge Bardal***
National Veterinary Institute, Section for Environmental and Biosecurity Measures
Tungasletta 2. NO-7485 Trondheim, Norway

Stein Ivar Johnsen
Norwegian Institute for Nature Research
Fakkelgården, N-2624 Lillehammer, Norway

During October 2006, the first documented discovery of signal crayfish in Norway (*Pasifastacus leniusculus*) was reported from the area Dammane in Telemark County. The introduced signal crayfish population was infected with the crayfish plague (*Aphanomyces astaci*). Dammane drainage consists of 5 small ponds, the largest measuring approximately 2000m^2 surface area. The crayfish plague is categorized as the most severe, or a group-A disease by the Norwegian food safety authorities.

The National Veterinary Institute in Norway produced upon request from the Norwegian food safety crayfish, with review of suitable methods. This resulted in recommending the use of the pharmaceutical BETAMAX VET® followed by draining of the ponds. Throughout Europe there have been several attempts to eradicate signal crayfish. No attempts not involving the use of chemicals have been successful.

The ponds were initially known to inhabit both a very rich insect fauna and the Norwegian red list salamander species Northern crested newt (*Triturus cristatus*) and common newt (*Triturus vulgaris*). During the 1960`s, rudd (*Scardinius erythrophthalmus*) had been introduced to Dammane, resulting in strongly reduced insect species diversity, and an apparent extermination of the salamanders. While working with the assessment, the environmental authorities identified eradication of the rudd as a secondary objective following a BETAMAX VET® treatment.

BETAMAX VET® is a cypermethrin-based pharmaceutical developed for treatment of salmon lice (*Lepeophtherius salmonis*), infestation of farmed Atlantic salmon (*Salmo salar*). Cypermethrin is a synthetic pyrethroid and a common agent in many insecticides licensed throughout Europe.

Pyretroids are toxic to coldwater fishes, aquatic insects and crustaceans, while other invertebrates, mammals and birds are relatively tolerant.

The National Veterinary Institute, section for Environmental and Biosecurity Measures was given the assignment to eradicate signal crayfish from Dammane, with eradication of the rudd as a secondary objective. Following a comprehensive mapping of the Dammane tributary, a two-step operation was performed 14.05.08 and 28.05.08. The eradication was performed by the help of powerful pumps placed in a boat and/or on the shore. The chemical was mixed well before and during the treatment, and dispersed both on the surface and along the bottom of the ponds. Draining of the ponds were conducted in the period 2-4.06.08. During the first treatment signal crayfish was found in the upper two ponds in Dammane, whereas rudd was found in all five. During and after the second treatment and draining of the ponds, no signal crayfish or rudd has been found.

As part of the eradication programme, the ponds will be drained again in the coming December or January, before being gradually re-filled during the spring 2009. A comprehensive monitoring programme is following the treatment. It is too early to conclude weather the treatment has been successful, but the results so far are promising. We believe that BETAMAX VET® can be a useful tool in managing alien crayfish.

NOTES

Stop Aquatic Hitchhikers!™ – A Successful Campaign Preventing the Spread of AIS

***Douglas A. Jensen**, David Henkel-Johnson, Luke Stewart and Marie E. Zhuikov*
University of Minnesota Sea Grant Program
2305 East Fifth Street, Duluth, MN 55812-1445 USA

Jay Rendall and Susan Balgie
Minnesota Department of Natural Resources, Invasive Species Program
500 Lafayette Road, Box 25, St. Paul, MN 55155-4020 USA

Kim Bogenschutz
Iowa Department of Natural Resources, Invasive Species Program
1436 225th Street, Boone, IA 50036 USA

Ronald Martin (retired)
Wisconsin Department of Natural Resources, Invasive Species Program
PO Box 7921, 101 South Webster Street, Madison, WI 53707 USA

Philip B. Moy
University of Wisconsin Sea Grant Institute
705 Viebahn Street, Manitowoc, WI 54220 USA

Since zebra mussels first invaded the Great Lakes more than 20 years ago, boaters and anglers have been targeted with information aimed to prevent the spread of zebra mussels and other aquatic invasive species (AIS). Based on several Sea Grant-sponsored surveys of boater and anglers in multiple states, we have more insight into their awareness, knowledge, attitudes, beliefs and behavior than any other audience. Results of those surveys helped provide the foundation for the national *Stop Aquatic Hitchhikers!™* campaign, which now has over 650 US partners nationwide. Recently, Minnesota Sea Grant teamed up with the Minnesota, Wisconsin and Iowa Departments of Natural Resources, Wisconsin Sea Grant, US Fish and Wildlife Service, US Forest Service, Wildlife Forever, and others to expand the campaign across the tri-state region. Based on a grant from NOAA/Sea Grant, resources were leveraged to focus multimedia on key invasion corridors aimed at reaching resident and non-resident boaters and anglers. Minnesota dedicated the greatest resources and used the most media compared to Wisconsin followed by Iowa. Surveys delivered at water accesses in 2006 and 2007 reveal not only that the campaign is reaching tri-state boaters and anglers, it continues to raise their awareness and empower them to take appropriate actions to prevent the spread of AIS. Minnesota boaters and anglers were more aware and likely to take future action at water accesses (99%) than the other two states both years. Importantly, 20% more Wisconsin and Iowa boaters and anglers in 2007 compared to 2006 were influenced to take future action at water accesses based on their exposure from the campaign! Results strongly suggest that states and other jurisdictions that make *Stop Aquatic Hitchhikers!™* a priority can work to protect our waters from the spread of harmful AIS.

NOTES

Watercraft Inspection Training for Dreissenid Mussels in the Western United States

Stephen H. Phillips
Pacific States Marine Fisheries Commission
205 SE Spokane Street, Suite 100, Portland, Oregon 97202 USA

William Zook
Contractor, Pacific States Marine Fisheries Commission
320 E. Penzance Road, Shelton, WA 98584 USA

Wen Baldwin
Lake Mead Boat Owners Association
850 S. Boulder Hwy. Ste 119, Henderson, NV 89015-7564 USA

Authorized by Congress in 1947, the Pacific States Marine Fisheries Commission (PSMFC) is dedicated to resolving fishery issues. The objective of the PSMFC ANS Program is to prevent harm from ANS species to important commercial and recreational fisheries and the ecosystems upon which these fish depend.

It is generally agreed that the most effective means of preventing the spread of Dreissenid mussels are mandatory inspection stations at key highway points for all recreational watercraft. However, to implement such a program is cost prohibitive, though the gravity of the Dreissenid expansion in the West is causing states to take another look at inspection stations. Therefore, resource managers have been using what resources are available to increase the capacity for water managers, law enforcement and marine safety personnel to detect and intercept contaminated watercraft.

PSMFC's Watercraft Inspection Trainings (WIT) began in 2006, with USFWS (100th Meridian Initiative) and Bonneville Power Administration funding, to train boating law enforcement personnel in the western US on the background, biology and impacts of zebra mussels; how to identify high risk watercraft and conduct inspections of all types of watercraft; how to perform a vessel decontamination; and what their legal authority is to stop, detain, and require decontamination of watercraft suspected of harboring zebra mussels. Since its inception the program has trained over 1500 people in and more than 80 entities in eleven western states.

In April 2008, trainings were split into "Level One" and "Level Two." Level One is the basic training course, instructed by Bill Zook. This course consists of three hours of instruction consisting of an overview of the Dreissenid threat, viewing parts 1 and 2 of the "Don't Move a Mussel" video, hands on watercraft inspection and a written exam. Level One is designed for those who are actively involved in conducting watercraft inspections within their jurisdiction. Level Two training is intensive and designed for professionals in all fields that expect to be actively involved in setting-up or supervising inspection and decontamination programs for trailered watercraft and those who wish to become trainers within their state or work group. Level two training is delivered over two days (12 hours) at Lake Mead located on the Nevada/ Arizona Border near Las Vegas and instructed by Wen Baldwin. This course focuses on actual field inspection of various types of watercraft leaving the lake which may or may not be contaminated with quagga mussels and the decontamination of those watercraft requiring it. The instruction includes the use of portable (low-cost) temperature controlled power wash units and a large permanent multi-station self-contained power wash systems.

This paper will discuss the successes and challenges of WIT as part of an overall ANS education/prevention program strategy and the future direction of WIT; including extending trainings to a larger audience such as commercial boat haulers and marina operators.

NOTES

Using Interactive Web Technology to Educate and Inspire Community Action to Address Aquatic Invaders

Robin Goettel
Illinois-Indiana Sea Grant Program
65 Mumford Hall, 1301 W. Gregory Drive, Urbana, IL 61801 USA

Nancy Balcom and Diana Payne
Connecticut Sea Grant Program
1080 Shennecossett Road, Groton CT 06340 USA

Samuel Chan
Oregon Sea Grant
200 Warner-Milne Road, Oregon City, OR 97045 USA

Helen Domske
New York Sea Grant
207 Jarvis Hall, SUNY, Buffalo, NY 14260-4400 USA

Dianne Lindstedt
Louisiana Sea Grant
103 Sea Grant Building, Baton Rouge, LA 70803-7507

The "Nab the Aquatic Invader!" interactive web site is a fun and informative tool for students in grades 4-10. Funded through a National Strategic Initiative Grant from the NOAA National Sea Grant College Program, this site is an exciting education technology venture that uses problem-based activities to captivate students as they learn about aquatic invasive species. The topic of aquatic invaders offers students and educators an interesting way to learn about biodiversity, ecological impacts, adaptations, and biology. An engaging detective theme raises awareness of the critical nature of problems caused by thirty-four (34) "criminal" invaders and inspires a desire to take action. Students hone their detective skills as they investigate these invaders, conducting research with the help of fact sheets, photos, web links, curricula, education kits, maps, and more.

For each of four regions of the country (Atlantic, Gulf, Pacific coasts and Great Lakes), students will learn about relevant "top ten" aquatic invaders, while incorporating science process skills including inquiry, critical thinking, and synthesis. Web site visitors can improve content knowledge by reviewing information on the origin and distribution, transport, environmental and economic impacts, and solutions for control for each of the featured species. Completion of interactive, grade-level appropriate activities leads the honorary detectives towards the final "booking" of the each suspect; these activities blend science, math, and geography with reading, writing (including limericks and songs), and artistic expression. Submitted student projects will be reviewed and exemplary examples posted on the site to help teach important concepts to their peers. The site enables students to "Ask the Experts" studying marine and aquatic invaders and "Meet the Scientists" to learn how they got excited about this field of inquiry and potential careers.

Formal and informal educators can use the web site to creatively enhance existing units or workshop sessions, access activities created by fellow teachers, enhance content knowledge, and work with technology that integrates science, geography, math, language arts, and cultural arts. One section of the site promotes ideas on how students can get involved in service projects to heighten awareness about invasive species problems in their communities. Summaries of selected stewardship projects will be added to the web site, and shared globally. By working to raise awareness of aquatic invasive species, students are empowered as stewards of their local environment, while making responsible decisions regarding oceans, Great Lakes, and inland waterways.

The site has already been incorporated into a university-level service learning course, which culminated in seven stewardship projects that engaged undergraduate students, 4^{th} -7^{th} graders, and numerous community partners to do their part to help stop the spread of invaders. Sea Grant educators and outreach specialists in Illinois, Indiana, Connecticut, Louisiana, New York and Oregon collaborated on this national project.

Invasive Wetlands Plants Campaign and Outreach Tools

Hélène Godmaire
Great Lakes United, Union Saint-Laurent Grands Lacs
3388, rue Adam, Montréal, QC H1W 1Y1 Canada

Horticulture is an important vector for the introduction and dispersion of exotic plants in Canada. In Québec, there are no rules regulating the production and distribution of ornamental exotic plants, nor do any official prevention programs exist. Consequently, plant producers and gardening centers often sell potentially invasive exotic plants without being aware of the risks. In turn, gardeners unwittingly spread invasive plants by multiplying specimens or disposing of them in nature.

Today, many wetlands along the St. Lawrence River are colonized by, and often dominated with, exotic plant species used in horticulture, landscaping and filtering marsh. In an effort to protect wetland biodiversity and integrity, Great Lakes United has undertaken a two-year 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. Building on this program, Great Lakes United is working with horticulture schools to press the importance of prevention focus and promoting voluntary codes of conduct. In tandem with the educational program, Great Lakes United is also developing a Plant Watch program to detect invasive plants. This program will involve gardeners, anglers, hunters, bird-watchers, boaters, hikers, and other groups and individuals that frequently visit wetlands along the St. Lawrence and other rivers and lakes in the province. Education strategies, tools, results and perspectives will be presented.

NOTES

Linking Science, Community, and Action through Aquatic Invasive Species (AIS) Education: Outcomes of a Pilot Project and Why it Worked

Samuel Chan *and Tania Siemens*
Oregon Sea Grant College Program and Extension Service, Oregon State University
307 Ballard Hall, Corvallis, OR 97331 USA

This abstract would provide some impressive actual case studies/products of classroom AIS prevention stewardship projects, tools and impacts that compliment a paper submitted by Robin Goettel "Using Interactive Web Technology to Educate and Inspire Community Action to Address Aquatic Invaders".

This paper describes outcomes of an aquatic invasive species education (AIS) project by Oregon Sea Grant as part of the NOAA funded Nab the Aquatic Invader (NABS: **http://sgnis.org/kids** see Robin Goettel's 2009 ICAIS presentation "Using Interactive Web Technology to Educate and Inspire Community Action to Address Aquatic Invaders"). We trained and supported 13 K-12 teachers in an 8 month pilot program that resulted in the teacher integrating AIS learning in the sciences classroom to over 900 students who also completed stewardship projects aimed at finding solutions to invasive species in their community. Projects ranged from a student designed survey of science and K-6 teachers for an entire city school district in Oregon, USA on invasive species awareness and the use of disposition of live plants and animals are released after a science project, laboratory studies, public commercials, field research and

Cross-curriculum learning includes invasive species haikus, songs, species profiles, and an animated *Claymation* film on invasive species pathways. One student project that cleverly defined invasive species and action through exceptional script and artwork won the prestigious Oregon Invasive Species Council's Invader Crusader Award — presented to the Oregon student(s) making a difference in protecting Oregon from invasive species.

Example of Student Outreach Projects

- AIS BLOG http://julielife-ais.blogspot.com/
- School Surveys: Students designed a survey on awareness and use of invasive species in the classroom that was administered to all teachers that taught science in the City's school district
- Cleverly designed and tailored PowerPoint presentations with original artwork and music developed by high school students that can highlight AIS issues.
- Letters to newspapers: Students published letters in local newspaper (link at julielife-ais-blogspot.com)
- Skits: 4th grade students created skits designed to discourage other students to release classroom pets or learning organisms.
- Claymation film "Barbershop of Horrors" with original sound track.
- Public Service announcement (videos) about invasive species, impacts and how people can be part of the solution
- T-shirts: "Start to Care - Stop AIS from being there!" sweatshirts and bumper stickers.
- Music: Original songs about AIS that were aired on the local radio station.
- Invasive Species float in the Earth Day Parade
- A theatrical story (using an endangered native turtle as the main character that conveys AIS concepts, pathways, impacts and human behavior).

Science and Language Arts Learning

- Circle books (a combination art, science, and research project) about global warming that integrate invasive species.
- Researched invasive species in the Willamette Coast Fork Watershed
- Students composed invasive species Haikus.

Scientific Inquiry Projects

- Students tested and observed the rapid growth and spread of English Ivy.
- Students experimented with how to control and aquatic invasive plant (water hyacinth) through controlled experiments in aquariums.
- Mapping and relating the distributions of native (red legged) and invasive frogs (bullfrog).

What We Learned from the Teachers and Students

Participating teachers naturally incorporated invasive species into their lessons to reach science benchmarks, foster inquiry, inspire student learning, and engage at-risk students. Teachers unanimously agreed that invasive species are an excellent tool for teaching science, language, history, and technology standards. Teachers reported that invasive species provided them with new and interesting examples that fit naturally into their existing and required curriculum, inspired student learning, and connected to the real world. Teachers noted AIS examples improved the interest, desire to learn, demonstrated learning and in some cases

Retention of At-risk Student

Invasive Species examples formed a framework for understanding complex systems like watersheds. Many teachers used AIS as a reoccurring theme that helped link together multiple related topics like climate change, ecology, land use change, watersheds, and human impact on the environment. For example one teacher wrote: *"As a high school teacher in a small rural school district, I have found many benefits for myself and students stemming from our involvement in the AIS Education Program. By connecting the Siuslaw Watershed Council, Mapleton Schools, and AIS education with funded student driven learning projects I have experienced many positive gains with my students' knowledge of watersheds and the impact of invasive species."*

Invasive species are a platform for community stewardship, outreach, and partnerships. Most of our teachers developed partnerships with local agencies and community groups to conduct research projects or engage in outreach campaigns.

Invasive species stewardship projects provide opportunities for student research in the classroom or the field. Many of our students engaged in field monitoring or classroom research related to invasive species distribution, growth and spread, and impact on native species and ecosystems.

We learned that using aquatic invasive species piqued student interest and generated a new interest in learning about science and watersheds.

The success of this initial project is attributed in part to three key factors:

1) **Provide the information,** but let teachers do the teaching. Instead of imposing a highly structured two-week unit for teachers to make room for in their already full curriculum, we invested in teacher's skills and creativity by educating teachers on invasive species and then providing them with classroom tools (fact sheets, activities, websites, power points, etc.) that teachers could insert where they saw relevant to support their existing curriculum and teach required benchmarks.
2) **Support teachers.** Teachers are passionate, but very busy and work with little to no money. We supported teacher's creativity and ability to lead students in a stewardship project by providing two-day training on invasive species, a $400 stipend for carrying out a project, and on-going support and guidance from Sea Grant staff. All teachers noted that the funding provided an essential catalyst to developing project materials and framework for a stewardship project.
3) **Keep in touch and mentor.** We regularly checked in with our teachers. We asked teachers to update us on their progress, developed a list serve to share current information and new resources, and made classroom visits when requested. Finally we reconvened teachers at the end of the project period to share feedback and successes. Teachers reported that our support reminded them that they are valued, that their projects are important, and allowed them to be successful.

Understanding Citizens' Attitudes and Beliefs Regarding Behaviors that Prevent the Spread of Invasive Species: Applications for a Statewide Awareness Campaign

Samuel Chan *and Gwenn Kubeck*
Oregon Sea Grant College Program and Extension Service, Oregon State University
307 Ballard Hall, Corvallis, OR 97331 USA

Currently, very little literature is available on perspectives and beliefs of stakeholders regarding behaviors that impact the introduction and spread of invasive species. In 2008, a two- year long statewide campaign to increase awareness and action on invasive species prevention was launched in Oregon, USA. This statewide invasive species and action campaign is unique in: 1) being among the first large-scale invasive species campaigning collaboration between government entities, the Oregon Invasive Species Council, public broadcasting (television and radio), private media (newspapers), non-government organizations (NGO's) and natural resource based trade associations and 2) establishing a baseline for measuring the effectiveness of the campaign through social-science research (a statewide survey and series of focus groups) on citizen awareness and behaviors towards invasive species and barriers that might prevent citizens from taking action towards invasive. In addition to establishing a baseline, findings were also used to guide the development of the invasive species awareness and action campaign. This paper emphasizes one aspect of our research to explore the barriers that prevent stakeholders from changing their hobby behaviors to help prevent the spread of invasive species in Oregon.

A series of exploratory focus groups comprised of gardeners, fishers, hunters and boaters were convened in the summer of 2007. The Theory of Planned Behavior was employed as a framework for elucidating the attitude, norm and behavioral controls beliefs that prevent people from changing their behaviors to reduce the potential spread of invasive species. Findings indicate six belief barriers to changing hobby behaviors. These include 1) the attitude that preventative behaviors, such as using pesticides, may be worse for the environment than invasive species, 2) the attitude that the fight against invasive species is a losing battle, 3) the norm belief that institutions don't care enough to prioritize action on the issue of invasive species, 4) the norm belief that the general public both doesn't know and doesn't care about invasive species, 5) the behavioral control belief that one doesn't know enough about the preventative behaviors to be effective, and 6) the behavioral control belief that preventative behaviors are too difficult to perform. Understanding the beliefs that prevent behavior change informs the creation of effective campaigns to engage stakeholders in being part of the solution to invasive species, as well as provide a foundation on which to build additional research.

This exploratory study is one of few on the human dimensions of invasive species, and is one of the only studies to examine the barriers that prevent stakeholders from changing their behaviors to help stop the spread of invasive species. Findings suggest that an effective way to engage stakeholders in being part of the solution to invasive species may include addressing social norms by targeting awareness messaging and engagement activities to hobby groups.

NOTES

Aquatic Invasive Species Watercraft Inspection Program in NW Ontario, Canada

Laurie Wesson
Fisheries and Oceans Canada
501 University Crescent, Winnipeg MB R3T 2N6 Canada

Alyson Rob
Ontario Ministry of Natural Resources
Fort Frances, ON

Vern Pham
Alberta, Canada

Moriah Rogoza
Red River College, Winnipeg, MB

Kevin Empey
University of Manitoba, Winnipeg, MB

In response to the invasion of Spiny Water flea (*Bathotrephes longimanus*) and Rusty Crayfish (*Orconectes rusticus*) into the waters of NW Ontario, Fisheries and Oceans Canada in 2007 initiated a Watercraft Inspection Program at International Borders in NW Ontario. The Canadian/US borders at Fort Frances (International Falls, MN), and Rainy River (Baudette, MN), have large numbers of recreational watercraft pass through them yearly.

The fishers move throughout the Rainy River – Lake of the Woods – Winnipeg River systems a primary pathway for the introduction of Aquatic Invasive Species (AIS) into NW Ontario and the Lake Winnipeg watershed.

As boats were inspected a short survey of fishers (n=1043) was conducted. Fishers were primarily from Minnesota and Wisconsin, though some traveled from as far away as Texas, Arizona and South Carolina. The survey found that many last launch lakes were listed as AIS infested; many of these lakes contained multiple AIS. Fishers primarily purchased live bait en route to their destination. Most fishers disposed of bait on land; however some gave bait to other fishers or disposed of bait directly into the lake. We removed small amounts of vegetation from boats and trailers; fortunately no Zebra Mussels, Eurasian Water milfoil or other potential AIS were detected.

The watercraft inspection program was increased in scope in 2008 to include trailer checks (n=1125), presentations and tournaments throughout NW Ontario.

NOTES

Piloting a Volunteer AIS Monitoring Program: Michigan's Experience with Clean Boats, Clean Waters

Carol Y. Swinehart
Michigan Sea Grant College Program
334 Natural Resources Building, East Lansing, MI 48824-1222 USA

Emily H. Finnell
Michigan Department of Environmental Quality, Michigan Office of the Great Lakes
525 W. Allegan St., 6th Fl Constitution Hall, South Tower, Lansing, MI 48933 USA

In 2006 and 2007, Michigan Sea Grant piloted Clean Boats, Clean Waters, a volunteer AIS monitoring program, which it adapted and streamlined from the original developed by Wisconsin Extension and Department of Natural Resources. This program trains volunteers to present aquatic invasive species (AIS) information to boaters at launch sites and to demonstrate the proper inspection and cleaning of recreational watercraft to prevent the introduction and spread of AIS to previously uninfested bodies of water.

In its first two years, Michigan Sea Grant and Michigan Office of the Great Lakes representatives developed materials, conducted seven training workshops and facilitated the formation of several volunteer teams, which conducted the program in a variety of ways and reached thousands of boaters. Other organizations within and from outside the state have expressed interest in using the program as a model. This presentation will describe the program, its outcomes and lessons learned.

NOTES

POSTERS

New York State Waterbird Mortality as a Result of Type E Botulism and Non-native Invasive Species

David Adams
New York State Department of Environmental Conservation, Office of Invasive Species Coordination
625 Broadway, Floor 5, Albany NY 12233 USA

Kenneth Roblee
New York State Department of Environmental Conservation, Bureau of Wildlife
270 Michigan Avenue, Buffalo, NY 14203 USA

Ward Stone
New York State Department of Environmental Conservation, Wildlife Pathology Unit
108 Game Farm Road, Delmar, NY 12054 USA

Periodic waterbird mortality, due to type E botulism (*Clostridium botulinum*) intoxication, has been documented on the Great Lakes since the 1960s. The most recent series of events are unique in that they appear to be linked to population increases of two nonnative invasive species, the quagga mussel (*Dreissena bugensis*) and the round goby (*Neogobius melanostomus*), and they have the potential to have significantly impacted waterbird populations in the US and Canada, due to their duration and distribution.

The first documented mortality due to type E botulism in New York State occurred in the eastern basin of Lake Erie November 2000. To monitor and evaluate potential impacts on waterbirds, thirteen 500-meter transects were established along the lake's shoreline and monitored weekly. Surveys were repeated during fall 2001 through 2007. Potential mortality was calculated by extrapolation. We estimate that during 2000 through 2007 up to 5415, 2862, 17301, 3008, 5943, 2297, 4375, and 8915 waterbirds may have died from type E botulism intoxication.

In an effort to detect any increase in the geographic extent of these annual mortality events, forty-seven 500-meter transects were placed at five mile intervals along the Lake Ontario shoreline during 2002. These transects were monitored weekly during the peak of Common Loon (*Gavia immer)* migration, 16 October to 14 November. Potential mortality was calculated by extrapolation. We estimate that up to 1046, 1529, 1693, 1193, 4933, and 3650 waterbirds may have perished on Lake Ontario from type E botulism intoxication during this time period.

The waterbird species with the greatest mortality differed for the 2000-02 mortality events. Red-breasted Merganser (*Mergus serrator*) had a predicted mortality of 2479 in 2000, Common Loon (*Gavia immer)* 1149 during 2001, and Long-tailed Duck (*Clangula hyemalis*) 13219 in 2002. Common Loon (*Gavia immer)* experienced the greatest mortality during the 2003-7 events. We estimate that up to 2101 birds may have died in 2003, 2915 in 2004, 1656 in 2005, 7878 in 2006, and 10040 in 2007.

Eight consecutive years of type E botulism related waterbird mortality on Lake Erie and Ontraio have the potential to have negatively impact waterbird populations which migrate through New York waters. It is anticipated that similar mortality will occur again in 2008. To evaluate the full impact of type E botulism caused mortality to waterbird population utilizing the Great Lakes annual beach surveys should be continued, and potentially be expanded to other Great Lakes states.

NOTES

Impact of the Zebra Mussel (*Dreissena polymorpha*) on Native Unionid Bivalves in European Ecosystems

Jean-Nicolas Beisel, *Céline Vellinger and Laure Giamberini*
Université Paul Verlaine – Metz, Laboratoire des Interactions Ecotoxicologie, Biodiversité, Ecosystèmes (LIEBE)
UMR CNRS 7146, rue du Général Delestraint, 57070 Metz, Borny, France

Dreissena polymorpha affects native molluscs by direct fouling, when mussels attach to the shell of a living unionid in large clusters. Evidences for this well known mechanism originate largely from studies of North American freshwater molluscs but few studies were devoted to this topic in Europe. We explored the relationships between zebra mussels and native unionid clams in European ecosystems. First, we examined if factors such as the local density of the zebra mussel populations and the size of the unionid influence the number of zebra mussels per unionid. Then, we used a self-made video recording device to investigate if the infestation interferes with normal valve movements and/or unionid behaviour. Finally, we explored the potential impact of the zebra mussel fouling on life history traits and morphological characteristics of unionids.

NOTES

Comparative Phylogeography of Two Invasive Colonial Tunicates Reveals Contrasting Invasion Histories in North America

***Dan Bock**, Christophe Lejeusne, Hugh J. MacIsaac and Melania E. Cristescu*
CAISN, University of Windsor, Great Lakes Institute for Environmental Research
401 Sunset Avenue, Windsor, ON, N9B 3P4 Canada

Members of the Tunicata subphylum have successfully colonized new ecosystems worldwide in recent decades. Two colonial tunicates *Botryllus schlosseri* and *Botrylloides violaceus* have recently invaded, spread, and become very abundant on the east and west coasts of North America. In this study we analyzed a fragment of the mitochondrial cytochrome *c* oxidase I gene from individuals from 32 locations that represent both invaded and native regions of these species (e.g., east and west coasts of North America, Australia, Europe and Japan). Population genetics, phylogenetics and phylogeography methods were used to assess the genetic structure of the populations, the phylogenetic relationships among them, and to determine their invasion histories in North America. Both species exhibited surprisingly low haplotype diversity (12 and 5 haplotypes) in North American populations, even compared to other conphyletic introduced species. A comparative analysis of sequence data for the two invasives revealed contrasting genetic structuring, with *B. violaceus* populations significantly more homogenous on the two coasts. Also, patterns of genetic relationship indicate different invasion histories. We propose that *Botryllus schlosseri* populations in North America were founded by multiple introductions from different donor regions. On the other hand, *Botrylloides violaceus* populations appear to have been seeded from a single region, with a limited number of introduction events. We discuss these results in the light of different vectors that could have mediated their range expansion and the discrepancies in the first record of introduction of these species in the New World.

NOTES

Control of the Highly Invasive Curly Leaved Pondweed (*Lagarosiphon major*) in a Lake in the River Shannon Catchment, Ireland

Joe M. Caffrey
Central Fisheries Board
Swords Business Campus, Balheary Road, Swords, County Dublin, Ireland

Mike J. Fitzsimons
Shannon Regional Fisheries Board
Ashbourne Business Park, Dock Road, Limerick, Ireland

Dan Minchin
Lough Derg Science Group
Caragh, Marina Village, Ballina, Killaloe, Cop Tipperary, Ireland

Lagarosiphon major is a highly invasive, submerged macrophyte that was introduced to Irish garden centres for use as an oxygenating plant in ornamental ponds. This plant is present in a large number of artificial ponds and lakes; however, its observed distribution in natural Irish watercourses is limited. It was first recorded in the wild in Lough Corrib, one of the ecologically unique Great Western Lakes in 2005 and has since dramatically expanded its range within this large watercourse (180 km^2). The weed spreads rapidly by fragmentation, with small plant fragments being capable of establishing new populations in suitable habitats. In areas colonised by the weed, it competitively excludes most indigenous plant species. It also creates a habitat that favours pike, perch and cyprinid species over salmonid species, for which the lake is internationally renowned. Efforts to control the spread of *Lagarosiphon* within the lake have met with limited success and there is serious concern that it will escape to colonise other natural watercourses in the country.

In March 2008 an infestation with *Lagarosiphon* was reported in an artificial lake (0.4 ha) within the River Shannon catchment. The lake was constructed on private land in 1996 to provide a habitat for wildlife. It was filled from a small stream that ultimately discharges to Lough Derg, the lowermost of three major lakes on the River Shannon, Ireland's largest river. Emerging from the lake, the narrow stream meanders for *circa* 5.9 km to discharge directly into Lough Derg. As the crow flies, the lake is 4 km from Lough Derg.

In 1998, 12 small fragments of *Lagarosiphon* (*circa* 30 gm wet weight) were introduced into the artificial lake. By March 2008, a survey revealed that the lake contained 64.4 tonnes of the weed, which occupied the full water column and created a dense canopy on the water surface. Because of the risk posed to Lough Derg and to the whole River Shannon catchment, immediate measures to eradicate it from the lake and from the tributary stream were undertaken. The supply stream was diverted away from the lake, thus isolating it from Lough Derg. In April 2008 a combination of manual, mechanical and chemical control methods were applied in the lake to eradicate the weed and prevent its spread. Sections of the tributary stream were also treated chemically, as a precaution. The stream to its confluence with Lough Derg was surveyed and no *Lagarosiphon* plants were recorded .A quantitative survey of the lake and the emerging stream in August 2008 revealed that practically all of the *Lagarosiphon* was dead and no regrowth was recorded. Monitoring will continue and a programme of replanting with indigenous aquatic plant species will be undertaken.

NOTES

Use of Mitochondrial Cytochrome *c* Oxidase I (COI) Gene Sequences to Suggest Probable Source Populations of Non-indigenous Ascidians in Newfoundland

***Ashley G. Callahan**, D. Deibel, J. Hall and M. Rise*
Memorial University of Newfoundland, Ocean Sciences Centre
St. John's, NL A1C 5S7 Canada

Cynthia H. McKenzie
Fisheries and Oceans Canada, Northwest Atlantic Fisheries Centre
80 East White Hills, St John's, NL A1C 5X1 Canada

Non-indigenous ascidians have been a significant biofouling problem for the aquaculture industry in Prince Edward Island (PEI) and Nova Scotia since the mid-1990s. Ascidians can be transported to new areas through ballast water, the sea chest or attached to the ship's hull. There are many shipping linkages from the Maritime provinces to Newfoundland (NL). Of the four invasive ascidian species in the Maritimes, *Botryllus schlosseri* and *Botrylloides violoaceus* have been detected in NL in the past two years. Eradication of non-indigenous species once they have become established is unrealistic. More realistic options are to prevent species introductions and control existing populations. Successful control of invasive organisms may be possible if they are detected early and if their source populations are known. Early detection can be achieved using molecular methods designed for rapid identification of propagules based on the mitochondrial cytochrome *c* oxidase subunit I (COI) gene sequence.

In this study, variation in COI gene sequences was analyzed for the two non-indigenous ascidians mentioned above as well as two indigenous species (*Boltenia echinata* & *Halocynthia pyriformis*). Non-indigenous samples were collected in NL, PEI and Massachusetts (MA) (N. America populations), and indigenous samples were collected in NL. The nucleotide sequences were aligned using the CLUSTAL W algorithm (AlignX, Vector NTI Advance 10). At this time, sequence data for *B. violaceus* is being analyzed. Within the N. American samples, there was greater nucleotide identity within the three species (≥ 96.5 %) than among species (75-82 %). This indicates that the 709 base-pair fragment of COI that we obtained is a highly accurate indicator of these ascidian species. Within NL, the two indigenous species *H. pyriformis* and *B. echinata* had higher nucleotide identities (≥ 99.7 %), than did *B. schlosseri* from the N. American populations (≥ 96.5 %). Initial comparisons of *B. schlosseri* sequences within N. American populations showed that PEI and MA sequences were identical, whereas *B. schlosseri* differed from PEI and MA by 25 base pairs. This suggests that *B. schlosseri* from NL, PEI, and MA have different source populations. To investigate this hypothesis, we compared our NL haplotypes with European haplotypes obtained from GenBank. The sequences were aligned as described above and the alignment was imported into MEGA version 4.0. A phylogenetic tree was constructed using the Neighbour-Joining method and bootstrap analysis was performed with 1000 replicates. The NL haplotype was most similar to two haplotypes from the Mediterranean coast of France (ca. 100 %) than it was to the North American haplotypes (≥ 96.5 %). Thus, it is likely that the non-indigenous *B. schlosseri* from NL came from the Northwestern Mediterranean Sea rather than from N. American populations.

NOTES

Prevention of Dispersion Strategy of Golden Mussels in Central Part of South America

Cláudia T. Callil
University of Mato Grosso, Biosciences Institute, Biology and Zoology Department
Cuiaba, MT 78010-900 Brazil

Márcia. D. Oliveira
EMBRAPA – Centro de Pesquisas do Pantanal
R. 21 de setembro, 1880, Corumbá, MS CEP 79320900 Brazil

Ligia Nara and Carolina Poter
SEMA – Secretaria do Meio Ambiente
Cuiabá, MT 78010-900 Brazil

Up to now, one of the bioinvasions considered most important and dramatic was that of the dreissenideos, *Dreissena polymorpha* PALLAS e *D. bugensis* ANDRUSOV. Unfortunately the golden mussel seems to gain the first place in the ranking of the bio invaders in continental waters. Today, *Limnoperna fortunei* (Dunker, 1857) has already traveled the whole South, Southeast and Center-West of Brazil going up the Paraguay River and has reached the port of the city of Cáceres, MT, in the northwest limit of the Pantanal in Brazil. Although we have registered the presence of this alien in this place the population is not yet actively installed. This fact made us create a strategy of actions to monitor and control the spreading of the golden mussel, not only to the other sub basins, but mainly to the Amazon Basin. In this way we involved federal, state, municipal and non-governmental organs in different approaches:

1. **Law:** Strategies of fitting in the existing legislation, adjustment and making of specific laws, legal ways of raising funds (penalty conversion).
2. **Research:** identification of the spreading vectors; generation of technology, population and community studies; diagnosis of ecological and biological characteristics, development of anti-incrusting paints.
3. **Environmental education:** mobilization and diffusion of knowledge; elaboration of teaching material; tourist and sports events for divulgation.
4. **Training:** Qualification of the technicians from different areas of society, proposal for a master's qualification course.
5. **Monitoring:** constant mapping control of the limits of the event, follow up of the density of the larvae, post larvae and adults.
6. **Surveillance:** sanitary inspection at ports, airports, bus stations, inspection of roads, boats, waterways and inspection of live aquatic organisms.
7. **Control:** Use of anti-incrusting paints; cleaning of boats in the docks, ship lanes and dockyards, sanitation of the place.

NOTES

Gametogenesis and Population Traces of *Limnoperna fortunei* (Dunker,1857) in a Brazilian Wetland

Cláudia T. Callil *and Edna R. Uliana*
Federal University of Mato Grosso, Biosciences Institute
Cuiabá, Mato Grosso, Brazil

Maria Cristina D. Mansur
Universidade Católica do Rio Grande do Sul
Porto Alegre, RS, Brazil

Alice M. Takeda
University of Parana State, Nupelia
Maringá, Parana, Brazil

Márcia D. Oliveira
EMBRAPA – Centro de Pesquisas do Pantanal, Corumbá
Mato Grosso do Sul, Brazil

Due to the lack of a law and poor port surveillance, bivalve mussels brought from Asia have invaded the south and central westerns part of Brazil occupying different habitats in the main hydrographic Basins of South America. There are already three species of invading bivalves that reached the central region of Brazil. Two belonging to the Corbiculidae, *Corbicula largillierti* (Philippi, 1844) and *C. fluminea* (Müler, 1774), and one species of Mytillidae, *Limnoperna fortunei* (Dunker, 1857). Aiming the management and control during the processes of spreading and installation of non natives populations, we are using the analysis of gametogenesis and reproductive dynamics as an efficient tool. We work with the population of *L. fortunei* using samples from 3 distinct regions: Porto Alegre, RS – Guaiba Lake Basin at South of Brazil (3 sampling stations), Porto Rico, PR – Paraná River Basin (2 sampling stations) and from Corumbá, MS – wetlands of Middle Paraguai River in the Center of Brazil (1 sampling station). Based on histological characteristics and quantitative analyses of diameter of the reproductive follicles and ovocites, same significant differences between the regions were observed. Two mainly factors influences the period of disposal of gametes, the level of water and temperature. The distribution of frequencies per classes of the reproductive (diameters ovocites and follies) and biometrical factors (high and length of valves), coincide with the recruitment period described by the subsequent growth of larvae densities. We infer that the seasonal fluctuations derived the seasonal flood pulse in the wetland and its physical, chemical and biological consequences can act as a controlling agent on the population densities.

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NOTES

Fragmentation and Dispersal of the Invasive Colonial Tunicate *Didemnum vexillum*

Mary R. Carman
Woods Hole Oceanographic Institution, Biology Department
360 Woods Hole Road, Woods Hole, MA 02543 USA

James A. Morris, Jr.
NOAA National Ocean Service, National Centers for Coastal Ocean Science
101 Pivers Island Road, Beaufort, NC 28516 USA

K. Elaine Hoagland
Independent Consultant
21 Bob White Lane, Falmouth, MA 02540 USA

The invasive colonial tunicate *Didemnum vexillum* is spreading throughout New England and is fouling substrata and aquaculture gear. *Didemnum vexillum* propagates by sexual and asexual reproduction and colonies can be artificially fragmented through human activity such as cleaning of boat hulls, docks, buoys, and aquaculture/fishing gear, or through fishing and dredging activities. To investigate the viability and reattachment success of *D. vexillum* fragments suspended in the water column over discrete time intervals, we performed a controlled laboratory experiment using flow-through seawater at ambient temperature. Uniformly sized fragments of healthy *D. vexillum* colonies were introduced into heavily aerated, flow-through seawater tanks and held in suspension for up to four weeks. To compare fragment viability (health, reproduction status) and reattachment success, suspended fragments and recently harvested (no suspension) control fragments were introduced into flow-through plastic containers and placed in the seawater along a nearby dock at a location containing established colonies of *D. vexillum*. We found that 60% of the suspended *D. vexillum* fragments reattached after one week in suspension and about one third reattached after longer periods of suspension, whereas 51% of the control fragments reattached. During the first two weeks of the experiment in early fall, *D. vexillum* fragments contained larvae while in suspension. These results suggest that fragmentation of *D. vexillum* is a potentially viable dispersal mechanism capable of distributing this invader significant distance away from the colony of origin. Human activities that create *D. vexillum* fragments are therefore likely contributing to the spread of *D. vexillum*. Resource managers concerned with the impacts of *D. vexillum* should consider reducing fragmentation of existing colonies as a management option.

NOTES

Biology and Post-emergence Herbicidal Management of Water Hyacinth (*Eichhornia crassipes*) in the Water Bodies of Southern India

Chinnagounder Chinnusamy, *T. Janagarathinam and S. Rathika*
Tamil Nadu Agricultural University, AICRP on Weed Control, Department of Agronomy
T.N. Coimbatore - 641 003, India

Waer hyacinth (*Eichhornia crassipes*) is a perennial, herbaceous monocotyledon member of the pickerelweed family (*Pontederiaceae*) and is native to tropical America, from which over the past century, it has been spread around the world by anthropogenic activities. Originally introduced to India in Bengal as an aquatic ornamental plant, it has become a major weed of rivers and dams. Not only does it destroy native habitats, but it also seriously depletes water bodies of oxygen, increases water loss and provides a breeding ground for mosquitoes. Cultural eutrophication of lakes is also a major problem around the world and this can amplify the problem of water hyacinth. Now a days water hyacinth becomes a notorious problem weed in southern parts of India, moreover for human population living around such water bodies, it reduces access to and quality of available drinking and irrigation water, prevents fishermen from making living, clogs water intakes at hydro-electric dams, increases vector-borne diseases, eutrophication and generally leads to an increase in human suffering. Hence, a study has been initiated to quantify the biological characteristics or water and evaluate efficient Post- emergence herbicide management in stagnant water body.

The biological characters of water hyacinth indicated that the mother plants grow very fast from one week after inoculation up to six weeks after that the growth rate decreased and it involved in seed maturation, senescence and ramet production. But incase of ramets they emerged from third week onwards and they involve in fast growth up to six weeks because of this continuous growth process the multiplication of water hyacinth resulted in very high rate and cause enormous problems to environment. Considering these situations, the tank culture experiment was conducted on *Eichhornia crassipes* to evaluate the efficacy of different post emergence herbicides like paraquat, glyphosate and 2, 4-D Na salt on both *Eichhornia crassipes* plant and on aquatic eco system. The results revealed that spraying of glyphosate at 10 ml lit-1 + ammonium sulphate 2% + 1% surfactant effectively reduced the *Eichhornia crassipes* density as well as biomass considerably.

NOTES

Navigational Buoy Monitoring for Invasive Species in the St. Lawrence River and Lower Laurentian Great Lakes (2007-2009), with Addition of Molecular Biomonitoring for Epidemiology of Zoonotic Pathogens

David Bruce Conn
Harvard University, Museum of Comparative Zoology and
Berry College, School of Mathematical and Natural Sciences
Mount Berry, GA 30149-5036 USA

Denise A. Conn
North American Scientific Enterprises (NASCENT)
Monteagle, TN 37356 USA

Thaddeus K. Graczyk
Johns Hopkins Center for Water and Health, Johns Hopkins Bloomberg School of Public Health
615 N. Wolfe Street, Baltimore, MD 21205 USA

We conducted our 18th (January 2008 for 2007 navigation year) and 19th (January 2009 for 2008 navigation year) years of monitoring the establishment and spread of benthic invasive species in the St. Lawrence River and the lower Laurentian Great Lakes, with continuing emphasis on the dynamics of *Dreissena polymorpha* (zebra mussels) and *Dreissena rostriformis bugensis* (quagga mussels), as well as native invertebrates such as *Brachycentrus incanus* (case-building caddisflies) and hydropsychid trichopterans (net-spinning caddisflies). Distribution and abundance patterns continued similarly to the trends over the last 10 years, with high densities of dreissenids primarily in the vicinity of Kingston Harbour, and slightly lower densities in the vicinity of Toronto Harbour, both on Lake Ontario. Much lower densities continued in the St. Lawrence River. Brachycentrids remained at much lower densities that before the invasion by dreissenids, but hydropsychids continue to sustain high densities in their historic sections of the river.

Beginning with the 2007 navigation year (January 2008 survey), we examined some dreissenid mussels for the presence of microbial pathogens, including the protozoan pathogen, *Cryptosporidium parvum*, which is transmitted through water between humans, wildlife, and domestic animals, as a zoonotic infection. Our previous studies have demonstrated that dreissenid mussels can serve as effective biomonitoring sentinels for these and other pathogens in the St. Lawrence River, as well as the Shannon River of Ireland. By coupling our established methodologies for identifying pathogens (Fluorescent *in-situ* Hybridization and immunofluorescent antibody) with our refined use of navigational buoys for geographical pinpointing, we are attempting to develop a powerful new tool to better understand dissemination of waterborne pathogens between major foci of human and animal infection within large-scale watersheds. Our epidemiological studies during 2007 using these combined methods in the St. Lawrence/Lake Ontario basin were targeted primarily at nearshore areas close to the urban centers of Toronto and Kingston, Ontario, Canada. For 2008 (i.e., 2009 survey), we have broadened our studies to more locations in Lake Ontario and the upper St. Lawrence River.

NOTES

Shell Growth of *Limnoperna fortunei* in Two Localities Under Different Climate in the Plata Basin (Argentina)

Gustavo Darrigran *and Nicolás Bonel*
Grupo de Investigación sobre Moluscos Invasores Plagas, División Zoología Invertebrados
Paseo del Bosque sin número (1900) La Plata, Argentina

Limnoperna fortunei (Dunker, 1857) commonly called the golden mussel, is a freshwater mytilid native to South East Asia. It is considered a freshwater invasive pest. In 1991 it reached the Americas. It entered the Plata Basin in South America, brought in by ballast water of transoceanic ships. *L. fortunei* is presently found in five countries in South America. It advances at a speed of 240 km per year. The information about the longevity of the golden mussel shows a great variability. Its life span in the natural environment of Bagliardi Beach, Argentina, is 3.2 years. The longevity of 2 years was estimated in the Uji River, Japan. In Korea the lifespan was reported to be 4 to 5 years and over 10 years in Central China. There are at least two tests to follow the shell growth; 1) analyzing the periodicity of growth line formation; or 2) following the growth of each cohort. The second alternative was applied in this research. Three net-bags were used in the experimental field work. A known number of specimens were placed within the net-bags, all of the same size (one cohort). The size of these specimens was followed, and their growth was tested. Two experiments were carried on simultaneously, one in the Río de la Plata river (34°51'S-57°53'W) (temperate locality) and other in Paraná River (31°41'S- 60°44'W) (subtropical locality) beginning in March of 2007. Individuals were removed from the net-bags monthly and the shell length measured with a digital caliper. For each sample a size-frequency distribution table was generated, with 1 mm class intervals. Water temperature, pH, oxygen concentration, conductivity, total solids and water transparency were measured. This kind of experimental work reduces the problems of establishing the cohorts. Through a variation of the growth coefficient (*k*), the results show a difference between the two locations. The *k* value is greater in the subtropical locality, and a relationship; mean temperature – bivalve growth rate was established.

NOTES

Population Structure of the Invasive Hydrozoan *Cordylophora* in the Great Lakes

John A. Darling
U.S. Environmental Protection Agency; National Exposure Research Laboratory
26 West Martin Luther King Drive, Cincinnati, OH, 45208 USA

Nadine C. Folino-Rorem
Wheaton College, Department of Biology
520 Kenilworth Avenue, Wheaton, IL, 60187 USA

The colonial hydrozoan *Cordylophora* has rapidly expanded from its native Ponto-Caspian distribution to become a common invader of both fresh and brackish water habitats throughout the world. In the Great Lakes *Cordylophora* is often observed establishing dense fouling colonies, and has become a nuisance in some areas where it is found clogging the intake pipes and filters of power plants. Here we utilize population genetics approaches to explore patterns of expansion of *Cordylophora* within the Great Lakes and the nearby Finger Lakes, and to assess the extent to which asexual reproduction contributes to the structure of local populations. Eighteen populations were sampled from five lakes, and multilocus genotype data were generated from ten highly variable microsatellite loci. Since previous genetic analysis has suggested the presence of multiple cryptic *Cordylophora* species in this region, we also employed DNA sequence data from the 28S large subunit ribosomal RNA gene to distinguish between invasive lineages. Our results 1) confirm the presence of multiple invasive *Cordylophora* lineages in the Great Lakes region; 2) indicate that asexual reproduction contributes little to the expansion of *Cordylophora* populations, and that the spatial extent of individual genotypes (e.g. colony size) is limited; and 3) reveal significant genetic structure at a regional scale (across lakes, on the order of 1000 kilometers), but little departure from panmixia on a local scale (on the order of 10 kilometers). We discuss the implications of these findings for understanding the patterns and processes by which *Cordylophora* species continue to expand their distribution within the Great Lakes and globally.

NOTES

Developing Robust, Risk-based Audit Protocols to Prevent the Accidental Introduction of Non-native Fishes in England and Wales

Gareth D. Davies
Bournemouth University, Centre for Conservation Ecology and Environmental Change, and Environment Agency
Bromholme Lane, Brampton, Huntingdon, PE28 4NE UK

J. Robert Britton and Rodolphe E. Gozlan
Bournemouth University, Centre for Conservation Ecology and Environmental Change
Dorset House, Talbot Campus, Fern Barrow, Poole, Dorset BH12 5BB UK

Given the difficulty of managing invasive fishes in the wild, it is imperative to minimise opportunities for their initial introduction. In England and Wales, invasive fishes such as topmouth gudgeon *Pseudorasbora parva* and sunbleak *Leucaspius delineatus* have established populations in the wild despite their insignificant value to fisheries. Introductions occurred through their accidental contamination of batches of fishes that were intentionally stocked to enhance recreational fisheries. In also introducing these pest species, the consequences of these stocking activities have actually been the opposite of that intended and has resulted in pest populations establishing to the detriment of fishery performance.

Prior to the regulated stocking of a batch of fish into a recreational fishery, a pre-introduction audit can be carried out that serves to inspect the fish being introduced and ensure there are no contaminants also being introduced. With over 5000 fish stockings into England and Wales each year, it is apparent that a robust, risk-based pre-introduction audit needs to be developed and implemented to minimise the occurrence of such accidental introductions. This poster discusses the process of determining what constitutes a high-risk fish stocking that requires an audit and then demonstrates the derivation of a statistically-based and tested fish introduction audit that is capable of identifying contaminant fishes within batches of fish and so prevent their accidental introduction. The application of this tool to other countries to also prevent accidental introductions of invasive fishes into the wild is discussed.

NOTES

Chinese Mitten Crabs in the St. Lawrence River and Estuary, Canada: Origin and Risk of Invasion

Yves de Lafontaine
Environnement Canada, Centre Saint-Laurent
105 rue McGill 7è étage, Montréal, QC H2Y 2E7 Canada

Jean-Marie Sévigny
Pêches et Océans Canada, Institut Maurice-Lamontagne
850 Route de la Mer, Mont-Joli, QC G5H 3Z4 Canada

Richard Calvé
Dawson College
3040 Sherbrooke St. West, Montréal, QC H3Z 1A4 Canada

Guy Verreault
Ministère des Ressources Naturelles et de la Faune du Québec
186 rue Fraser, Rivière-du-Loup, QC G5R 1C8 Canada

Recent reports of Chinese mitten crabs (*Eriocheir sinensis*) in the St. Lawrence River and Estuary were compiled to assess the possible sources of the species based on genetic analyses and data on shipping traffic. Between 2004 and 2007, nine specimens were captured in both the fresh and estuarine waters of the St. Lawrence; a number unprecedented in the 40 years since the mitten crab was first sighted in the Great Lakes–St. Lawrence Basin. These sightings, added to those of the eastern United States, are indicative of a large-scale wave of introduction of the mitten crab to Eastern North America. Genetic analyses have suggested that the St. Lawrence specimens likely originated in Europe. No significant changes have been noted in maritime traffic to the St. Lawrence in recent years, but analyses have revealed that 42% of ships came from European countries where established populations of Chinese mitten crab have exhibited recent bursts in abundance. It is suggested that the recent wave of introduction of mitten crabs to Eastern North America is related more to changes in the abundance of European populations than to changes in shipping vector activity. These recent sightings are of major concern with regard to the establishment and spread of the species. It is therefore recommended that long-term monitoring programs be set up immediately to track the progress of the mitten crab invasion in the St. Lawrence River basin.

NOTES

Non-indigenous Species in Montreal Harbour, St. Lawrence River: Where Are They?

Yves de Lafontaine *and Simon-Pierre Despatie*
Environnement Canada, Centre Saint-Laurent
105 rue McGill 7è étage, Montréal, QC H2Y 2E7 Canada

Ports and ship harbours are thought to be zones at high risk of transferring non-indigenous aquatic species, but information on species diversity and relative abundance of exotic species around harbours is often not so well described. A sampling program was recently initiated to assess the diversity, distribution and abundance of non-indigenous species in Montreal Harbour in the St. Lawrence River (Canada), sampling was conducted at 14 harbour sites and 7 non-harbour sites to test the hypothesis that port activities may favour biological communities including higher proportion of exotic species. Assemblages of zooplankton, benthos and fish at harbour sites differed significantly from those at non-harbour sites, being generally less species rich and less diversified. This could be due to the lesser habitat heterogeneity at harbour sites. Spatial variation in species richness and abundance was also observed among harbour sites distributed along a 13 km upstream-downstream gradient was mainly related to the presence of lotic (harbour sites along the river) and lentic (semi-closed harbour basins) environments. Risk of species transfer via shipping activities is discussed at the light of information on ballasting and de-ballasting operations in Montreal Harbour.

NOTES

Numerical Modelling for the Economic Costs of Biological Invasion

Simone A. Delphim, *Claudia M. Dias, Luiz Bevilacqua and Augusto C. N. R. Galeão*
National Laboratory for Scientific Computing – LNCC
Av. Getulio Vargas, 333, Quitandinha, Petropolis/RJ 25651-075 Brazil

Owing to the significative impacts of the biological invasion some new papers concerning this problem have arisen in recent years. Some models that consider interspecific iterations between the invader and the resident species are well known. However, the economic impact due a well succeeded invasion in not observed in the most part of the models. Barbier presented an interesting approach where the biologic invasion model with interspecific competition is seen as a model with economics consequences. Using this model as starting point new terms of high order will be incorporated to take in account the contents retention in the redistribution process and the asymmetry of the distribution. The model considers two distinguished species: the invader and a resident species economically valuable, hence, a well succeeded invasion will lead to economic losses. In that meeting it can occur or an interspecific competition, or the diffusion of the species, or both.

The population dynamics problems considered here are mathematically modeled by a non-linear advection-diffusion-reaction equation, which analytical solutions are restricted to rare cases. Hence, numerical solutions can play an important role in the study of the interplay between diffusion, advection and reaction phenomena regarding species invasion. We will use here a stabilized finite element method to solve this class of problem. The bioeconomic problem will be solved using the continuous-time deterministic optimal control. A well known technique, very popular nowadays is the dynamic programming that it will be used here to solve the control problem.

NOTES

Recruitment, Growth and Survival of the Exotic Brazilian Pepper (*Schinus terebinthifolius*) at Restored Mosquito Impoundments in Mosquito Lagoon, FL

Melinda Donnelly *and Linda Walters*
University of Central Florida, Department of Biology
4000 Central Florida Blvd., Orlando, FL 32816 USA

During the 1960s, impoundments in Mosquito Lagoon were created for mosquito control by building dikes that elevated saltmarsh substrate over one meter above mean high tide. The loss of tidal inundation led to drier and less saline soil conditions and facilitated the invasion of both native and non-native terrestrial plant species, including the non-native *Schinus terebinthifolius* (Brazilian pepper). *Schinus terebinthifolius* can alter the structure of natural habitats and negatively impact biodiversity of these systems, and has invaded nearly every habitat in Florida, including disturbed saltmarsh and mangrove systems. Chemical and mechanical methods are typically used to control and remove *S. terebinthifolius*. Vegetation surveys during the past year found *S. terebinthifolius* accounted for over 20% of the flora on dikes at mosquito impoundments. In Mosquito Lagoon, removal of the dikes at mosquito impoundments began in the 1990s by mechanically leveling the substrate to marsh elevations and six impoundments have been leveled at this time. During the leveling process, existing *S. terebinthifolius* was mechanically removed from the dikes and tidal inundation was restored. The extent in which *S. terebinthifolius* has recruited to the leveled substrate or recovered from stumps damaged during the leveling process is currently unknown. The purpose of this study was to evaluate recruitment, growth and survival of *S. terebinthifolius* at restored mosquito impoundments in Mosquito Lagoon to determine the effectiveness of dike removal as a potential control method for *S. terebinthifolius* in estuarine environments. In addition, we examined the relative influence of the elevation of substrate, soil salinity, and soil moisture on *S. terebinthifolius* growth and survival. Surveys were conducted along the anterior, middle, and posterior portion of the restored dike substrate every four months for one year. Each *S. terebinthifolius* found was marked with a small flag, and height, stem diameter, and presence of reproductive structures was recorded. Elevation of substrate, soil moisture and salinity was measured at five locations at each impoundment. To understand the relative importance of these abiotic factors on recruitment to the restored site, we also experimentally tested the tolerances of *S. terebinthifolius* to a range of soil salinities and soil moisture. Previous studies have tested the growth and survival of *S. terebinthifolius* at low salinities (< 15 ppt) and under different freshwater soil inundation regimes. We tested the interaction between salinity and soil inundation at salinities up to 30 ppt on germination, growth, and survival of *S. terebinthifolius*. Understanding the rate of recruitment and recovery of *S. terebinthifolius* at restored sites and the role of substrate elevation, soil salinity and moisture in *S. terebinthifolius* invasions will assist resource managers in managing this highly invasive exotic species, including predicting areas this exotic may invade and identifying areas where chemical treatment may be necessary. Additionally, results from this study will identify optimal substrate elevations to prevent future establishment of *S. terebinthifolius* and provide valuable information for planning future restoration projects in disturbed estuarine systems.

NOTES

Analyzing the Economic Benefits of Regulating Ships' Ballast Water Discharges

Sabrina J. Lovell
NOAA Fisheries Service, Office of Science and Technology
1315 East-West Highway, Silver Spring, MD 20910 USA

Lisa A. Drake
Science Applications International Corporation
c/o Naval Research Laboratory, Code 6136
PO Box 1739, Key West, FL 33041-1739 USA

Research on ship-borne aquatic invasive species has been conducted in earnest over the past two decades, but determining the economic damages invaders can cause remains troublesome. Furthermore, with the exception of harmful algal blooms, the economic consequences of microscopic invaders have not been studied, despite their potentially great negative effects. Here, we show how to estimate the economic benefits of preventing the introduction and spread of harmful bacteria, microalgae, and viruses delivered to US waters. Our calculations of net social welfare show the damages from a localized incident, cholera-causing bacteria found in shellfish in the Gulf of Mexico, to be approximately $706,000 (2006$). On a larger scale, harmful algal species have the potential to be transported in ships' ballast tanks, and their effects in the U.S. have been to reduce commercial fisheries landings and impair water quality. We examine the economic repercussions of one bloom-forming species. Finally, we consider the possible translocation within the Great Lakes of Viral Hemorrhagic Septicemia Virus, which has been implicated in fish kills of commercial and recreational species. These calculations illustrate an approach to quantifying the benefits of preventing invasive aquatic microorganisms following controls on ballast water discharges.

NOTES

Re-evaluating Eradication of Nuisance Species: Invasion of the Tunicate, *Ciona intestinalis*

Paul Edwards *and Brian Leung*
McGill University, Department of Biology
1205 Avenue Docteur Penfield, Montreal, QC H2X 1B1 Canada

Eradication is an important concept in the management of biological invasions, but it is rarely considered in practice. This may be because managers commonly work with incomplete data and little or no practical guidance. Past eradication frameworks provide some useful criteria, but do not provide quantitative guidelines. Here, we argue that eradication is not always adequately considered, and we develop a framework for rapid assessment of its feasibility, despite limited data. This quantitative model offers criteria to rapidly assess the potential for eradication and provide estimates of the necessary effort and timing, and of the size of the target area. This framework is applied to a recent tunicate (*Ciona intestinalis*) invasion around Prince Edward Island, Canada, which is causing considerable economic damage to harvesters of blue mussels (*Mytilus edulis*). Our framework suggests that eradication may be feasible and, based on a cost–benefit analysis, could require only a > 16% chance of success to constitute a worthwhile risk."

NOTES

Do Round Gobies Benefit from Parasite Release: Comparison with the Parasite Fauna of Native Fish Species in the Great Lakes-St. Lawrence Basin

Andrée Gendron *and David J. Marcogliese*
Environnement Canada, Centre Saint-Laurent
105 rue McGill 7è étage, Montréal, QC H2Y 2E7 Canada

According to a growing number of studies, introduced species may benefit from a lighter parasite load than that in their native range. When a species invades a new territory, a large proportion of the parasites from its native range will not follow or survive, and although it could accumulate novel parasite species from its new location, the number utimately gained would only be a fraction of the number lost. According to this hypothesis, escape from parasites and other natural enemies that usually exert a control over populations may favor certain alien species over native ones. To further explore this hypothesis, we studied the parasite fauna of the round goby (*Neogobius melanostomus),* a Eurasian fish introduced in the early 1990s into the Great Lakes. The species was first recorded in the St. Lawrence River near Quebec City in 1997 and later invaded the upstream reach where it is now well established. Young round gobies were collected in 2006 and 2007 at several localities in the Great Lakes and St. Lawrence River and examined for metazoan parasites. Three parasite genera were predominantly found in fish examined to date (n=347) : the eyeflukes *Diplostomum* spp., ubiquitous parasites in the St. Lawrence River known to infect round gobies in their native range, as well as the larval nematode *Raphidascaris* sp. and the thorny-headed worm *Neoechinorhynchus* sp., which both have a circumpolar distribution. Interestingly, more than half of the specimens of the latter species were found encysted in different stages of degradation suggesting a strong host immune reaction against the parasite. Less prevalent taxa observed in gobies included a few digenean trematodes (*Tylodelphys* sp., *Neochasmus* sp., *Rhipidocotyle* sp., *Azygia* sp.), larval cestodes and unionid glochidia. Regardless of locality, the parasite community of the round goby was always two to three times less diverse than that of two co-occuring native fish species. Parasite load expressed as the mean number of metazoan parasites per host was up to ten times lower in round goby than in logperch (*Percina caprodes*), a fish sharing a similar trophic niche that was found to decline in the Great Lakes following goby invasion. These observed low levels of infection give support to the enemy-escape hypothesis referred to above. We did not observe higher parasite richness and abundance in localities where gobies were established for a long time compared with recently invaded areas, suggesting that the acquisition of local parasites did not increase with time post-invasion. However, preliminary results suggest that habitat could be a determining factor in the colonization of gobies by native parasites. Gobies appeared to acquire a wider array of parasite taxa and in larger numbers in less degraded or modified habitats. If confirmed by further reasearch, this finding would suggest that alien fish acquire more local parasites and could lose part of their competitive advantage over indigeneous species in habitats where biodiversity is high.

NOTES

Genetic Tracks of the Invasion of *Limnoperna fortunei* in South America

Sara Ghabooli*, Francisco Sylvester, Chritophe Lejeusne, Melania Cristescu and Hugh MacIsaac*
CAISN, University of Windsor, Great Lakes Institute for Environmental Research
401 Sunset Avenue, Windsor, ON N9B 3P4 Canada

Esteban Paolucci and Paula Sardiña
Universidad de Buenos Aires, Facultad de Ciencias Exactas y Naturales, Departamento de Ecología, Genética y Evolución
(C1428EHA) Buenos Aires, Argentina

Limnoperna fortunei was introduced into South America from South East Asia via shipping vectors, and has since spread to 4 countries. However, details of the route(s), and number of introductions remain unexplored. We obtained *Limnoperna* samples from 8 introduced locations in South America and 2 native and 7 introduced range populations in Asia, and assayed them for the mitochondrial genetic marker COI. Preliminary analysis showed the Chinese (i.e., native) populations were genetically more diverse than any of the introduced ones, suggesting the occurrence of invasion bottlenecks in all invaded areas. Genetic structure of South American stocks indicates that Argentinean and Uruguayan populations received individuals from at least two sources in Asia. Genetic diversity in Río de la Plata is consistent with at least two introduction events, some of which may have had a large inoculum. During 2009, additional sampling will be conducted from other putative sources to provide better resolution of genetic composition in the native range and to identify more precisely the source of South American populations.

NOTES

Could *Limnoperna fortunei* Be Worse than *Dreissena Polymorpha*? Population Density and Potential Impacts

Alexander Y. Karatayev *and Lyubov E. Burlakova*
Buffalo State College, Great Lakes Center
300 Elmwood Avenue, Buffalo, NY 14222, USA

Vadim A. Karatayev
City Honors School
186 East North Street, Buffalo, NY 14204, USA

Demetrio Boltovskoy and Daniel Cataldo
University of Buenos Aires, School of Exact and Natural Sciences, Department of Ecology, Genetics and Evolution
C1428EHA Buenos Aires, Argentina

The freshwater golden mussel, *Limnoperna fortunei* (Mytilidea, Bivalvia) is considered to be the most aggressive invader in the southern hemisphere. In late 1980s – early 1990s, *Limnoperna* invaded South America and has already spread into Argentina, Paraguay, Uruguay, Brazil, and Bolivia, causing significant ecological and economic impacts. In the near future, *L. fortunei* is very likely to invade North America. *Limnoperna fortunei* is a suspension feeder and much of its ecosystem effects are due to shifting energy and matter from the water column to benthic communities (benthic pelagic coupling). Therefore, the overall ecosystem effects of *Limnoperna* will depend on their densities. However, with the exception of isolated records, to date there was no information on the population densities of *Limnoperna* over large areas. We studied the distribution of *L. fortunei* across different substrates and depths, and estimated its population density in a waterbody using Río Tercero Reservoir (Córdoba, Argentina) as an example. *L. fortunei* was found in 57 of the 109 diver-collected samples. Densities and biomass varied significantly with substrate type, being lowest on silt, medium on sandy substrates, and very high on rocks. Rocky and sandy substrates were most common at 4-8.5 m, resulting in the highest densities and biomass of *L. fortunei* on these depths. Comparison of these data with our previous results on the distribution and density of *D. polymorpha* in several European lakes, indicates that across all substrates *L. fortunei* attains substantially higher densities and biomass and will therefore have much stronger impacts on the ecosystems invaded than *D. polymorpha*. Moreover, because the ecosystem impact of both species is a function of their biomass rather than numerical density, *L. fortunei*, being significantly larger than *D. polymorpha,* will reach a higher biomass the zebra mussel, even in situations when both species attain similar densities, and will therefore have stronger ecosystem impacts. In addition, *L. fortunei* has broader environmental tolerance to high temperatures, low pH, low calcium content, oxygen depletion and water pollution than *D. polymorpha*. Therefore, *L. fortunei* may be much more successful than *D. polymorpha* in regions dominated by acidic, soft and contaminated waters. Although to date *D. polymorpha* is considered the most aggressive freshwater invader, many waterbodies that are already affected by *D. polymorpha* may soon host another, even more aggressive invader with much stronger environmental impacts.

NOTES

Ships as Vectors for Freshwater Bryozoans

Rebekah Kipp, *Sarah A. Bailey, Hugh J. MacIsaac and Anthony Ricciardi*
McGill University, Redpath Museum
859 Sherbrooke Street West, Montreal, QC H3A 2K6 Canada

As part of a larger study of the overseas transport of invertebrates in ship ballast tank sediments, the resting stages (statoblasts) of freshwater bryozoans were identified from ships visiting the Great Lakes during the years 2000 to 2002. A total of 69 ballast tanks in 39 ships were sampled. Statoblasts are often buoyant and thus can be taken up easily during ballasting operations. They are also resistant to extreme environmental conditions and can generate new colonies after being dormant for decades; as such, they would likely remain viable propagules after lengthy transport in ship ballast tanks.

Our results indicate that a remarkably high diversity of bryozoans can be transported in ballast sediments: our survey identified 10 species, representing over 10% of the total number of bryozoan species known worldwide. Over 80% of the 400 statoblasts examined were intact and undamaged; 13% had signs of damage that suggested predation by benthic fauna, either before or after uptake in the ballast tanks. A few of the undamaged statoblasts were successfully hatched in the laboratory.

Particularly noteworthy is the occurrence of *Lophopus crystallinus*, which is extremely rare worldwide and not previously recorded from the Great Lakes. Furthermore, the presence in ballast tanks of "cosmopolitan" species (*Plumatella casmiana, P. fungosa*, and *P. repens*) and an invasive species (*Lophopodella carteri*) already recorded in the Great Lakes suggests the strong possibility of cryptic invasions via the introduction of exotic genotypes.

NOTES

Dinoflagellate Cysts as Indicators of Potential Introduction of Invasive Marine Species in East Coast Canadian Ports

Olivia Lacasse, *André Rochon and Suzanne Roy*
CAISN, Université du Québec à Rimouski, Institut des Sciences de la Mer de Rimouski
310, allée des Ursulines, Rimouski, QC G5L 3A1 Canada

The constantly increasing commercial shipping has become an important vector for invasive marine species (IMS) since the end of the 1950s. One of the objectives of the Canadian Aquatic Invasive Species Network program is to identify the IMS already present in coastal and intertidal marine habitats, and determine the effects of different sources and degree of propagule pressure from commercial shipping. Resting cysts of dinoflagellates can be a good indicator of the establishment of new species in coastal regions because they are extremely resistant to the harsh conditions found in ships ballasts. This study focused on dinoflagellate cysts found in the sedimentary deposits of selected East coast Canadian ports (project 1.4). The samples were collected in July 2008 from eight ports in Nova Scotia. For each port, surface sediment samples from six sites were sampled in triplicate using an Ekman Bottom Grab Sampler. Samples were sieved on Nytex membranes of 100 and 20 µm mesh size, and the recovered fraction on 20 µm was analysed with an inverted microscope. Early results show important intra- and inter-port variations in both specific diversity and the proportions of potentially living (with cell content) and dead (without cell content) cyst assemblages. For the samples analyzed so far, cyst concentrations in studied ports range between 86 and 2 410 cysts.cm^{-3}. These preliminary results don't allow us to talk about IMS just yet, but they suggest a positive correlation between dinoflagellate cysts concentration and ships traffic in ports.

NOTES

Feeding Activity of Suspended Mussels and Invasive Tunicates in Prince Edward Island: A Mesocosm Approach

Mayi Lecuona *and Philippe Archambault*
Université du Québec à Rimouski, Institut des sciences de la mer (ISMER)
310, allée des Ursulines, CP 3300, Rimouski, QC G5L 3A1 Canada

Christopher W. McKindsey
Pêches et Océans Canada, Institut Maurice-Lamontagne
850 route de la Mer, C.P. 1000, Mont-Joli, QC G5H 3Z4 Canada

In the last ten years, mussel aquaculture areas in Prince Edward Island have been subject to an important invasion of exotic tunicates. Laboratory experiments have shown that mussels usually ingest particles between 4 and 16 µm even if they are able to consume larger particles, while clubbed and vase tunicates (*Styela clava* and *Ciona intestinalis*) ingest particles from 1 to 16 µm. Therefore, these tunicates may compete directly with mussels and take advantage on mussels in waters with low concentrations of particles or in waters dominated by bacteria and small phytoplancton. In this study, a mesocosm approach using 40-cm mussel socks was used to determine the food sources of mussels and solitary tunicates to better understand the trophic relationships between these organisms. A total of 72 socks (8 treatments with 9 replicates: all possible combinations of a) empty shell (controls) or mussel socks, b) with or without tunicates, c) the tunicates *C. intestinalis* or *S. clava*) were constructed and placed in mesocosms for 1 hour periods. Water samples were taken to evaluate phyoplancton, zooplancton, bacteria and SPM before and after the experiment. These results will contribute to revising models of carrying capacity for mussel aqualculture areas and to better understand the influence of mussel aquaculture to the establishment of exotic tunicates.

NOTES

Aquatic Invasive Species Research in the Bay of Fundy (2006-08)

*Murielle M. LeGresley, **Jennifer L. Martin** and Paul McCurdy*
Fisheries and Oceans Canada, Biological Station
531 Brandy Cove Road, St. Andrews, NB E5B 2L9 Canada

Bruce Thorpe
New Brunswick Department of Agriculture, Fisheries and Aquaculture
107 Mount Pleasant Road, St. George, NB E5C 3S9 Canada

Very little formal work on aquatic invasive species, such as the invasive tunicates, had been done in the Bay of Fundy prior to 2006. Collectors were deployed to look for *Ciona intestinalis* (Vase tunicate), *Botryllus schlosseri* (Golden Star tunicate), *Botrylloides violaceus* (Violet tunicate), *Styela clava* (Clubbed tunicate) and *Didemnum vexillum* during the three summers (2006-08) from floating docks, marinas, wharfs, buoys, or salmon cages in southern New Brunswick at 11 sites in 2006 and expanded to include the following 21 sites in 2007 and 2008: St. Andrews Biological Station, St. Andrews Town Wharf, Harbour de Loutre, Head Harbour, Roosevelt Park, Back Bay, Lime Kiln, Charlie Cove, Fairhaven (marine and floating dock), Beaver Harbour, Hog Island, North Head, Seal Cove, Ingalls Head, Leonardville, Dipper Harbour, Letete, Wallace Cove, Kennebecasis Yacht Club, and Saint John Harbour. Collectors included an inverted flower pot base with 4 petri dishes attached to the underside and a line with 6-4" PVC plates suspended. Some collectors were removed in August while some remained suspended through October/November. Results from the June-November plates resulted in the best cover and showed a large degree of interannual variability between 2006 and 2007. *Botryllus schlosseri* was found only at a few locations in 2006 but at 9 sites in 2007. *Ciona intestinalis* in 2006 was observed to be very abundant in cover on the plates (over 75%) in the Lime Kiln area, but decreased in intensity in 2007 throughout the sample region as it was observed at less than 50% cover on collector plates. *Ciona intestinalis* was present as minimal cover on plates at all sites excluding Dipper Harbour, Head Harbour, Ingalls Head, Kennebecasis Yacht Club and Saint John Harbour. *Botryllus schlosseri* was observed at Back Bay, Beaver Harbour, Fairhaven, St. Andrews town wharf, Seal Cove, Ingalls Head, North Head, Harbour de Loutre and Dipper Harbour with the highest densities (>50% cover) on the Seal Cove, Harbour de Loutre and Beaver Harbour collectors. Although *Didemnum vexillum* has not been observed to date on the collectors, there is the concern that it has been confirmed in nearby Eastport, Maine – about 1 km from Deer Island and there is speculation that it is simply a matter of time before it is in Canadian waters, if not already.

This project was expanded in 2008 due to concerns of invasion and spread in other regions of Atlantic Canada and the Northeast United States to look at distribution and abundance of the European green crab, *Carcinus maenas*, which was first reported in 1951 in the Bay of Fundy from the Digdeguash River and the non-indigenous Asian shore crab, *Hemigrapsus sanguineus*, which was reported in Portland, Maine. Beach transects and quadrats were initiated on the New Brunswick side of the Bay of Fundy. Preliminary results show that *C. maenas* continues to be a common species to the area.

NOTES

Structure of the Community of Invertebrates Associated with *Eichhornia crassipes* Mart. (Solms-Laubach) After the Introduction of *Limnoperna fortunei* (Dunker, 1857) (Bivalvia, Mytilidae) in the Upper Paraguay River, MT, Brazil

Sandra Francisca Marçal *and Cláudia Tasso Callil*
Federal University of Mato Grosso
Av. Fernando Corrêa da Costa, Cuiabá, MT, 78000-900, Brazil

This work was based on the assumption that the community structure of invertebrates associated with *Eichhornia crassipes* is influenced the water's physicochemical conditions, and abundance of *Limnoperna fortunei* of the plant's roots. In the dry season, 0.1875 m^2 of *E. crassipes* were collected for a study of the associated invertebrates, including the exotic bivalve species *L. fortunei* from 15 lakes along the banks of the Paraguay River. 86943 invertebrates were collected and the predominant taxa found in the roots were Hydrobiidae, Ostracoda, Hydracarina, and *Eupera* sp. Trichoptera, Odonata and Conchostraca showed a negative correlation to dissolved oxygen and depth, while Cladocera showed a slightly negative correlation to *L. fortunei.* The physical-chemical variables ordination showed 69,28% of the variation explained by the conductivity, transparency and dissolved oxygen. The composition and abundance of the invertebrates were summarized and did not show a relationship with the physical-chemical variables. However the depth and oxygen concentration were factors that had influence directly with *E. crassipes* and consequently the community invertebrates. The absence of a significant relation between community invertebrates and *L. fortunei* abundance can be associated with lower densities of golden mussel, meaning that the environment is resilient to the aggressive growth of this population into the Pantanal.

(FAPEMAT/ CNPq - 003/2003 Register number: 4.2.28.2/02-2004.E).

NOTES

Alien Fishes of Belarus: Diversity, Vectors of Introduction and Risk Assessment

Sergey E. Mastitsky*, Alexander Y. Karatayev, Lyubov E. Burlakova*
Buffalo State College, Great Lakes Center
1300 Elmwood Ave., 269 Science Building, Buffalo, NY 14222 USA

Twenty-five alien species of fishes are currently known to be in Belarus (www.aliensinbelarus.com). Sixteen of them have been intentionally introduced for aquaculture during the 20th century from the Far East, Siberia, and North America. At least two exotic species (topmouth gudgeon *Pseudorasbora parva* and rotan *Perccottus glenii*) have likely been unintentionally introduced with contaminated consignments of Far Eastern plant-eating fishes. The other invaders colonized Belarusian waters by natural dispersal, including Ponto-Caspian gobies of the genera *Neogobius* and *Proterorhinus*, as well as sticklebacks *Pungitius pungitius* and *Gasterosteus aculeatus*. The latter two species naturally occur in Belarusian rivers draining into the Baltic Sea. However, the sticklebacks are considered to be alien to the Belarusian rivers draining into the Dnieper River (Black Sea basin), which they invaded via interbasin canals. A number of new alien species of fishes are expected to appear soon in Belarus from neighboring countries, especially Ukraine.

We used Fish Invasiveness Screening Kit (FISK) developed by Copp et al. (2005) to distinguish which of the alien species of fishes pose the highest risk to aquatic ecosystems of Belarus. The highest total scores in our analysis were obtained for *Pseudorasbora parva, Perccottus glenii, Cyprinus carpio, Cyprinus carpio haematopterus, Carassius gibelio, Ameiurus nebulosus,* and *Neogobius melanostomus.* Based on the results of FISK-analysis, bioecological traits that can be used to predict fish invasiveness will be discussed.

NOTES

Early Colonisation of the Zebra Mussel (*Dreissena polymorpha*) in Lough Neagh Northern Ireland: Ecological and Consequential Socio-economic Impacts for the Rural Eel Fishing Industry

Sarah McLean
Queens University Belfast
35 Monroe Rd., Donacloney BT667LZ Northern Ireland

The observation of 5 adult *D. polymorpha* on the hull of a boat moored in Kinnego Marina, Lough Neagh in 2005 initiated a preliminary investigation to assess whether zebra mussels were present throughout the Lough. The investigation found 44 settled juveniles on debris from 20 sites. No adults were observed and no plankton sampling was carried out. In October 2006 plankton tows, spat collection and shoreline surveys were carried out. Veliger larvae were at densities of 0.0211 veligers per m^3. Spat collectors showed settlement at a mean density of 523.76 juveniles per m^2. No adult zebra mussels were found on natural substratum. 24 adult zebra mussels were found on a boat hull. These adults ranged in size from 7.5 to 24mm.

Since October 2007, spread has been monitored at all stages of the life cycle using plankton pumps, larval settlement disks, dredging, shore survey and boat hull surveys.

To determine potential impacts of an invasion on the eel, stomach content analysis was carried out on eels caught during the commercial fishing season (May-October). Eels were sampled at Lough Neagh fishery Toomebridge. This work builds on survey work ongoing since 1998 and provides scope for observation dietary preferences over time.

Results indicate a breeding population of *D. polymorpha* exists in Lough Neagh and potential exists for ecosystem changes which may have impacts on the European eel.

NOTES

Evaluations of Phytoplankton Enumeration Experiment Workshop Samples Using the Digital Signal Processor Based FlowCAM®

Bruce N. Nelson
Battenkill Technologies Inc.
Bourne Brook Business Center, 3429 Richville Road, Suite C, Manchester Center, VT 05255

Edward J. Lemieux
Naval Research Laboratory
Code 6136, PO Box 1739, Key West, FL 33040

Penny Herring
United States Coast Guard Research & Development Center
1 Chelsea Place, New London, CT 06320 USA

Between January 6 and 16, 2008, the Naval Research Laboratory (NRL) and the US Coast Guard conducted a Phytoplankton Enumeration Experiment Workshop at the NRL Key West. The overall objective of this workshop was to evaluate the efficacy of various methods for both enumerating and classifying (live/dead) phytoplankton in complex samples.

To support this workshop a team consisting of the NRL and Fluid Imaging Technologies was assembled. Prior to the start of this workshop, Fluid Imaging Technologies updated the NRL's FlowCAM® to be consistent with its current state-of-the-art configuration. Fluid Imaging additionally provided both training and field support during the first few days of testing in support of the workshop. The NRL provided its methods for applying vital stains to phytoplankton samples prior to the introduction of samples to the FlowCAM®, developed the specific methods that were to be used to evaluate each of the workshop's test samples, and performed the measurements and analysis of each of the workshop test samples.

There were two major updates made to the NRL FlowCAM®. First the unit was modified from the original analog circuit based configuration to a digital signal processor (DSP) based configuration. This change was made because the analog circuit based FlowCAM® is not capable of measuring fluorescence and forward scatter intensity values simultaneously from phytoplankton cells. Without this change it is not possible to determine both the number and viability of phytoplankton cells in a test sample. The second change was a switch to a new "solid state" flow cell configuration. The entire width of the flow cell is imaged by the FlowCAM® reducing the potential of not detecting phytoplankton cells that are introduced to the system. This change is essential to ensure accuracy when characterizing samples that have a low number of viable cells (or just a low number of cells).

The presentation will first describe the updated FlowCAM® system. This will be followed by descriptions of the methods that were used to both stain and introduce test samples into the FlowCAM. The methods that were used to analyze the FlowCAM® data and to generate live, dead, and total cell counts are next detailed. This will be followed by test results that show both the consistency of the FlowCAM® measurements across replicates as well as comparisons of the FlowCAM® results to other technologies that were evaluated at the workshop. The paper will conclude with a summary of the improvements that NRL believes are still required in the FlowCAM®, before this instrument can be used to support Ballast Water Treatment Equipment evaluations at the Ballast Water Treatment Test Facility.

NOTES

An Evaluation of Viability Assays Using a Continuous Imaging Particle Analyzer (FlowCAM®) for Ballast Water Analysis and Regulatory Compliance

*Kent A. Peterson and **Harry Nelson***
Fluid Imaging Technologies
65 Forest Falls Drive, Yarmouth Maine 04096 USA

Nicole J. Poulton
Bigelow Laboratories for Ocean Sciences
Boothbay, Harbor, Maine 04575 USA

A major source of invasive species in aquatic environments is ballast water discharge from vessels as they travel from port to port. A Ballast Water Convention has been adopted by the International Maritime Organization that will require vessels to treat discharged ballast water limiting the number of viable organisms from entering the environment.

The FlowCAM®, an imaging flow cytometer, is an instrument used for rapid plankton detection and analysis, with the ability to detect auto-fluorescence (chlorophyll) or stain-induced-fluorescence in organisms. The fluorescence is used as a "trigger" for a camera to capture images of target organisms within a sample. The FlowCAM® adds a unique capability to the ballast water monitoring process by using different stains to determine the viability of organisms in ballast water. Data such as concentration calculations, measuring the minimum diameter of organisms, and size distribution, are easily determined by the instrument. Compared to traditional microscopic methods which are laborious and plagued by operator error, the value of FlowCAM® lies in the immediate feedback the user receives with regard to viability and data analysis. We present results of different viability assays using the FlowCAM®, using both fluorescent and visual stains, in order to determine how effective these assays are at detecting viable organisms in ballast water.

NOTES

Assessing the Economic Impacts of Aquatic Invasive Species in the United Kingdom

Matthew P.J. Oreska
University of Cambridge, Department of Zoology
Downing Street, Cambridge, CB2 3EJ UK

David C. Aldridge
University of Cambridge, Department of Zoology
Downing Street, Cambridge, CB2 3EJ UK

Aquatic invasive species (AIS) establishment threatens ecosystems and economic interests alike; however AIS adverse impacts are often difficult to ascertain and quantify owing to the complexity of aquatic systems. The effects of established AIS are often diverse and poorly documented, which complicates efforts to devise and implement effective AIS management practices. Stakeholders with a vested interest in AIS control and prevention would benefit greatly from a standardized means of weighing AIS impacts, such as a systematic monetization of AIS costs and benefits. By valuing AIS impacts using a common measure, it becomes possible to assess the relative magnitude of various AIS impacts across multiple species and over differing time periods. Unfortunately, few studies have attempted to value the effects of prominent nuisance AIS and even fewer studies have considered the economic impacts of lesser publicized aquatic invaders.

This study seeks to identify problem AIS in the United Kingdom (U.K.) and to monetize their costs through an ecosystem services framework. A literature survey of U.K. freshwater ecosystem services provides a Total Economic Value (TEV) baseline for the consideration of AIS induced economic changes to freshwater economic benefits. By establishing which benefits are susceptible to the effects of species establishment, it is subsequently possible to identify and survey U.K. stakeholders directly impacted by AIS. Using a standardized survey method, these affected stakeholders identify problem species and describe the species' damage and control costs. By focusing primarily on direct costs to provisioning and regulating services, as defined by the Millennium Ecosystem Assessment, the direct effects of prominent AIS can be readily compared, and net changes in TEV caused by AIS can be ascertained. AIS Non-use effects, such as those affecting cultural services, are also considered but are largely excluded from the comparative analysis owing to valuation subjectivity. Consequently, AIS damage estimates presented herein underestimate total effects of establishment but reasonably approximate those damages affecting marketable goods and services.

Freshwater ecosystem service benefits most impacted by AIS in the U.K. include water provisioning for consumption and industrial processes, recreational fishing/angling, recreational boating, and transportation. Among those AIS identified by stakeholders as nuisance species, special attention is paid to *Dreissena polymorpha* (the zebra mussel), a prolific industrial biofouler and ecosystem engineer with pronounced direct economic costs both in the U.K. and elsewhere around the world. Other economically damaging AIS in the U.K. include *Hydrocotyle ranunculoides* (floating pennywort), which impacts transportation and boating, and *Pacifastacus leniusculus* (the American signal crayfish), which impacts native biota, including fish stocks. Numerous introduced fish species are found to impact native fish stocks, but their net economic effects on recreational fishing are minimal. Other identified AIS cause ecosystem changes and non-use impacts but few direct economic costs.

NOTES

Phyllodistomum folium, a Fish Helminth Parasite Introduced by Zebra Mussels in the Ebro River, Spain

Miguel A. Peribáñez
University of Zaragoza, Faculty of Veterinary Science
Miguel Servet 177, Zaragoza 50013 Spain

Zebra mussels (*Dreissena polymorpha*) were detected for first time in the lower Ebro River in Spain during the summer of 2001. After the discovery of zebra mussels, we carried out further studies to determine if this exotic bivalve had introduced nonindigenous species of parasites in this basin.

Zebra mussels were collected from Ribaroja dam to Ascó meander. Only one helminth species was identified in the bivalves examined. After macroscopic and histologic observation, we identified sporocysts stages of *Phyllodistomum folium* (Digenea) in the gills of these bivalves. *P. folium* is the only species of this genus known to infect *D. polymorpha.*

Prevalence of *P. folium* in mussels has notably increased from 0.14% in 2004 to 4.67% in 2006. The percent of infection seems to be highly dependent on the mussel length and the peak rate of parasitic infection occurred during the end of the summer.

Fish were sampled by electrofishing in the littoral zone of the Flix Reservoir. The ureters and urinary bladders of 143 fish were microscopically observed to detect the presence of adult parasites and/or were processed to isolate *Phyllodistomum folium* DNA for PCR analysis.

The presence of the *Phyllodistomum folium* adults has been detected in three cyprinid species: rudd (*Scardinius erythrophthalmus*), carp (*Cyprinus carpio*) and roach (*Rutilus rutilus*). The prevalence may vary depending on the host species, the sampling date and the identification method. However, we have not found the presence of this helminth in any of the European catfish (*Silurus glanis*) examined.

Adult phyllodistome´s taxonomic identification is quite difficult using morphological characterization. Multiple sequence alignment allowed us to obtain a consensus sequence for each DNA fragment obtained from the gills and fish urinary tissue. Our DNA consensus sequence of a region containing the genes ITS1-5.8S-ITS2 has resulted in 100% sequence identity between sporocysts found in the zebra mussels and adults found in the urinary system of fish.

Acknowledgements

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NOTES

Corbicula fluminea (Muller, 1774) – Invasive Species in Romanian Waters

***Oana P. Popa**, Dumitru Murariu, Elena Iulia Iorgu and Luis O. Popa*
Grigore Antipa National Museum of Natural History
Sos. Kiseleff no.1, 011341 Bucharest, Romania

Beatrice S. Kelemen
Babeş-Bolyai University, Molecular Biology Center
42 Treboniu Laurian Street, 400271 Cluj-Napoca, Romania

Native distributional area of *Corbicula fluminea* (Asian clam) is South-East Asia. *Corbicula fluminea* is an opportunist species which develops mainly in sandy areas. At the beginning of the 20th century, the species was introduced in North America and, recently it succeeded in colonizing the European continent. In North America, where it developed important populations, this species generates negative effects which we can compare with those generate by another invasive species, *D. polymorpha* (zebra mussels).

After 1980, *Corbicula fluminea* (Asian clam) was introduced in South America and in Europe. It is reported by Mouthon from France and Portugal, in 1981. From Portugal, it was reported by Nagel, in 1989, from Duero River. In Europe, *C. fluminea* distributed from west to east, and in the Danube it penetrated after the opening of the canal Rin-Main-Danube, which offers the possibility of mixing the faunas of the Rin and the Danube basins. The first living specimens collected from the Romanian sector of the Danube were juveniles (3-4 mm), taken from the Iron Gates area, at Berzeasca, by Skolka and Gomoiu, in the winter of 1997. Later, in 1999, living specimens were collected from the Danube, at Vadu Oii.

According to the specialized literature, reports of this species for the main tributaries of the Danube on the Romanian territory were not given, but probably, in the next years, *Corbicula fluminea* will be reported from these new habitats, too

The authors' subsequent collecting (2004 from the Danube, at Galați, 2005 from the Danube, km 929 – unpublished data) confirms the presence of some stable populations of this species, at least in the Romanian sector of the Danube.

NOTES

Detection of a Colonising, Aquatic, Non-indigenous Species

Chad T. Harvey, ***Samir A. Qureshi*** *and Hugh J. MacIsaac*
CAISN, University of Windsor, Great Lakes Institute for Environmental Research
401 Sunset Avenue, Windsor, ON, N9B 3P4 Canada

Detecting the presence of rare species has interested ecologists and conservation biologists for many years. A particularly daunting application of this problem pertains to the detection of non-indigenous species (NIS) as they colonise new ecosystems. Ethical issues prevent experimental additions of NIS to most natural systems to explore the relationship between sampling intensity and the detection probability of a colonising NIS. Here we examine this question using a recently introduced waterflea, *Cercopagis pengoi,* in Lake Ontario. The species has bi-phasic population development, with sexually-produced 'spring morphs' developing prior to parthenogenetically-produced 'typical' morphs. Thus, this bi-phasic morphology allows distinction between new colonists (spring morphs) from subsequent generations. We repeatedly sampled Hamilton Harbour, Lake Ontario for the presence of both spring and typical morphs. Probability of detection was positively related to both the number of samples taken and animal density in the lake; however, even highly intensive sampling (100 samples) failed to detect the species in early spring when densities were very low. Spatial variation was greatest when densities of Cercopagis were intermediate to low. Sub-sampling, which increased space between adjacent samples, significantly decreased the number of samples required to reach greater, calculated detection probabilities on these dates. Typical sampling protocols for zooplankton have a low probability (<0.2) of detecting the species unless population density is high. Results of this study suggest that early detection of colonising, aquatic NIS may be optimized through use of a risk-based sampling design, combined with high sampling intensity in areas deemed most vulnerable to invasion, rather than less intensive sampling at a wider array of sites.

NOTES

Do *Nodularia spumigena* Blooms Force Back *Neogobius melanostomus* (the Round Goby) Invasion in the Gulf of Gdańsk?

Ilona Złoch and ***Mariusz R. Sapota***
University of Gdańsk, Institute of Oceanography
Al. Marszałka Piłsudskiego 46, 81-378 Gdynia, Poland

The degree to which fishes are affected by the toxin is difficult to predict, as it depends on the toxicity and duration of the toxic bloom. In spite of this fact it is possible to distinguish the possible risk: decreasing organism condition caused, to a great extent, by toxin accumulation in fish muscles, liver and gonads. In the Gulf of Gdańsk this problem seems to be even more emerging than in other open seas because cyanobacterial blooms often cover large areas of that sea.

The aim of the present study was to find out what is the impact of *Nodularia spumigena* on nonindigenous fish *Neogobius melanostomus* (the round goby) in the Gulf of Gdańsk. In the conducted laboratory experiments round goby individuals were treated with various concentrations of nodularin extracts.

The results show that in the group of fish exposed to nodularin longer than 24 hours, movement disorders were observed. The highest nodularin concentration was found in alimentary tract, gills, liver and gonads. The round gobies from all experimental sets had operculum and pectoral fin damage. Results obtained can be considered a possible factor limiting the expansion of the round goby in the Gulf of Gdańsk.

NOTES

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

Rochelle A. Sturtevant
NOAA National Center for Research on Aquatic Invasive Species
4840 S State Road, Ann Arbor, MI 48108-9719 USA

The Great Lakes have a long history of introductions — intentional and unintentional — of aquatic non-indigenous species. As of 2007, at least 186 non-indigenous species have been recorded as having reproducing populations in the Great Lakes basin, i.e. lakes Superior, Michigan, Huron, St. Clair, Erie, Ontario, and their connecting channels and water bodies within their respective drainages (Mills et al. 1993, Ricciardi 2001, Ricciardi 2006, Ricciardi unpubl. data).

The Great Lakes Aquatic Nuisance Species Information System (GLANSIS) functions as a Great Lakes specific node of the USGS NAS national database of freshwater aquatic invasive species. Information entered for GLANSIS automatically appears in both databases. GLANSIS allows more direct access to the Great Lakes specific information — especially collection records. Individual fact sheets have been developed for each of the established nonindigenous species in the Great Lakes basin. GLANSIS is available at: http://www.glerl.noaa.gov/res/Programs/ncrais/glansis.html

NOTES

The American Mud Crab *Rhithropanopeus harrisii* in the Southern Baltic Sea – Is there an Invasion?

Monika Normant, Joanna Hegele-Drywa, Magdalena Gibowicz and ***Anna Szaniawska***
University of Gdańsk, Institute of Oceanography
Al. Marszałka J. Piłsudskiego 46, 81-378 Gdynia, Poland

The mud crab *Rhithropanopeus harrisii* Gould, 1841 invaded Europe from North America, where its indigenous regions of occurrence are the brackish waters of the Atlantic coast. In Poland this species appeared in 1951 and since that time a stable and abundant population has been observed in the oligohaline waters of Vistula Lagoon (3 psu) and Dead Vistula River (0.5-5 psu). In recent years, increase in the abundance of this species occurred in the coastal waters of the southern Baltic Sea (7 psu) – in places where the crab had not been observed previously. Numerous surveys performed in years 2002-2007 in the Gulf of Gdańsk show that *R. harrisii* is stable component of the benthic communities in this area, where it readily lives between shells of *Mytilus trossulus*. The maximal abundances of *R. harrisii* reaching up to 40 ind. 100 m^{-2} were recorded in the summer months. Among 246 analyzed specimens there were 103 males, 98 females and 45 juveniles.

It is interesting why *R. harrisii* appeared so numerously in the Gulf of Gdańsk after more than 50 years of appearance in the surrounded environments. Is that the natural extension of the occurrence range or the invasion? In the coastal Baltic waters crabs may find better throphic conditions. Stomach analyses performed on 72 crabs showed that they feed on *Chlorophyta, Amphipoda, Ostracoda, Polychaeta, Gastropoda* i *Bivalvia*. Baltic waters offer also more favorable conditions in regard to temperature (higher range) and salinity (stability) what may significantly affect *R. harrisii* biology (e.g. reproduction) and physiology (e.g. osmoregulation and growth). Experimental studies showed that at the salinity of 3 psu haemolymph osmolality of *R. harrisii* is 6.3 times higher compared to environment, whereas at 7 psu this difference decreases to 2.9 times. Reduction of the osmolality gradient cause significant changes in the metabolic rate due to lowering of energy expenditures for osmoregulation.

NOTES

Investigation About Growth and Settling of *Limnoperna fortunei* in Artificial Substrate at Three Different Channels of Upper Paraná River Floodplain, Brazil

Alice Michiyo Takeda
Universidade Estadual de Maringá/DBI/Nupelia/National Council of Scientific and Technological Development
Av. Colombo, 5790, Bloco H-90. Maringá-PR. CEP 87020-900 Brazil

Sue Ellen Prata Fernandes and Daniele Sayuri Fujita
Universidade Estadual de Maringá
Av. Colombo, 5790, Bloco H-90. Maringá-PR. CEP 87020-900 Brazil

Shell growth and settlings of *Limnoperna fortunei* (golden mussel) were evaluated in artificial substrate installed at three different channels in the upper Paraná River floodplain (Curutuba and Ipoitã channels and Baía River). The density was related with physical and chemical variables as temperature, dissolved oxygen, pH, electrical conductivity, turbidity, and water velocity. Samples were collected monthly from October 2006 to October 2007. Artificial substrate was made with buoy, attached to the bottom, where artificial substrate (20 cm x 10 cm) of wood in **X** form was fixed at buoy. Thirty-nine substrates were installed in each channel in the September 2006 (continuous substrates) and three substrates of each channel were replaced every month to assess the monthly colonization rates (month substrates). In each channel was taken out three continuous substrates and three month substrates. The first two axes of a PCA applied to abiotic variables explained 58.21% of total variability of data. According to axis 1, October 2006 to March 2007 were characterized by lower values of conductivity and dissolved oxygen. Axis 2 separated November from the other months because it presented the highest values of turbidity. The highest density of *L. fortunei* was registered in Baia River, followed by Ipoitã and Curutuba channels. This experiment showed continuous settlement of *L. fortunei* and, differences in length shell of Curutuba channel and Baía River had bigger individuals than Ipoitã channel. The geomorphology of the channels is quite different because Curutuba channel links the Baía River (lentic river – affluent of Paraná River) and Ivinhema River while Ipoitã River links the Paraná River and the Ivinhema River (both, lotic rivers). On the other hand, the water velocity is near to zero most time in the Baía River. During a year, Curutuba channel received mainly the water from the Baía River whereas the Ipoitã channel received water from the Paraná River. In Paraná River, about 30 km of floodplain has hydropower Eng. Sérgio Motta that retained much suspension matter. Ipoitã channel received Paraná River water, poor in phytoplankton and organic matter that probably impeded their shell growth. The minimum temperature was found in the Baía River (19.2°C) and maximum in the Curutuba channel (30.47°C), but no significant differences between the sampling stations were recorded constant settling of larvae of *L. fortunei*.

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NOTES

Trends on the Publications of 100 Worst Invasive Species from 1965–2007

Rahel A.Tedla *and Hugh J. MacIsaac*
CAISN, University of Windsor, Great Lakes Institute for Environmental Research
401 Sunset Avenue, Windsor, ON, N9B 3P4 Canada

The study of biological invasions has gained the attention of many ecologists. Information on non-indigenous species (NIS) appears to have increased significantly in recent decades. A lot of books and journals related to issues of invasive species are being published at an increased rate. Here, I quantify the patterns of change in the scientific literature to explore this trend. In order to do this, I used the Thomson's ISI web of knowledge 4.0 to reach literature publications in the 100 worst invasive species from 1965 to 2007. To decrease the bias of selecting different species, I used the 100 worst invasive species that are listed in the IUCN (International Union for Conservation of Nature) website. The first set of searches was conducted based on common and scientific names of the 100 worst invasive species. Subject areas were refined to ecology related fields such as, ecology, zoology, environmental sciences, marine and freshwater biology, evolutionary biology, plant sciences, and conservation biodiversity. Fields that are not related to ecology were excluded from the search results. To make sure all the search results pertain to invasion biology and are not simply studies on a species in its native range that is invasive elsewhere, a combined search of species name (scientific and common) was conducted with seven synonym names of invasive species. Synonym names include 'invasive species' or 'non-native species' or 'alien species' or 'non-indigenous species' or 'introduced species' or 'colonizing species' or 'exotic species'. Non-linear regression was used to model cumulative growth in studies. Results of this study suggest that invasion ecology has exploded, with large increases in publications since 1990 for both terrestrial and aquatic NIS. Animal-related papers accumulated significantly faster than plants, although no differences were observed between vertebrate and invertebrate aquatic species or between aquatic and terrestrial species.

NOTES

Use of NaCl Brine and Road Salt as a Ballast Water Treatment Technology for Transoceanic Vessels Entering the Great Lakes

Tony Wang *and Hugh MacIsaac*
CAISN, University of Windsor, Great Lakes Institute for Environmental Research
401 Sunset Avenue, Windsor, ON N9B 3P4 Canada

Sarah Bailey
Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences
867 Lakeshore Road, Burlington, ON, L7R 4A6 Canada and
University of Windsor, Great Lakes Institute for Environmental Research
401 Sunset Avenue, Windsor, ON N9B 3P4 Canada

Christopher J. Wiley
Fisheries and Oceans Canada/Transport Canada
100 Front Street South, Sarnia, ON N7T 2M4 Canada

Philip T. Jenkins
Philip T. Jenkins & Associates, Ltd.
1 Forest Hill Crescent, Fonthill, ON L0S 1E1 Canada

Thomas Johengen
CILER/University of Michigan
2205 Commonwealth Blvd, Ann Arbor, MI 48105-2945 USA

David Reid
National Oceanic and Atmospheric Administration, GLERL
4840 S State Road, Ann Arbor, MI 48108-9719 USA

All transoceanic ships coming to Canada from foreign ports are required to conduct ballast water exchange (BWE) at least 200km from the nearest shore and water of at least 2000m depth, achieving a final salinity of at least 30 ppt. Despite high compliance, some vessels still arrive with un-exchanged, or incompletely exchanged, ballast water with salinity below 30 ppt. As there is currently no technology available for treatment of ballast water under these circumstances, the addition of brine/road salt may be an effective way to artificially augment ballast salinity for compliance with current Canadian regulations.

The objective of this study is to evaluate the biological efficacy of brine treatment of ballast water under normal operational conditions at full ship scale. A total of 12 experiments will be conducted in 2008 and 2009, comprised of six NOBOB and six BOB tanks. Two hypotheses are being tested: 1) brine/road salt can be uniformly distributed in ballast tanks and 2) at least 95% of organisms will be exterminated. This study examines application of rock road salt for treatment of tanks in ballast, while brine is used for treatment of residual ballast. Due to large water volume in ballasted tanks, treatment objectives are 40ppt salinity for multiple days of exposure. Conversely, NOBOB tanks are being treated with high salinity (115 ppt) for a short duration (hours).

Preliminary results from experiments conducted to date will be presented, including information on the ability to achieve uniform application of road salt and brine, and zooplankton viability assessments.

NOTES

Does Increased Regulation Effectively Prevent New Introductions of AIS?

Ivan Lantz, *Anne Legars and Caroline Gravel*
Shipping Federation of Canada
300 Saint-Sacrement, Suite 326, Montreal, QC H2Y 1X4 Canada

When the first attempts to regulate ballast water introduced in the late 1980's, the impetus was plain and simple: to reduce the risk of introducing alien organisms that could become invasive.

Twenty years later, the US, a major trading partner for just about everyone in shipping and transportation, is leading the charge in developing an unenforceable patchwork of regulations at the federal and state levels. Indeed, the regulatory environment of one of the world's leading port states appears to be nearing chaos due to the sheer volume of court actions mandating just about every possible agency to regulate ballast water discharges – with little or no attention being paid to the development of preventive measure. It is clear that permit mania across individual states and across the country as a whole is not only creating mountains of new paperwork. What is far less clear is whether these actions are helping to effectively prevent the introduction of potentially invasive alien aquatic species. Even as the US Coast Guard steadfastly soldiers on with its regulatory duties, the scenario begs the question: "Why so many regulators?"

This paper presents a critical overview of the regulatory morass that has befallen ballast water management, particularly in the United States. The work of the National Academy of Sciences as commissioned by the Great Lakes Protection Fund, provides science-based justification to past prevention strategies and looks to the future with reasoned focus. This paper will explore practical means of bringing science-based solutions to reality, with a view to improving current prevention strategies in the process, either with regulation or without!

The members of the Shipping Federation of Canada are the owners, operators and agents of ships engaged in international trade and calling at Canadian ports. Our member companies have proposed and supported voluntary guidelines, welcomed scientists on board their ships to test and implement new programs, and supported the development of national and international regulations.

The Federation proposes to bring the future strategy of the National Academy into practical perspective, undertake a revision of its Code of Best Practices for Ballast Water Management, and present this project to ICAIS for critical review.

NOTES

Challenges and Solutions to Test the Performance of Ballast Water Treatment Systems Onboard Vessels According to the IMO Type Approval Guideline

Stephan Gollasch
GoConsult
Grosse Brunnenstr, 61, 22763 Hamburg, Germany

The International Maritime Organization (IMO) developed a set of guidelines to provide technical guidance for the implementation of the Ballast Water Management Convention principles. One of these guidelines outlines how to undertake tests to evaluate the performance of ballast water treatment systems, i.e., Guidelines for the Approval of Ballast Water Management Systems (G8), adopted at the 53rd meeting of the Marine Environment Protection Committee (MEPC) in July 2005. It was further agreed that the guidelines are living documents and may need to be revisited for updates. G8 was reconsidered at recent meetings of MEPC and some adjustments were made. This presentation will outline some of the critical aspects in G8 and will address the challenges when undertaking performance tests of ballast water treatment systems onboard vessels, including logistical aspects, working in a ship environment, sampling of larger amounts of water, how to meet the required intake concentrations of organisms, sample processing and analysis onboard as well as problems during land and air sample shipment. From our experience gained during more than 15 sampling trips we will describe and discuss solutions to overcome some of these constraints.

NOTES

U.S. Coast Guard's Proposed Ballast Water Discharge Standard Rulemaking

Bivan R. Patnaik *and Richard A. Everett*
U.S. Coast Guard, Environmental Standards Division (CG-5224)
2100 2nd Street SW, Washington, DC 20593 USA

The U.S. Coast Guard is the U.S. agency authorized by Congress to develop a national regulatory program to reduce, and eventually prevent, introductions of non-indigenous aquatic organisms into U.S. waters via the operations of vessels. In addition to the current regulations and policies in place, the Coast Guard published a proposed rulemaking on [XX, 2009] that would set a performance standard for the quality of ballast water discharged in U.S. waters. This rulemaking is being carried out under the Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990 as reauthorized and amended by the National Invasive Species Act of 1996. These laws authorize the Coast Guard to approve alternative ballast water management systems (BWMS) that are found to be at least as effective as mid-ocean ballast water exchange (BWE) in preventing NIS introductions. As the effectiveness of ballast water exchange varies from vessel to vessel, the Coast Guard believes that setting a performance standard would be the most effective way for approving BWMS that are environmentally protective and scientifically sound. The proposed rulemaking also describes the types of vessels that would be required to install and operate Coast Guard approved BWMS, lays out an implementation schedule, while taking the International Maritime Organization's International Convention for the Control and Management of Ships Ballast Water & Sediments, and Canada's ballast water regulatory program, into consideration. 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. These would include requirements for: pre-approval reviews, application package contents and format, land-based/shipboard testing, design and construction, electrical components, engineering, and piping. This presentation will provide a general overview of this rulemaking and provide information on the current status and next steps.

NOTES

U.S. Coast Guard's Proposed Ballast Water Management System Approval Procedures

Richard A. Everett *and Bivan R. Patnaik*
U.S. Coast Guard, Environmental Standards Division (CG-5224)
2100 2nd Street SW, Washington, DC 20593 USA

The Coast Guard is directed and authorized by Congress to approve Ballast Water Management (Treatment) Systems (BWMS) used on vessels to meet the requirements of regulations on ballast water management established under the National Invasive Species Act (NISA). Approval of BWMS requires procedures to ensure that BWMS work not only in the laboratory but under shipboard conditions. Coast Guard approves a number of other engineering systems for use on vessels, and the general procedures for determining the acceptability of engineering systems are described in detail in the Code of Federal Regulations, Title 46, Subchapter Q. Included in Subchapter Q are the explanation and requirements for submitting applications; specifications for design and construction of electrical, engineering, and piping components; and specifications and requirements for Independent Laboratories that conduct tests of BWMS for purposes of approval. In its proposed ballast water discharge standard regulation, Coast Guard would update these existing sections to reflect requirements for BWMS, and add new sections to address unique requirements specific to BWMS. This presentation will provide a general overview of the major elements of the proposed procedure for type approval of BWMS and in particular will discuss the requirements for testing.

NOTES

U.S. Coast Guard's Ballast Water Management Program: Developing a U.S. Administration Type Approval Process for Ballast Water Management Systems that Make Use of Biocides, Active Substances or Preparations

John C. Morris
U.S. Coast Guard, Environmental Standards Division (CG-5524)
2100 2nd Street SW, Washington, DC 20593 USA

The U.S. Coast Guard is the Federal agency authorized and directed by Congress to develop a national regulatory program to reduce, and eventually prevent, introductions of non-indigenous aquatic organisms into U.S. waters via the operations of vessels. The Coast Guard has established a mandatory ballast water management program for vessels operating in U.S. waters.

Current Coast Guard regulations require vessels to conduct mid-ocean exchange, retain their ballast water while in U.S. waters, or use a Coast Guard-approved alternate environmentally sound method as management practices. There are no Coast Guard-approved alternate methods at this time, so vessels must either conduct mid-ocean exchange or retain their ballast water while in U.S. waters.

Draft Coast Guard regulations currently in development would establish a discharge standard for the allowable concentration of organisms in treated ballast water. The proposed ballast water discharge standard would be used as a performance standard by which the Coast Guard would approve ballast water management systems. Effective implementation of these draft regulations depends upon the development of a U.S. Administration Type Approval process for ballast water management systems.

One of the challenges will be how to evaluate systems that make use of biocides, active substances or preparations. Under the U.S. Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), companies must register chemicals with the U.S. Environmental Protection Agency for specific biocidal uses, such as ballast water management, before they may be used. The Coast Guard is working with the U.S. Environmental Protection Agency to develop an inter-agency review process for ballast water management systems that may be regulated under FIFRA and other environmental laws.

The Coast Guard is also coordinating with the U.S. Environmental Protection Agency, the Fish and Wildlife Service, and the National Oceanographic and Atmospheric Administration on U.S. Administration positions regarding implementation of the "International Convention for the Control and Management of Ships' Ballast Water and Sediments." A summary and comparison of the U.S. and IMO programs will focus on those ballast water management systems that will use biocides, and those active substances or preparations as defined by the IMO Convention that may not be considered biocides under current U.S. law.

NOTES

Invasive Species Threat to the Arctic

Christopher J. Wiley
Fisheries and Oceans Canada/Transport Canada – Ontario Region
100 Front St. Sarnia, ON N7T 2M4 Canada

Kim Howland
Fisheries and Oceans Canada
501 University Crescent, Winnipeg, MB R3T 2N6 Canada

Farrah Chan
CAISN, University of Windsor, Great Lakes Institute for Environmental Research
401 Sunset Avenue, Windsor, ON N9B 3P4 Canada

Canada currently has regulations that require Ballast Water management (exchange, treatment to IMO Standards, pump shore or retention on board) for ships that are entering waters under Canadian jurisdiction from outside the Exclusive Economic Zone. These regulations apply to ships heading to ports into the Arctic and into Hudson Bay. Current records indicate a high compliance for vessels heading into the Arctic, but with the reality of climate change in these waters, and the potential for more shipping via the Northwest Passage, there has been an increase in interest on the environmental impacts of shipping traffic. Ballast water discharge has been highlighted although there is needed research into the issues of hull fouling, the role of the domestic fleet (as most vessels heading for the Eastern Arctic originate their voyages in the St. Lawrence River and the potential effect of invasive species entrained in cargos)

Fisheries and Oceans Canada provides scientific advice to Transport Canada on the ballast water issue and has undertaken a number of studies to ascertain the overall risk to the Arctic from shipping and to provide a baseline for recommending alternate ballast water exchange zones that might be utilized as a back up for ships heading to the Arctic that are unable to exchange ballast on the high seas 200 miles off in depths of 2000 metres as required in the regulations.

To date scientific advice on alternate exchange zones has been provided for Hudson Strait and the Beaufort Sea. And exchange area prior to entry into Lancaster Sound is of interest and will be the target of future research.

NOTES

Have the New Ballast Water Regulations and Inspection Program Reduced the Risk of NIS Introductions for the Laurentian Great Lakes?

Matthew G. Deneau
Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences
867 Lakeshore Road, Box 5050, Burlington, ON L7R 4A6 Canada

Sarah A. Bailey
Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences
867 Lakeshore Road, Box 5050, Burlington, ON L7R 4A6 Canada and
University of Windsor,Great Lakes Institute for Environmental Research
401 Sunset Avenue, Windsor, ON N9B 3P4 Canada

Laurent Jean
Transport Canada
901 Cap-Diamant, Québec, QC G1K 4K1 Canada

Christopher J. Wiley
Fisheries and Oceans Canada/Transport Canada Marine Safety
100 Front Street South, Sarnia, ON N7T 2M4 Canada

Ballast water associated with commercial shipping activities has been implicated as the most important vector for the introduction of aquatic nonindigenous species (NIS) to the Laurentian Great Lakes. While vessels with ballast on board (BOB) have been required to exchange coastal ballast water for open ocean water for more than 15 years, research completed in 2004 indicated that vessels with no ballast on board (NOBOB) remained a possible vector for NIS introductions. As a result, Transport Canada, while backed by the U.S. Coast Guard, implemented more stringent rules (voluntary in 2005, mandatory in 2006), requiring all foreign vessels to exchange or flush all ballast tanks with open ocean water of at least 30 ppt salinity before entering Canadian waters. The U.S. and Canadian St. Lawrence Seaway Corporations enacted similar regulations in 2008. It is now mandatory for all foreign vessels entering the Great Lakes, regardless of ballast status, to manage their ballast water. Concomitant with the new regulations has been the implementation of a 4-agency joint inspection program where compliance is evaluated and enforced by Inspectors representing Transport Canada, the U.S. Coast Guard and the two Seaway Corporations. We examine here whether the new regulations and inspection program have significantly reduced the risk of NIS introductions associated with ballast water.

We analyzed data collected by Inspectors to determine trends in ballast management practices immediately before, during and after the introduction of the voluntary and mandatory regulations (2005-2007 shipping seasons). The risk associated with ballast water of both BOB and NOBOB vessels appears to have decreased as the number of ballast tanks with water <30‰ decreased from 18.9% to 7.2% for NOBOB vessels and 30.7% to 4.2% for BOB vessels over the study period. Independent biological sampling of ballast water and residuals indicates that the corresponding biological composition of ballast water may be changing, with a trend towards reduced densities of both marine and low-salinity taxa. We conclude that the new regulations and inspection program have significantly reduced the risk of NIS introductions by ballast water to the Laurentian Great Lakes.

NOTES

The U.S. Environmental Protection Agency's Vessel General Permit

William Bolen
U.S. Environmental Protection Agency, Great Lakes National Program Office
77 W. Jackson Blvd., G-17J, Chicago IL 60604 USA

This abstract was unavailable at the time of printing

NOTES

Changes in Behaviour of *Dreissena polymorpha* (Bivalvia) Induced by Potential Fish Predators of Various Species and Size

Jarosław Kobak *and Małgorzata Poznańska*
Nicolaus Copernicus University, Department of Invertebrate Zoology
Gagarina 9, 87-100 Toruń, Poland

Tomasz Kakareko
Nicolaus Copernicus University, Department of Hydrobiology
Gagarina 9, 87-100 Toruń, Poland

Zebra mussel *Dreissena polymorpha* has invaded a large part of European and North American water bodies. In these non-native areas, it is involved in complex relationships with other species, some of them co-occurring with the mussel in its native Ponto-Caspian region. It creates a suitable habitat for many invertebrate species and is consumed in great numbers by fish (e.g., roach), waterfowl (Eurasian coot) and large crustaceans (crayfish, crabs). The ability to respond adequately to the presence of other organisms, including predators, would be extremely advantageous for mussels, and thus occurrence of various anti-predator defences might be expected.

We studied behaviour of zebra mussel in the presence of fish predators with different feeding habits and capabilities to feed on molluscs: 1) large roach *Rutilus rutilus* (180-250 mm total length), which is an efficient molluscivore occurring in the native region of zebra mussels; 2) small roach (80-110 mm), unable to feed on zebra mussels; 3) perch *Perca fluviatilis* (100-180 mm), not reported to feed on zebra mussels at all. We kept small (<10 mm) or large (10-17 mm) mussels on PVC substratum in 100-L tanks containing fish or empty (control). The mussels were separated from the predators with 1-mm nylon mesh. We measured their attachment strength and counted aggregated (i.e., touching one another's shell) and single individuals after one or six days of exposure.

After a one-day exposure, we found no significant differences in attachment strength of mussels between treatments. At the same time, in all the fish treatments, mussels were more clustered than the control individuals. After six days in the presence of large roach, small and large mussels were attached more strongly than in the other treatments. Proportion of mussels forming aggregations increased with time in the large roach and control treatments, contrary to the other fish treatments, where a longer exposure did not affect mussel clumping. As a result, after six days of exposure, the percentage of aggregated mussels in the control treatment became similar to those found in the presence of small roach and perch, while the percentage of clustered mussels in the presence of large roach was greater than in the other treatments. Thus, an initial (after one day) mussel response was probably a non-specific reaction to the presence of any kind of fish and consisted in faster clumping, while the final proportion of aggregated individuals was unaffected. After a longer exposure (six days), we observed a specific response to large roach. In the presence of this efficient molluscivore, not only the clumping speed, but also the final percentage of clustered mussels was greater.

The zebra mussel was able to recognize predators constituting a real danger (large roach) and respond to them by changing its attachment strength and aggregation activity. The observed defensive reactions of mussels may enhance their resistance to predators in the field, by limiting access to them (aggregation) and increasing handling costs during prey capture (attachment). However, its real effectiveness is yet to be assessed in the future studies.

This study was supported by the Grant of Polish Ministry of Science and Higher Education No. N N304 1530 33.

NOTES

Do Life History Traits Mediate Exotic Species Replacement? A Case Study of Zebra and Quagga Mussels

Lisa A. Jones *and Anthony Ricciardi*
McGill University, Redpath Museum
859 Sherbrooke West, Montreal, QC H3A 2K6 Canada

Few studies have examined the replacement of one exotic species by another, even though such events can generate a new suite of impacts on the recipient community. One example involves two closely related bivalves, the zebra mussel (*Dreissena polymorpha*) and the quagga mussel (*D. bugensis*), which colonized the upper St. Lawrence River during the early 1990s. After nearly a decade of zebra mussel dominance, the quagga mussel has increased in abundance and replaced the zebra mussel as the dominant bivalve at many sites. We examined the patterns and mechanisms of this replacement in the Soulanges Canal, a waterway connected to the St. Lawrence River west of Montreal. Long-term monitoring shows that the quagga mussel has been consistently dominant in the canal for several years and is more abundant in the deeper areas than the zebra mussel ever was. However, the zebra mussel remains more abundant at shallow depths on the canal wall in the zone disturbed by ice scour. We hypothesize that these patterns result from subtle differences in the life history strategies of the two species, with the quagga mussel having more K-selected traits. Classical r-K theory predicts that disturbance favors early colonization and dominance by species with r-selected traits and, as resources diminish, subsequent dominance by species with K-selected traits.

We have simulated disturbance by clearing quadrats within extensive mussel patches at two depths on the canal wall, and we are tracking the re-colonization of these quadrats over a 3-year period. If r-K selection theory applies, zebra mussels should be the first species to colonize disturbed areas; otherwise, the proportion of colonists of either species should reflect their relative densities in the canal. We present the results from the first 2 years of our study, which lend support to the role of life history traits in explaining this species replacement.

NOTES

Distribution and Ecology of Zebra Mussels (*Dreissena polymorpha*) in the Newly Formed Cardiff Bay

***Muriel F. Alix**, Faye L. Merrix and Steve J. Ormerod*
Cardiff University, Catchment Research Group
Biosciences 2 Room 6.14, CF10 3US Cardiff, UK

Cardiff Bay Barrage construction began in 1994 and was completed by 2001 creating a shallow freshwater lake of 200ha fed by the Taff and Ely rivers. Zebra mussels (*Dreissena polymorpha*) invaded the lake between 2001 and 2003. The potential impacts on both the lake infrastructure and the new ecosystem demonstrated the need for research.

The broad aims of this research project are to assess the ecology, distribution, density and biomass of zebra mussels in Cardiff Bay and the effects of the mussels on oxygen dynamics and the zooplankton community.

Results to date show that larval (veliger) density differs with both season and year with reproduction in 2006 and 2007 lasting between June and September. Mean veliger densities of between 1.15 and 2.80 individuals/L were recorded, with temperature possibly triggering reproduction in this temperate lake system. Veliger densities were correlated with temperature and river discharge rate (respectively R^2= 0.34 and R^2=0.32). Spatial distribution patterns differ slightly between veligers and adults implying that settlement and colonisation patterns affect adult densities. Current work to determine the distribution and density of adult zebra mussels includes: quadrate samples, grab samples, side-scan sonar and settlement rates on artificial substrates. A laboratory study is assessing the impact of zebra mussel on oxygen dynamics whilst a mesocosm experiment will assess the effect of zebra mussels on zooplankton community structure.

NOTES

Does Size Matter? A Quantitative Assessment of Human Waterborne Pathogens in Zebra Mussel (*Dreissena polymorpha*) Size Ranges Found in an Irish "at Risk" Lake

Frances E. Lucy, *Michelle Connolly, Monica Sullivan and Hui-Wen Cheng*
Institute of Technology, Sligo, School of Science and Centre for Biomolecular Environmental and Public Health Research
Sligo, Ireland

Thaddeus K. Graczyk and Leena Tamang
Johns Hopkins Center for Water and Health, Johns Hopkins Bloomberg School of Public Health
615 N. Wolfe Street, Baltimore, MD 21205 USA

Lough Arrow, Co. Sligo is a small freshwater limestone lake (12.5 km^2), which has been characterized as 1a (i.e., "at risk") in the impact assessment for the EU water framework directive. This reservoir is utilized for drinking water abstraction but two wastewater treatment plants and livestock farming are also present in this watershed, which are recognised risk factors for the human enteropathogens *Cryptosporidium* and *Giardia*. This study utilises zebra mussels (*Dreissena polymorpha*) and native duck mussels (*Anodonta anatina.*) as biotools to determine the presence and viability of waterborne *Cryptosporidium* species, *Giardia* and human-virulent microsporidia in this lake.

The research introduces a previously untested hypothesis, i.e., is size of zebra mussel important in terms of recovery efficacy of human waterborne pathogens? To address this hypothesis, different size ranges of zebra mussels were analysed from sites throughout Lough Arrow. These included samples from 1) GPS defined transects from point-source pollution influents; 2) drinking water plant intake areas; and 3) potentially pristine control sites?.

Mussels were tested for *Cryptosporidium parvum*, *C. hominis, Giardia lamblia*, and human-virulent microsporidia (i.e., *Encephalitozoon intestinalis*, *E. hellem*, *E. cuniculi*, and *Enterocytozoon bieneusi*), by multiplexed fluorescence *in situ* hybridization (FISH) and PCR.

Assessing the importance of size range in the utilization of zebra mussels as bioindicators is a necessary step in fine-tuning the efficacy of this invasive species which serves as a sentinel organism for pollution and contamination of freshwater environments. As additional monitoring is required for drinking water sources, under the water framework directive, the results of this research provide important scientific data for river basin management.

NOTES

Recent Dramatic Changes in the Offshore Benthic Community of Lake Michigan

Thomas F. Nalepa
NOAA, Great Lakes Environmental Research Laboratory
4840 S State Road, Ann Arbor, MI 48108-9719 USA

Lake-wide surveys were conducted in Lake Michigan in 1994/1995, 2000, and 2005 to determine trends in the native amphipod *Diporeia* spp., and the invasive bivalves *Dreissena polymorpha* (zebra mussel) and *Dreissena bugensis* (quagga mussel). More frequent surveys were conducted in the southern region of the lake between 1980 and 2007. *Diporeia* was once the dominant benthic organism in the lake and served as an important pathway of energy flow from lower to upper trophic levels. Between 1994/1995 and 2005, lake-wide density of *Diporeia* declined from 5,365·m^{-2} to 329·m^{-2}, and biomass declined from 3.9 g DW·m^{-2} to 0.4 g DW·m^{-2}. The percentage of all sites with no *Diporeia* increased over time: 1.1% in 1994/1995, 21.7% in 2000, and 66.9% in 2005. *Diporeia* was rarely found at depths < 90 m in 2005, and continued to decline at depths > 90 m through 2007. On the other hand, total dreissenid density increased from 173·m^{-2} to 8,816·m^{-2}, and total biomass increased from 0.4 to 28.6 g DW·m^{-2} over the 10-year time period. The guagga mussel has replaced the zebra mussel as the dominant dreissenid in the lake, comprising 97.7% of the total population in 2005. As of 2007, quagga mussel densities appeared to have stabilized at depths < 50 m, but continued to increase at depths > 50 m.

With the loss of *Diporeia* and increase in quagga mussels, the benthic community has become a major energy sink rather that a pathway to upper trophic levels. We estimate that the relative benthic energy pool increased from 17 kcal·m^{-2} to 109 kcal·m^{-2} between 1994/1995 and 2005, and to 342 kcal·m^{-2} by 2007. We project that previously observed impacts on fish populations will continue and become more pronounced as the quagga mussel population continues to expand into deeper waters.

NOTES

Recent Dramatic Dreissenid-induced Changes in Offshore Pelagic Food Webs of the Great Lakes: Mechanisms and Global Implications

***Henry A. Vanderploeg**, Steven A. Pothoven, Thomas F. Nalepa, Gary L. Fahnenstiel, James R. Liebig and Joann F. Cavaletto*
NOAA, Great Lakes Environmental Research Laboratory
4840 S State Road, Ann Arbor, MI 48108-9719 USA

There have been large decreases in chlorophyll, zooplankton, and planktonic forage fishes in offshore regions of the Great Lakes in recent years that are likely to have significant impacts to pelagic sport fishes. Of particular note was disappearance of the spring phytoplankton bloom that is important to the whole food web. Potentially negative impacts of zebra mussels on nearshore food webs are well known, including the nearshore phosphorus shunt in which mussel ecosystem engineering leads to nearshore communities dominated by *Cladophora* that retain phosphorus in nearshore regions. As the quagga mussel replaced the zebra mussel and expanded into deeper offshore zones of the Great Lakes, we wondered if quagga populations were high enough in those regions to explain the offshore impacts through their filtering, nutrient excretion, and engineering. We performed experiments to calculate filtering rates of quagga mussels across a broad range of temperatures so we could estimate their filtering impact across seasons. We hypothesized that impacts would be greatest during isothermal seasons (autumn, winter and spring), when the mussels had access to phytoplankton throughout the water column and phytoplankton growth was limited by light owing to vertical mixing. Consistent with these findings, we found mussel filtering impact approached or even exceeded expected phytoplankton growth rates during these seasons. The timing of some of the changes preceded expansion of the quagga mussels into offshore regions suggesting other factors were acting synergistically with mussel expansion. Mussel impacts, whether nearshore or offshore, are strongly affected by site conditions such as substrate, temperature, eutrophy, and food-web structure. The lessons learned in the Great Lakes will be useful for projecting potential impacts of quagga mussels as they spread through the western USA and Europe.

NOTES

Chlorine Minimization for Biofouling Control in Industrial Cooling Water Systems: Comparison of Different Modes of Chlorination

Sanjeevi Rajagopal *and Gerard van der Velde*
Radboud University Nijmegen, Institute for Wetland and Water Research
Heyendaalseweg 135, 6525 AJ Nijmegen, The Netherlands

Vayalam Purath Venugopalan
BARC Facilities, Water and Steam Chemistry Division
Kalpakkam 603 102, India

Henk A. Jenner
KEMA Power Generation and Sustainables
PO Box 9035, 6800 ET Arnhem, The Netherlands

Chlorine is the most commonly used chemical antifoulant in industrial cooling water systems. Chlorination is practiced either in continuous or intermittent modes. The most important criteria deciding the chlorine dosing frequency are type of biofouling control required, cost and environmental discharge specifications. Chlorine acts on the target organism at organ, cellular and subcellular levels, and kills the organism, depending on the dose and contact time. Interestingly, in the case of mussels, the organisms are capable of protecting themselves, to some extent, from the deleterious effects of chlorine by shutting their shells. They have the ability to sustain themselves on anaerobic metabolism for a considerable length of time, often for several days. Rajagopal et al. (37,329-338, 2003) have demonstrated the inadequacy of intermittent chlorination to control fouling mussel species, employing 4 h on 4 h off cycle in their intermittent mode experiments. The present work was carried out using the invasive mussel *Perna viridis* (L.), which was subjected to continuous and inter-mittent (intermittent 1: 28 min on and 28 min off cycle and intermittent II: 4 h on and 4 h off cycle) chlorination at concentrations (as TRO) varying from 1 to 3 mg l^{-1}. Lethal and sublethal responses of the mussels were compared to those of control mussels.

The mussels subjected to continuous chlorination at 1 mg l^{-1} showed 100% mortality after 1074 h, while those subjected to 4 h on and 4 h off intermittent chlorination at 1 mg l^{-1} showed very little (about 4%) or no mortality during the same period. Surprisingly, *P. viridis* subjected to intermittent I chlorination (28 min on and 28 min off) at 1 mg l^{-1} showed 100% mortality after 784 h. In continuous and intermittent I chlorination, oxygen consumption, filtration rate, foot activity index and byssus thread production decreased more than 90% at 1 mg l^{-1} chlorine residual when compared to control. However, mussels subjected to intermittent II chlorination showed only about 3% reduction in oxygen consumption, filtration rate and foot activity index during breaks in chlorination, indicating that mussels try to resume their normal activity during breaks in chlorination. The data show that *P. viridis* fouling can be effectively controlled using intermittent chlorination with 1 to 3 mg l^{-1} chlorine applied at 28 min on and 28 min off cycle. Such carefully timed intermittent dosing can be expected to control biofouling dominated by *P. viridis* more efficiently than continuous chlorination, leading to overall reduction in environmental discharges of chlorine.

NOTES

The Use of Potassium Chloride to Control Zebra Mussels in an Open Body of Water

Dan Butts
ASI Group Ltd.
250 Martindale Road, St. Catharines, ON L2R 7R8 Canada

In August 2002 mussels were observed for the first time in Virginia. Adult mussels were discovered in Millbrook Quarry (Millbrook), a popular recreational diving location, located in Prince William County near Haymarket. Although it is not certain how the mussels were introduced into this isolated water body, it is speculated that human activity was responsible. Regardless of how the mussels were introduced into Millbrook, the Virginia Department of Game and Inland Fisheries (DGIF), in consultation with various federal, state and local agencies determined that the best course of action to deal with the Millbrook mussels is eradication. Although the quarry is ground water fed, and thus is not hydrologically connected to any adjacent waterways or water bodies, its proximity to Broad Run and to two major drinking water reservoirs, Lake Manassas and Occoquan Reservoir, that supply drinking water to over 2 million people and supply raw water to several power supply facilities, indicate that if the infestation were to spread from Millbrook, the impacts would be severe and far reaching.

The DGIF invited multiple firms to submit written proposals for eradication of mussels from Millbrook Quarry located near the Town of Haymarket, County of Prince William and State of Virginia. From information provided in the Request for Proposal (RFP) along with that provided by the DGIF during the pre-proposal meeting and site visit, Aquatic Sciences LP, a subsidiary of ASI Group Ltd. compiled the following summary of requirements, objectives and/or concerns of interested parties and consider them when designing an effective treatment methodology:

- Eradicate (100% mortality) zebra and quagga mussels from Millbrook Quarry
- Residual effect of treatment to control future infestation of mussels in the quarry is desirable
- Sensitivity to surrounding environment (non target aquatic species and organisms toxicity; wildlife and fowl; ground water and surface water quality)
- Long term environmental impacts from treatment
- Sensitivity to the seasonal (April to November) dive operations
- Sensitivity to the property owner and their continued enjoyment of the property
- Site safety and site security
- Post treatment site rehabilitation

Aquatic Sciences proposed that the entire water column of Millbrook Quarry would be infused with potassium by pumping 131,000 kg of muriate of potash (potassium chloride – KCl) solution in to the water body. Evidence suggests that at optimum concentrations potassium kills mussels by interfering with the organisms' ability to transfer oxygen across gill tissue, resulting in asphyxia while not effecting non target organisms. (Aquatic Sciences 1997).

NOTES

Pseudomonas fluorescens Strain CL145A as a Zebra and Quagga Mussel Control Agent

Daniel P. Molloy *and Denise A. Mayer*
New York State Museum, Division of Research and Collections
51 Fish Hatchery Road, Albany, NY 12230 USA

The bacterium *Pseudomonas fluorescens* strain CL145A is a leading candidate for the biological control of zebra and quagga mussels. Cells of this bacterial strain contain a natural byproduct that is lethal to these mussels when ingested. Dead cells are equally as effective against these mussels as live cells, providing clear evidence that the mussels die from a toxin, not from infection. Commercial formulations based on this microbe will contain dead cells, thus further reducing environmental concerns.

Funding to bring this biocontrol agent to commercialization was recently awarded to the biopesticide company Marrone Organic Innovations by the US National Science Foundation. and product availability is targeted for 2010. The progress to date in moving toward this commercialization will be reviewed, including recent advances in mass production through large scale fermentation, efficacy trials, and non-target testing. Using both genetic and biochemical approaches, one of the project's primary goals is identification of the natural product that is selectively lethal to these mussels.

The research focus of this project has long been the control of attached mussels in pipes to reduce the use of the polluting biocides that are currently being used in power plants. Recent trials, however, have indicated that zebra and quagga mussel veligers appear more susceptible than attached life stages (juveniles and adults). The lack of significant non-target impact may allow this green technology to be used for control of these mussels against both planktonic and attached life stages in open waters, such as lakes and rivers.

NOTES

Commercialization of a *Pseudomonas fluorescens* strain for Controlling Zebra and Quagga Mussels

Pamela Marrone, *Marja Koivunen, Keith Pitts, Eunice Tan, Brian Campbell*
Marrone Organic Innovations, Inc.
2121 Second Street, B-107, Davis, CA USA

Marrone Organic Innovations (MOI) discovers, develops, and markets effective and environmentally friendly natural products that fill unmet needs for pest, weed and plant disease management. MOI is the commercial partner with New York State Museum (Dan Molloy and Denise Mayer) for developing and commercializing their bacterium *Pseudomonas fluorescens* strain CL145A that is effective in dead cell form on zebra and quagga mussels. MOI received a $500,000 Phase II STTR National Science Foundation grant to partially assist in development and commercialization activities of this strain. MOI has the responsibility for building on the excellent and extensive work conducted by Molloy's lab to bring this product to the market. To do so, in collaboration with NYSM, the company is developing:

a) unique assays to more quickly detect activity without using live mussels,

b) appropriate formulations to meet different customer needs,

c) fermentation and downstream processes to scale the product to manufacturing scale,

d) characterizing the active natural compounds produced by the bacterium,

e) conducting field trials, and completing the necessary documents for submission to state regulatory agencies and the U.S. Environmental Protection Agency (EPA).

This talk will describe the scientific work conducted at MOI behind the technical processes (a-e) and regulatory steps in the advancement of this microbial to an end product.

NOTES

BioBullets: Effective Control of Zebra and Quagga Mussels in Industrial Settings and the Open Environment

David C. Aldridge
University of Cambridge, Department of Zoology
Downing Street, Cambridge CB2 3EJ UK

BioBullets offer a cheap and environmentally favourable option for the control of biofouling zebra and quagga mussels. The technique uses the encapsulation of active ingredients with an edible coating to by-pass the valve-closing response of mussels typically seen when they are presented with a toxic substance. Moreover, the filtering activity of the mussels concentrates the BioBullets from the water column and the coatings are engineered so that any material not consumed by mussels degrades to harmless concentrations within hours of entering the water column. There is therefore no accumulation of BioBullets in the environment and no impact on non-target organisms adjacent to treated outfalls.

We now have the capacity to manufacture BioBullets at a commercial scale. Our products use materials and concentrations approved for use in European drinking waters. Trials with the UK water industry have proved highly successful and large-scale applications are planned for 2009. Independent trials by KEMA in the Netherlands has reported 100% mortality. Tests with the U.S. Geological Survey indicate that BioBullets can kill zebra mussels but leave native unionid mussels unharmed, presenting an opportunity for open water applications. An independent assessment of current technologies for the control of *Dreissena* in the Canadian power industry recommended BioBullets as the best option for end-of-season control.

NOTES

Application of Citizen Science and Search Theory to Optimally Detect a Species at Low Density: A Case Study of Monitoring the Asian Shore Crab (*Hemigrapsus sanguineus*)

David Delaney *and Brian Leung*
McGill University, Department of Biology and School of Environment
1205 Docteur Penfield Avenue, Montreal, QC H3A 1B1 Canada

Monitoring is an important precursor to effective management of invasive species. Unfortunately, resources for monitoring are typically limited and large spatial gaps will likely continue to exist in the monitoring coverage. False negatives are probably quite common in monitoring, no matter the scale or the sampling approach. For eradication of invasive species to be feasible, detection of the bioinvaders must be accomplished at an early stage, when the population is localized and at a low density. Unfortunately, introduced species often remain undetected or are usually only detected years after the initial colonization, when eradication is no longer an option. We conducted an experiment in rocky intertidal areas of New England and New York to determine how effective different levels of sampling intensity using two sampling techniques, total area search (TAS) and random quadrat sampling, were in detecting different mobile and sessile targets at low densities (i.e., early detection). Using logistic regression we built detection curves for each sampling approach that related the number of searchers and the density of targets to the probability of detection. The TAS approach reduced the probability of false negatives and detected targets faster than the quadrat approach. Mobility of targets increased the time to detection but did not affect detection success. This technique allowed us to estimate the sampling intensity needed for a certain level of effectiveness for each sampling approach. Given high levels of sampling intensity and the right approach, false negatives were infrequent even at sites with low densities of the introduced species. Nevertheless, given real-world limitations (insufficient funding, personnel), we are currently under-prepared for early detection on a large-scale. Volunteer-based monitoring could be a potential solution to this problem by supplementing scarce resources, provided the results of the volunteers are accurate. To increase the available effort we developed a citizen scientist monitoring network to increase our monitoring coverage and conducted a validation study that evaluated the accuracy of approximately 1,000 volunteers to assess the presence of native and invasive crabs within the intertidal zones of seven coastal states of the U.S., from New Jersey to Maine. Citizen scientists, even with limited training, collected data with high levels of accuracy.

NOTES

A Habitat-based Probabilistic Sampling Approach for Invasive Species in a Columbia River Reservoir

***Timothy D. Counihan**, Jill M. Hardiman, Christopher E. Walker and Amy L. Puls*
U.S. Geological Survey, Western Fisheries Research Center, Columbia River Research Laboratory
5501a Cook-Underwood Rd. Cook, WA 98605 USA

Rates of aquatic non-indigenous species introductions and their social, economic, and ecological impacts are increasing. Thus, there is a need for sound survey techniques for early detection and monitoring of invasive species in large systems. Surveys that are probabilistic based are efficient, ensure adequate habitat coverage, are flexible to allow habitat sampling disproportionate to its occurrence, and allow inference to larger geographic areas. All too often sampling for invasive aquatic species in a large area relies on convenience or non-probabilistic sampling. Surveys designed in this fashion are not conducive to making inferences to larger areas comprised of diverse habitats and, unfortunately, can result in a false sense of security when species are not detected. Surveys that fail to adequately cover all potential habitats that could be infested with a particular species are inherently biased.

We will present a pilot habitat based probabilistic sample design for aquatic invasive species in a reservoir on the Columbia River. To accomplish this, we used the results of 2-dimensional hydraulic model simulations and a Geographic Information System (GIS) to develop strata based on water depth and velocity. We designed our survey to include three river zones based on water velocity and two zones based on depth. The three river zones were characterized as lotic, transitional, and lacustrine. The depth zones included pelagic (> 8 meters) and littoral. A GIS was used to overlay a 30 x 30 meter grid across the reservoir. Locations sampled were randomly selected from the representative habitat classes from cells within the reservoir. The sampling crew used a boat and Geographic Positioning System integrated with a GIS computer system to navigate to the center of the selected cells for sampling. We will present distribution data on benthos (*Pacifastacus leniusculus, Corbicula fluminea*, etc.) collected from the reservoir and associations within our habitat strata.

NOTES

Risk-based Surveillance for the Management of Invasive Species

Christopher L. Jerde *and David M. Lodge*
University of Notre Dame, Department of Biological Sciences
PO Box 369, Notre Dame, IN 46556-0368 USA

W. Lindsay Chadderton
The Nature Conservancy
University of Notre Dame, Department of Biological Sciences
PO Box 369, Notre Dame, IN 46556-0368 USA

David C. Finnoff
University of Wyoming, Department of Economics and Finance
Ross Hall 130, 1000 E. University Ave., Laramie, WY 82071 USA

Invasion is a rare event – that is to say, many populations fail to establish, most naturalized species cause no measureable harm, and even the most notorious invaders, such as zebra mussels, infest a small proportion of inland lakes each year. Rarity imposes limitations on the management of biological invasions. Specifically, it will be rarely possible to consistently have predictive accuracy as to which species will invade, when, and where. The diminishing predictive capability caused by rare events has many managerial questions of concern, but here we emphasize one: How do we optimally perform surveillance for new invasions? One key motivation for performing an invasive species risk assessment is to inform resource managers on the most efficient combination of invasive species to look for and where to spend that effort. In addition, these combinations need to be assessed in the light of whether or not interventions exist, such as quarantine or eradication, which can be implemented to slow or prevent spread. It is critical to define those species and circumstances that make management impossible. In these cases, no investments in surveillance would be justifiable. Where management is possible, and under conditions such that occurrence of a target species generally has a very low probability, little differentiation in probability exists between greater and less likely locations; consequently there is little differentiation in recommended surveillance effort. In this situation, priority should be placed on developing surveillance strategies that emphasize efficient coverage – repeatedly evaluate the presence of all species, at all locations, quickly. In contrast, as probability increases, greater spatial differentiation in effort becomes justifiable. We will further consider how recommendations for surveillance strategies differ when the economic risk of invasion (i.e., the product of the probability of an invasion occurring and the cost, ecological or economical, of an invasion occurring) is included in these considerations. Including costs into the allocations of sampling effort provides a risk based surveillance strategy. This requires additional inputs such as damages, surveillance costs, consumer benefits and the distribution of these flows over time. Surveillance is critical for rapid response and active adaptive management of invasive species, and here we demonstrate two approaches to surveillance motivated by the underlying biology of invasions and the economic trade-offs that will guide management.

NOTES

Influence of Pest Population Size at Time of Detection on the Efficacy of Ensuing Management Measures

Oliver Floerl, *Graham J. Inglis and K. Dey*
National Institute of Water And Atmospheric Research
PO Box 8602, Christchurch, New Zealand

Despite attempts to prevent the introduction and spread of marine organisms by human activities, "leaky borders" result in the continual establishment of new populations of non-indigenous species in locations worldwide. Sometimes detection of a species triggers incursion response or longer-term management to prevent or ameliorate the ecological and economic impacts associated with the uncontrolled spread of the species. We here examined how the size of a non-indigenous species' population at the time of its detection affects the efficacy of two response strategies – vector management and attempted eradication of invasive populations – in reducing geographical spread. Using a stochastic epidemiological model, we simulated the establishment, proliferation and human-assisted dispersal (hull fouling on recreational yachts) of a hypothetic invader around the coast of New Zealand over a 10-year period. Our simulations show that failure to detect non-indigenous species that have a high affinity for human vectors before they have attained a large population size (10% of local habitat) may render management futile because spread to other locations is likely to have already occurred. In contrast, if detection and onset of management occurred while the founder population was still small (0.1% of habitat), transportation frequency of the invader to new locations was reduced by 77 – 99%, and the number of new infected locations was reduced by 74 – 78%. Our study suggests that allocation of resources to survey and monitoring programmes designed to detect non-indigenous species shortly after they become established is likely to reduce the costs required for management of invasive populations.

NOTES

New Method to Detect and Identify Invasive Bivalves Using a Continuous Imaging Particle Analyzer (FLOWCAM®)

***Harry Nelson**, Kent A. Peterson and Christian K. Sieracki*
Fluid Imaging Technologies
65 Forest Falls Drive, Yarmouth, ME 04096 USA

Monitoring water systems for the invasive zebra and quagga mussel is an extremely important yet daunting task for the water quality professional. Current methods to detect and measure the abundance of these organisms is extremely time consuming. Interestingly, these two species each have very unique yet similar optical properties that differentiate these organisms from others. The shells of the zebra and quagga mussels are *calcerous,* and when viewed with a cross-polarized light source, reflect the light from the calcite, emitting a unique pattern commonly referred to as the 'Maltese Cross' (a phenomena called *Birefringence*), even when viewed as veligers in their planktonic state.

The imaging particle analyzer — FlowCAM® — has been in use since 2000 by aquatic microbiologists to study plankton and other microorganism in marine and freshwater systems. The instrument utilizes a combination of light sources and filters to rapidly detect and image microscopic organisms and particles in a continuous fluid stream. With an understanding of the natural optical properties of the zebra and quagga mussel, Fluid Imaging Technologies, Inc., manufacturer of the FlowCAM®, has added a cross-polarizing filter set that allows the instrument to detect the natural birefringence of mussel veligers. Once detected, individual veligers possessing this unique characteristic can be detected, imaged, identified and their concentration determined by the instrument. An overview of the technology will be given, along with data from natural samples.

NOTES

The Application of Multiple Gene PCR to Single Cell Diatoms from Fixed Ballast Water Samples

Imke Lang *and Irena Kaczmarska*
CAISN, Mount Allison University, Department of Biology
63B York Street, Sackville, NB E4L 1G7 Canada

The development of polymerase chain reaction (PCR) techniques has been a major step forward in resolving many of the taxonomic ambiguities among biota. But still, for most PCR protocols, required quantities of pure template DNA exceeds the volume of a single cell. Therefore, uncultivable phytoplankton species are excluded from these analyses. In the last decade PCR methods improved and pure DNA for PCR may be obtained from even a single cell of preserved plankton. The focus of those protocols was set on alveolates and some heterokonts, which either have multiple copies of genes and/or accessible DNA due to organic cell walls, leaving organisms such as diatoms virtually unexamined. Orsini et al. (2004), for example, successfully amplified the internal transcribed spacer (ITS) on short chains of *Pseudo-nitzschia* spp, demonstrating that such protocols can also be used on diatoms.

Our purpose was to expand this methodology to single cells of diatoms and therefore available approaches needed to be optimised. The development of single cell PCR protocols from alcohol preserved samples is of advantage, as it would allow to analyse not only current but also archived samples. Here we report on a newly developed protocol for detection of intraspecific variability in ballast-tank populations of diatoms during transoceanic voyages arriving in Canadian ports. Although there are examples of large spatial-scale genetic homogeneity in marine systems, there are also many examples of locally divergent populations. Likewise, in diatoms different genotypes within one species could be observed and it was shown that toxin content of certain harmful algal species varies among different clones. Therefore intraspecific analysis of ballast water samples is not only important for the identification of potentially invasive species, but also for the identification of potentially invasive genotypes.

Combining the PCR parameters from available protocols, we tested and optimised the PCR amplification of multiple genes from a single cell of a diatom isolated from fixed ballast water samples. We chose a multiple gene approach to verify the reproducibility and reliability of each molecular marker. The amplification of two genes was performed in a two-step protocol. Initial PCR was carried out using two sets of external primers to amplify the ITS region (ITS1, 5.8SrDNA and ITS2) and the large subunit of RubisCo (rbcL). In the second step the respective genes were amplified in separate PCR reactions. With this approach we could follow the change in the composition and frequencies of specific genotypes in a 21-day long time series from ballast water tanks during the transoceanic voyages. Once the respective species are identified by barcodes, the ITS 2 region could be used as marker for denaturating gradient gel electrophoresis (DGGE), which would facilitate the rapid identification and quantification of greater number of certain diatom species, that isolation of single cells would not allow.

NOTES

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

LCDR Brian Moore
U.S. Coast Guard, Commandant USCG, Environmental Standards Division
2100 2nd Street SW, Washington, DC 20593 USA

In December of 2004 the U.S. 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, this incentive offered an equivalence determination to qualified ships that had 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- which ever if shorter. This "incentive" to ship owners has been sufficient to generate four applications for enrollment.

The presentation will focus on the evolution of the USCG's program as the applications have been received and reviewed for technical validity and for meeting U.S. environmental protection laws and policies. Successful applicants have engaged other agencies to ensure all required technical as well as safety and environmental protection needs were addressed. In some cases other agencies have been able to provide grant money to treatment technology developers, which has effectively lowered the costs associated with installation of the management systems to the vessel owners. Additional information on the preliminary efficacy research may also be presented as data become available from the shipboard trials and evaluations.

NOTES

Testing and Evaluation of Experimental Shipboard Ballast Water Treatment Systems for STEP: Experience and Lessons Learned

Michael G. Dyer

U.S. Department of Transportation. Volpe National Transportation Systems Center

55 Broadway, Cambridge, MA 02142 USA

The U.S. Coast Guard's Shipboard Technology Evaluation Program (STEP) is a key element of their effort to prevent the introduction of new non-indigenous species (NIS) to US waters via the discharge of ballast water from ships. STEP's purpose is to accelerate the transition of mature and new technologies into the shipboard ballast water treatment (BWT) application and to acquire valid engineering and performance data in this arena for use in the Coast Guard's formulation of policy and ballast water management (BWM) regulations. Ship owners and operators apply to the program through a process requiring the input of BWT system and ship engineering information and a description of the biological performance study plan.

The Volpe Center's STEP Review Panel, consisting of engineers and biologists, supports STEP by acting as the Coast Guard's technical agent in the review of applications, and the monitoring and assessment of shipboard testing. The Panel's technical reports and recommendations support decisions taken by the Coast Guard as the regulatory authority.

The Review Panel and Coast Guard have processed applications from six shipowners and operators. This presentation highlights both the successes and the difficulties seen in the technical elements of these applications, the Coast Guard's efforts to improve the application process, and the results of the shipboard tests to date.

NOTES

The European Union in the Dawn of Ballast Water Management Approaches

Matej David
University of Ljubljana, Faculty of Maritime Studies and Transport
Pot pomorščakov 4, 6320 Portorož, Slovenia

Stephan Gollasch
GoConsult
Grosse Brunenstr. 61, 22763 Hamburg, Germany

Apart from harmful effects such as consequences of shipping disasters, shipping activity exerts other negative influences on the environment due to regular ship operations. One of the most recent waterborne concerns is the translocation of harmful organisms and pathogens via ballast water and sediments inside ballast water tanks. In recent years the severely harmful effects of introduced species on the natural environment, human health and the world's oceans, attracted attention of the scientific and professional public worldwide to the ballast water issue.

The significance of the ballast water issue was already acknowledged in a 1973 International Maritime Organization (IMO) resolution. After almost two decades of intensified research, regulatory and political activities focussed on the prevention of harmful organisms and pathogen transfer around the world, the *International Convention on the Management of Ships' Ballast Water and Sediments* (BWM Convention) was adopted in February 2004 at a diplomatic conference in London. The BWM Convention at the moment of this writing is not yet in force, but represents a solid framework for the introduction of preventive measures from individual countries or joint approaches.

Two ballast water management approaches were developed: (a) ballast water exchange (BWE) and (b) ballast water treatment to meet the IMO D-2 Ballast Water Performance Standard (BWPS). BWE seems the most practical way to minimize species translocations since most ships can do it. However, studies have proven its limited effectiveness. On the other side, despite the global efforts and international conventions, efficient, financially feasible, environmentally friendly and safe methods to minimize the translocation of harmful organisms via ballast water are still developing and the first ballast water treatment systems became recently certified.

By now, many countries around the world seem to be aware of the ballast water issue and its management limitations. In the EU, different approaches have been identified at regional and national levels. First voluntary BWE requirements have been introduced by the HELCOM and OSPAR countries, Adriatic countries have prepared a common approach looking at new legal frameworks, and some national level requirements have also been identified. However, a common EU wide approach is still lacking.

In this paper the authors review the main ballast water management approaches developing in Europe, and the EU response on BWM. The authors further provide recommendations which may be considered when planning to approach the BWM issue in the EU. This contribution focuses on the BWM issue in European Seas in light of the EU Maritime Policy and EU Marine Strategy. The Caspian Sea was also considered.

NOTES

Aquatic Biosecurity: Bug Hunts in an Environment of Uncertainty

Marty R. Deveney
South Australian Research and Development Institute, Aquatic Sciences
P.O. Box 120, Henley Beach SA, 5022, Australia

International systems for managing aquatic animal health are derived from their terrestrial equivalents, but aquatic pathogens and their hosts are less well understood, fewer practical disease control mechanisms exist and aquatic organisms are often farmed in close proximity to economically valuable wild con-specifics. Legal frameworks do not permit control of pathways to disease entry and instead require a focus on control of known pathogens by surveillance and certification. The occurrence of transboundary aquatic diseases, therefore, has a long history and outbreaks are continuing to occur. In contrast, developing international systems for managing pest introductions focus on pathway management and although embryonic, these appear to have a much better chance of working once established. The development of pathway-based controls to prevent aquatic disease spread with translocated livestock and commodities seems unlikely in an environment of increased focus on trade and consolidation of the current management system.

NOTES

The Effect of Temperature on Zebra Mussel (*Dreissena polymorpha*) Densities in Two Oklahoma Reservoirs

Chad J. Boeckman *and Joseph R. Bidwell*
Oklahoma State University, Ecotoxicology and Water Quality Research Laboratory
430 LSW, Stillwater, OK 74078 USA

Zebra mussels were first discovered in Oologah Lake, Oklahoma in June 2003, with veliger densities near 30/L. By June 2006 peak veliger densities had increased to 480/L, with adult densities reaching 40,000m^2. However, by October of that year a significant die-off occurred, resulting in adult mussels no longer visible in the littoral zone, and veliger densities less than 0.5/L. We hypothesize the trigger for this die-off was a combination of temperatures increasing to 30˚C and high zebra mussel densities. Furthermore, record flooding events in 2007 and early 2008 have kept veliger densities below 1/L until July 2008. A study to test the temperature-density hypothesis is currently being conducted at another Oklahoma reservoir that serves as a cooling system for a coal-fired power plant and which has a distinct temperature gradient. Zebra mussel densities, (veligers and adults) as well as growth under the various temperatures are being characterized. During May 2007, zebra mussels colonized concrete panels in the plant discharge channel, however by July they were gone as temperatures increased above 30˚C. Adult mussel densities elsewhere within the lake reached 150,000/m^2. Attempts to assess zebra mussel growth in the discharge channel during this time were unsuccessful as mussels died within 2 weeks of deployment. Zebra mussel growth in other areas of the lake exceeded 0.1mm/day. Peak veliger densities, outside the influence of the thermal plume, have increased from 140 in June 2007 to 580/L in July 2008. Lastly, laboratory-based thermal tolerance experiments are currently underway to determine if druses of zebra mussels may be more susceptible to the effects of high temperatures, as opposed to individuals being exposed alone. We hypothesize water chemistry within the druse will decline, (low dissolved oxygen, high ammonia, high nitrite) and increase the sensitivity of zebra mussels to high temperatures.

NOTES

Laboratory Spawning and Mortality of Quagga Mussel (*Dreissena bugensis*) Embryos and Larvae from the Newly Established Population in the Southwestern United States

Kevin B. Johnson
Florida Institute of Technology, Department of Marine and Environmental Systems
150 W. University Blvd., Melbourne, FL 32901 USA

During the *Quagga and Zebra Mussel Control Strategies Workshop*, hosted in Las Vegas in 2008, an uncontested recommendation emerged that the new southwestern (U.S.) population of *Dreissena bugensis* (quagga mussels) be considered distinct from their source populations with regard to physiological tolerances and reproductive frequencies. They have invaded lakes previously thought uninhabitable and their reproductive patterns appear to be possibly continuous throughout the year. This study provides reproduction details and examines the potential usefulness of the oxidizing biocide Ferrate (Fe VI) in the eradication or control of planktonic embryos and larvae.

Quagga mussels from Skinner Reservoir (California), collected in July 2008, were spawned in a laboratory setting for the purposes of studying early life history and examining the efficacy of lethal agents for use in control or eradication. Adult and larval cultures were maintained at 22 ˚C on a 10:14 light:dark cycle. Adult mussels were induced to spawn by injection of $1x10^{-3}$ M serotonin solution via artificial mussel blood (AMB) into the gonad; 100 individuals were injected, yielding 6 spawning females and 16 males. Males spawned within 1-20 minutes of injection, while females spawned within 10-30 minutes. Individual female fecundity was not measured, but overall egg count was estimated to be > 113K ova, which averages to almost 19K per female. Mean ovum diameter was 69.1 µm (± 0.1, n= 100). Male and female gametes were mixed immediately upon spawning, then washed and allowed to develop for 1-4 hours before the commencement of the first biocide treatments.

D. bugensis embryos (hours old) were divided into 500 ml containers of pondwater at densities of 10 ml^{-1}. Eradication treatments were 1 ppm, 3 ppm, and 5 ppm (by weight) of Ferrate, while controls were the absence of any biocide. All treatments and the control were replicated 4x. All treatments including 1 ppm resulted in 0% survival of embryos across all replicates (i.e., ± 0.0%), while the controls yielded 53.5% survival (± 1.04%).

Individual *D. bugensis* veliger larvae (4 days old) were isolated in fifty-four 3-ml wells, each in 1 ml of natural pondwater. Eradication treatments consisted of 1 ppm and 3 ppm of Ferrate, while controls were the absence of any biocide. The treatments and control were each replicated 18x (i.e., 18 veligers per treatment, each in separate wells). Results were unequivocal: both ferrate concentrations, including 1 ppm, resulted in 0% survival of veliger larvae in all cases (i.e., ± 0.0%), while the controls yielded 100% survival (± 0.0%).

Ferrate has more oxidizing potential than ozone (O_3) and chlorine (Cl_2), and is as effective or more effective at eradicating dreissenid mussels. Within minutes of dilution in water, Ferrate oxidizes and reverts to Fe III or iron-oxide, substances naturally and abundantly present in rivers lakes and streams.

NOTES

When is an Invasive Species Not Invasive? Contrasting Filter-Feeding Mussels in Coastal Ecosystems and Freshwater Lakes

Kevin B. Johnson
Florida Institute of Technology, Department of Marine and Environmental Systems
150 W. University Blvd., Melbourne, FL 32901 USA

Two properties of dreissenids (quagga and zebra mussels) contribute to their reputation as egregious invaders: their propensity for fouling infrastructure and equipment, and their ability to remove microalgae from the water column through filter-feeding, essentially undercutting the natural trophic web. Coastal invasive mussels, such as *Perna viridis* (the Asian green mussel), also occupy space on hard surfaces and filter-feed on phytoplankton. With regard to their filter-feeding trophic effects, however, the impact of *P. viridis* on a coastal ecosystem is potentially lessened by the larger, open nature of a coastal system. A dense population of dreissenids may process, or "turn-over", an entire lake in days to weeks. For example, in Lake Erie dreissenid densities average 20,000 m^{-2} in the littoral region (Pontius et al., 2003) and each individual mussel may clear up to 0.41 L hr^{-1} (Baldwin et al., 2002). Lake Erie has a volume of 484 km^3 (Fuller, Shear & Wittig, editors, Great Lakes Atlas, 1995), a volume that could be cleared by the dreissenid population in a relatively short period of time in contrast to the estimated 2.6 years required for the volume of the Lake to turn over through outflow (Fuller, Shear & Wittig, editors, Great Lakes Atlas, 1995). However, it is not clear whether coastal mussels might fully process a local water mass before it is replaced by the influx of new ocean water from an adjacent region. This study examines the diet and filtration rates of coastal and freshwater mussels in the context of their potential for impacting their respective ecosystems. Volumes, clearance rates, and water mass flux calculations are compared using algebraic models.

The gut contents and filtration rates of *Perna viridis* (the Asian green mussel) were determined by dissecting field-collected mussels, comparing their gut contents to plankton simultaneously collected in nearby tows, and measuring filtration flow speed and microalgal clearance rates in the lab. Mussels and plankton tows were collected in Ponce Inlet in Fall 2007 and Winter 2008. In addition to dietary preferences, this data is allowing an indirect estimation of field clearance rates when coupled with gut digestion time measured in the laboratory.

It is hypothesized that, unlike lake ecosystems, the water volume cleared by invasive mussels in a coastal system will be insignificant compared to coastal advection of ocean water from adjacent regions. Therefore, the invader will not be responsible for native filter-feeders failing to acquire sufficient food. Data currently being collected and analyzed will help to address this hypothesis.

NOTES

Interactions Between Pollution and Parasitism in Zebra Mussels (*Dreissena polymorpha*)

Laëtitia Minguez, *Antoinette Meyer, Jean-Nicolas Beisel and Laure Giambérini*
Université Paul Verlaine – Metz, Laboratoire des Interactions, Ecotoxicologie, Biodiversité, Ecosystèmes (LIEBE)
CNRS UMR 7146, Campus Bridoux, Rue du Général Delestraint, F-57070 Metz, France

Daniel P. Molloy
New York State Museum, Division of Research and Collections
51 Fish Hatchery Road, Cambridge, NY 12816 USA

Throughout their life cycles, aquatic organisms are often exposed to stressors of different nature like extreme temperatures, contaminants, disease, etc. The individual impact of these stress factors on organisms is known but few studies concern their combined effects.

Parasitism modifying the host's physiology is another stressor to consider since all organisms can represent a host for a parasite. In the framework of environmental risk assessment, it is important to determine combined effects of ecosystem pollution and parasitism. In this context different questions arise:

1. Could the diversity of parasites be an indicator of environmental quality?
2. Could parasites modify biological responses of their hosts and interfere with bioindication procedures?

To answer these questions, the zebra mussel (*Dreissena polymorpha*) was chosen as test organism since it can accumulate large amounts of pollutants. More than thirty parasite and symbiont species have been described in *D. polymorpha*. Two sampling sites were selected in North East of France presenting different levels of contamination: Commercy on the Meuse River as reference site and Sierck-les-Bains on the Moselle River as impacted site. About 150 zebra mussels were collected twice a year and studied microscopically for the presence of parasites. According to the parasite species and host gender, experimental groups are formed and tested for biological responses as structural changes of lysosomal system and neutral lipid accumulation, by histochemistry and automated image analysis.

Altogether, eight parasite or symbiont species were found but the two sites differed one to the other in the composition of their parasite communities. Moreover, parasitism in terms of parasite species or infection intensity seemed to be an important factor influencing the physiological responses of mussels face to their environment and could represent a confounding factor in ecotoxicological studies.

NOTES

Stock-recruit Model: An Underused Tool to Manage Aquatic Invasive Fishes

Michael Hoff
US Fish and Wildlife Service, Fisheries Division
Bishop Henry Whipple Federal Building, 1 Federal Drive, Fort Snelling, MN 55111-4056 USA

Factors important in population dynamics of fishes include mortality, growth, immigration/emigration, and recruitment. The stock-recruit model was developed to manage species we love. However, that model can be used to manage invasive species by assessing:

1) at what level adult stock size needs to be reduced in order to control recruitment, and

2) what biotic and abiotic factors can be managed to control recruitment.

Examples of stock-recruit models are provided for ruffe (*Gymnocephalus cernuus*) and rainbow smelt (*Osmerus mordax*) in the Great Lakes, and for bighead carp (*Hypophthalmichthys nobilis*) in the Upper Mississippi River system. Recruitment of those species can be controlled by harvest, and management of predators and river discharge.

NOTES

Population Increment of Native and Alien Fish Species in the Dutch Rivers Rhine and Meuse: Competition and Relations with Environmental Variables

Martijn Dorenbosch *and Gerard van der Velde*
Radboud University Nijmegen, Institute for Wetland and Water Research
Heyendaalseweg 135, 6525 AJ Nijmegen, The Netherlands

The native fish fauna from the Dutch lower Rhine and Meuse rivers greatly declined during the 20th century as a result of habitat destruction, over exploitation and water pollution. However, during the last decades water quality greatly improved, exploitation is strictly regulated and various river habitats and fish migration opportunities have been restored. As a result of this habitat quality improvement, populations of various native fish species increased.

The rivers Rhine and Meuse have also been subject to invasions of alien aquatic species including fish, either as a result of man-made connections with other European river basins, or introductions by ships, aquaculture and aquarium fish trade. Besides the native fish species that benefited from habitat quality improvements, also populations of alien fish species rapidly increased. In contrast to native fish species, these alien species particularly benefited from new habitat types that have been created to regulate rivers (such as groins and basalt river banks). Nowadays, it is therefore very likely that an ongoing competition for space and food exists between native and alien fish species in the Rhine and Meuse rivers.

Recent nature conservation projects along these rivers try to recover natural habitat diversity of floodplains in the Netherlands (such as secondary side channels). It can be hypothesized that these new habitats predominantly encompass habitat requirements of native fish species rather than of alien species. These conservation projects may therefore be an important tool to manage invasions of alien fish species in the Dutch river systems.

Based on long-term monitoring studies from the nineties until 2008, we reconstruct population development of both native and alien fish species in the rivers Rhine and Meuse and compare these with historical data and environmental variables (i.e., water quality data, temperature, hydrology, substrate, migration barriers). We try to answer the following questions:

1) Which native and alien fish species showed a population increment in the Rhine and Meuse rivers?
2) Can population increment of these species be related to environmental variables such as water quality, hydrology, water temperature, substrate type, and fish migration opportunities?
3) Are there taxonomic related native and alien species that compete each other for space and food?
4) What is the function of new aquatic river habitats that are created by recent nature recovery projects in relation to native and alien fish species?

NOTES

Some Life-history Patterns of Non-native Monkey Goby *Neogobius fluviatilis* (Pallas, 1814) from the River Ipel' (Slovakia)

Mária Čápová-Plachá *and Vladimír Kováč*
Comenius University, Department of Ecology
Mlynská dolina 842 15 Bratislava, Slovakia

Mária Balážová
Catholic University, Department of Biology and Ecology
Námestie A. Hlinku 56/1, 034 01, Ružomberok, Slovakia

Ponto-Caspian gobies represent typical examples of fast and successful invasions of aquatic organisms from their native area into new regions and environments. Over the last decade of 20th century, four species (bighead, monkey, racer and round goby) have invaded the middle and upper sections of the River Danube and its tributaries, and some of them (round goby, as well as tubenose goby) also invaded the Great Lakes in North America.

Monkey goby, *Neogobius fluviatilis*, was first time observed in Slovakia in 2001 (at the mouth of the river Hron, a tributary of the Danube). However, in contrast to bighead and round goby, monkey goby spreads rather slowly and locally. An effective tool for understanding biological invasions is the evaluation of various biological traits (morphological, life history, ontogenetic) within an epigenetic context. In our previous study, monkey goby were found to reach their definite phenotype very early in their ontogeny and thus represent a strongly precocial (specialized) species with direct development. The morphological analysis on 102 specimens from the River Hron (Slovakia) also revealed their strong specialization for sandy substrata and smaller prey types.

One of the typical attributes of successful invaders is their life-history plasticity. Such plasticity is often closely associated with growth and sexual maturity, which is influenced in fishes by environmental (local) and geographical (regional) factors. Therefore, age and growth of 165 monkey goby specimens from the River Ipel' (a tributary of the Danube, Slovakia) was also examined. The standard length of the specimens ranged from 33.44 to 123.16 mm. The population of monkey goby from the River Ipel' appears to be composed from individuals of the age groups 0 + to 5+, though the age group 3+ predominated (n = 73). The patterns of age and growth of this population are further discussed and compared with both the native populations of monkey goby and the invasive Danubian populations of two other goby species (round and bighead).

In conclusion, our preliminary results suggest that monkey goby are more specialized than both round and bighead gobies, and therefore not expected to spread to new areas as fast as these two extremely successful invaders. In other words, the distribution of monkey goby is likely to be limited to sandy and/or sandy-gravel substrata. If this assumption is correct, then the potential adverse impact of monkey goby on native fauna or even ecosystem is likely to be less than that of the bighead and round gobies.

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NOTES

Observations of the Ecology of the Goby *Rhinogobius brunneus*, a Recent Introduction to the Columbia River

***Christopher Walker**, Tim Counihan, Amy Puls and Jill Hardiman*
U.S. Geological Survey, Western Fisheries Research Center
5501-A Cook-Underwood Road, Cook, WA 98605 USA

In 2004, a non-native goby *Rhinogobius brunneus* was discovered in the East Fork Lewis River, a tributary of the Columbia River in Washington, USA. This constituted the first documentation of the occurrence of this species in North America. Thereafter, they were collected at other locations in the lower Columbia River Basin. Information regarding the ecology and biology of *R. brunneus* comes from observation in their native range. Currently, little is known about how this species will affect native fish species, particularly ESA listed salmonids, in the Columbia River Basin. Our objectives were to develop capture techniques and to collect samples that could be used to assess abundance, diet, population structure, sex ratios, distribution, and taxonomic verification from genetic analyses.

Our primary study site is located at the La Center Bottoms wetlands that are connected to the E. Fork Lewis River. During 2007, this wetland was reconnected to the E. Fork Lewis River by the excavation of a channel, which created 400 acres of floodplain wetlands and restored the historic floodplain. The wetland is tidally influenced and floods seasonally. We sampled fish assemblages as well as physical and chemical parameters from April through July, 2008. Fish assemblages were sampled using a fyke net or dip nets and enumerated. *R. brunneus* were measured for length and weight and preserved in ethanol. Water quality parameters such as pH, dissolved oxygen, and conductivity were measured. Temperature and water levels were measured continuously using data loggers.

During our sampling at the La Center Bottoms wetlands, water temperatures fluctuated between 6.5˚C to 22.8˚C. Water temperatures were similar during April and May averaging 11.1˚C. Water temperatures increased to an average monthly temperature of 14.0˚C for the month of June further increasing to 19.7˚C for the month of July. Fyke net catches of *R. brunneus* peaked in late April to early May. Thereafter, spring runoff significantly elevated water levels. After elevated water levels subsided, catches in the fyke net were low. However, goby were observed congregating off a rocky shoreline. We captured specimens in this area using dip nets. We captured 31 *R. brunneus* with a fyke net and 13 additional specimens using dip nets. Fish length ranged from 26 to 69 mm and weighed 0.2 to 2.8 g. Sampling and analyses are ongoing.

NOTES

Binational Aquatic Invasive Species Rapid Response Policy Framework – An Update on International Joint Commission Activities

Mark J. Burrows
International Joint Commission, Great Lakes Regional Office
100 Ouellette Avenue, Windsor, ON N9A 6T3 Canada

Organisms, such as the sea lamprey, zebra mussel, ruffe, round goby and many others, have caused significant economic damage worldwide and have led to severe changes in aquatic food webs and the environment of receiving waters. Considerable resources have been expended in North America and internationally responding to the environmental and economic impact of aquatic invasive species (AIS).

Both Canada and the United States have put in place a number of initiatives at federal, provincial, state and local levels to prevent or slow introductions of aquatic invasive species in our waters. However, the task is complex considering the host of pathways available for aquatic invasive species to invade. Measures to prevent new introductions of aquatic invasive species are still being developed in both countries, thus it is likely to be many years before the threat is fully contained and vectors are effectively addressed. In addition to efforts to eliminate introductions of new aquatic invasive species, it is prudent to have contingency plans and rapid response strategies to address those species that do manage to invade. Strategies may include eradication, containment, or control.

The reality is that the Great Lakes are shared waters and any contingency plan in one jurisdiction may not be feasible to implement in another. The discovery of ruffe in Duluth Harbour is a case in point. Ruffe, an invader introduced through ballast water discharge, were first observed in Duluth Harbour in 1987. Many believed ruffe were at first localized such that the species could be eradicated or contained with a chemical treatment. The decision making process was cumbersome and slow to the point that ruffe spread before a final agreement over a proper response could be developed, rendering rapid response a moot point. The International Joint Commission (IJC) work group examined lessons learned from that experience and others, along with the roles and responsibilities of potential responders at all levels of government to create a binational rapid response framework. This framework or protocol will support the timely development of effective regional AIS rapid response plans that may be implemented in our shared waters.

It identifies the range of rapid response options, the level of success of past or current rapid response activities, current regional rapid response activities and the legal and regulatory actions that must occur prior to the implementation of any rapid response plan. The study focused on trans boundary waters in the Great Lakes region including the upper St. Lawrence River (i.e. freshwater sections), all the federal, state, provincial, municipal and aboriginal/tribal agencies therein, and non government organizations and stakeholder groups that might be positively or negatively impacted by efforts to affect rapid response initiatives. The goal is to provide policy makers with as much information as possible so that rapid response plans can be developed and "pre-approved" prior to an invasion. This work provides the IJC and appropriate binational agencies with strategic and specific policy direction that can be used to facilitate the development and implementation of binational rapid response plans.

NOTES

Rapid Detection of Invasive Species in Ballast Water Using Molecular Methods

Andrew R. Mahon, *Matthew A. Barnes, David M. Lodge, Carsten A. Nowak and Jeffrey L. Feder*
University of Notre Dame, Center for Aquatic Conservation
PO Box 369, Notre Dame, IN 46556 USA

Satyajyoti Senapati and Hsueh-Chia Chang
University of Notre Dame, Department of Chemical and Biomolecular Engineering
PO Box 369, Notre Dame, IN 46556 USA

John Darling and Eric Pilgrim
U.S. Environmental Protection Agency, National Exposure Research Laboratory
27 West Martin Luther King Boulevard, Cincinnati, OH 45268 USA

Invasive species have inflicted high levels of environmental and economic damage to the North American Great Lakes region. During recent decades, approximately 70% of Great Lakes invasives were introduced through transoceanic shipping. One vector for species introduction is ships' ballast water. Because treatment systems for ballast water have yet to be implemented, real-time monitoring of the biological contents of ballast tanks could inform decisions about ship movements and ballasting practices. We are currently developing a portable real-time genetic probe for the detection of target invasive species in ships' ballast. By combining modern molecular methods with microfluidic chip-based technologies, ballast samples can potentially be rapidly screened for multiple target organisms, thus allowing informed decisions about the risk of invasions to be made *en route*. Target species for our work to date include the green crab (*Carcinus maenas*), the golden mussel (*Limnoperna fortunei*), the zebra mussel (*Dreissena polymorpha*), the quagga mussel (*Dreissena bugensis*) and the Chinese mitten crab (*Eriocheir sinensis*). These species, excluding the green crab, have either already invaded the Great Lakes watershed or have been identified as potentially threatening to the region. In order to rapidly detect these species in ballast water samples, we have optimized our system by designing species specific PCR primers for each and asymmetrically amplifying a fragment of the cytochrome oxidase c subunit I (COI) gene for detection in our novel microfluidic chip-based system. We also have begun to analyze both artificial and real ballast samples for presence or absence of the target organisms. The results of our work show that we can rapidly and accurately detect target invasive species in samples of ships' ballast. Additionally, our results are compared with results of quantitative PCR (qPCR) surveys of ballast water samples for accuracy of detection, sensitivity limits, and speed of analysis. These data support further analyses of the system and continued development of a portable real-time detection system that could be used on board a ship during transport, prior to discharging ballast.

NOTES

Development of a Standardized PCR Method for Dreissenid Mussel Monitoring

Kevin L. Kelly
US Department of Interior, Bureau of Reclamation
PO Box 25007, 86-68220, Denver, CO 80225 USA

***John S. Wood** and Janet K. Epp*
Pisces Molecular, LLC
2200 Central Avenue, Suite F, Boulder, CO 80301 USA

Sensitive and accurate methods for detection of Dreissenid mussels, have become increasingly important with the recent discoveries of *Dreissena polymorpha* (zebra mussel) and *Dreissena rostiformis bugensis* (quagga mussels) in reservoirs in the western USA. Early detection of the presence of Dreissenid mussels or their veliger larval forms will allow implementation of measures for the protection of water delivery systems and the environment in a timely manner, and assist in preventing the spread of the mussels to other, neighboring water bodies.

Previous detection methods have relied on visual examination of artificial substrates for the presence of adult mussels or microscopic examination of plankton tow net samples to locate veligers. Both of these methods have significant limitations: Detection of adult mussels on small artificial substrate requires long-term incubation and monitoring of the substrates in the water body, and if present, may indicate that a dreissenid population is already established in the water body. Due to the limited number of morphological characteristics available for scoring, and the large volume of particulate matter frequently found in plankton tow net samples, detection of larval veliger forms is tedious and subject to ambiguous results.

Our research has focused on developing a standardized sampling and PCR-based procedures for detecting, and identifying to the species level, dreissenid veligers. In contrast to other PCR protocols developed for dreissenids, we have focused on the Internal Transcribed Spacer (ITS) regions of the ribosomal DNA locus. We have sequenced the ITS1 and ITS2 regions from *D. polymorpha, D. r. bugeni*s, *D. stankovici , and Mytilopsis leucophaeata*, as well as a number of other native and non-native North American mussel species. Using these sequences we have designed & optimized PCR protocols specific for *D. polymorpha* or *D. r. bugensis*, which can be used as diagnostic assays for the presence or absence of zebra or quagga mussel DNA in a sample. Additionally, we have designed a multiplex quantitative PCR assay that can determine the number of target sequence molecules of both *D. polymorpha* and *D. r. bugensis* in a single reaction. This assay can be used for quantifying the number of veligers in a given volume of water, or across a temporally collected series of samples. Finally, we have developed improved protocols for extracting and purifying DNA from tow net samples that significantly increase the detection sensitivity of the entire procedure..

NOTES

Aquatic Invasive Species Monitoring in Alaska

Tammy Davis
Alaska Department of Fish and Game
PO Box 115525, Juneau, AK 99811 USA

Dan Gilson and ***Lisa Ka'aihue***
Prince William Sound Regional Citizens' Advisory Council
3709 Spenard Road, Suite 100, Anchorage, AK 99503 USA

Ingrid Harrald
Kachemak Bay Research Reserve
95 Sterling Highway, Suite 2, Homer, AK 99603 USA

Linda Shaw
National Oceanic and Atmospheric Administration, NMFS Alaska Region
PO Box 21668, 709 West 9th Street, Juneau, AK 99802 USA

Despite many challenges, regulators, scientists, educators and citizens have come together in Alaska to initiate, maintain and expand aquatic invasive species monitoring programs.

Alaskans rely on approximately 44,000 miles of sparsely populated coastlines for seafood and coastal resources. These resources represent limitless economic and cultural value.

It has become a priority for Alaskans to work together to leverage the funding and resources to bring about invasive species monitoring in our state. Traditionally, federal funds have been made available for management of existing invasions. However, a network of interested parties has joined forces to focus on the prevention of new introductions. This joint effort is using its resources and energy to monitor for species in areas in Alaska. In order to succeed in sustaining our existing pristine environments and to remain proactive in their safe keeping, it will be necessary for Alaskans to pool their resources. In recent years, successful partnerships have developed between government agencies and other Alaska stakeholders. These partnerships have enhanced monitoring efforts and have initiated new goals for monitoring/early detection research and education.

One of the ways we educate the public is through hands on involvement. This is the best way for people to learn how to protect their coastal communities from invasive species. There is a common myth that Alaska is too cold or isolated for harmful invasive species to become established. However, climate change and the proximity of Alaska to significant air and water trade routes, proves this is simply not true. For example, research performed by the Smithsonian Environmental Research Center suggests that the European green crab could easily take hold in coastal Alaska waters. Although not here yet, the green crab has successfully migrated up the West Coast of the United States into Canada since it was first detected in San Francisco Bay in 1989. Through our continued efforts, school children and members of coastal communities are provided information and tools to become actively involved in learning about their environment and fighting complacency when it comes to aquatic invasive species.

In this presentation, we will present a successful model for cooperation amongst diverse groups with the same goal: protecting Alaska's natural resources and marine environments from harmful invasive species. We will also discuss planning for future projects such as rapid response plans.

NOTES

Determining the Viability of Organisms in Size Classes Defined by the IMO Convention and the U.S. Environmental Technology Verification Program

Lisa A. Drake, *Stephanie H. Robbins and Scott C. Riley*
Science Applications International Corporation
c/o Naval Research Laboratory
Code 6136, PO Box 1739, Key West, FL 33041-1739 USA

Mia K. Steinberg and Edward J. Lemieux
Naval Research Laboratory
Code 6136, PO Box 1739, Key West, FL 33041-1739 USA

Requirements pertaining to the viability of organisms are found in proposed ballast water management standards at international and national levels: in the IMO's International Convention for the Control and Management of Ships' Ballast Water and Sediments as well as the Draft Protocol for the Verification of Ballast Water Treatment Technologies, which was developed by the U.S. Environmental Protection Agency's Environmental Technology Verification Program. Among the proposed standards are limits on the density of viable organisms discharged in ballast water from two size classes: > 10 µm and < 50 µm in minimum dimension and $\geq$ 50 µm in minimum dimension.

From a functional standpoint, organisms in the first size class generally represent phytoplankton (autotrophic protists or cyanobacteria), and organisms in the latter size class generally represent zooplankton (heterotrophic, multicellular organisms). In practice, however, each size class contains representatives from both functional groups, rendering the determination of viability in samples more complicated than in samples composed of only one functional group.

The ideal method to determine number and viability of organisms in both size classes would allow a relatively large volume of water to be sampled, would be relatively quick and straightforward to perform, and would unambiguously identify all viable cells and organisms. We are investigating a microscopy-based approach to this problem. Given that many vital stains are not taken up by all organisms within a functional group, let alone organisms spanning two functional groups, it seems prudent to use multiple approaches. We will discuss our results using vital stains and chlorophyll *a* autofluorescence to determine viability of ambient organisms collected from subtropical waters and from organisms sequestered in ballast water tanks.

NOTES

Validation of Biological Methods for Full-scale Treatment Testing

Scott C. Riley, *Stephanie H. Robbins and Luke E. Davis*
Science Applications International Corporation
c/o Naval Research Laboratory
Code 6136, PO Box 1739, Key West, FL 33040 USA
Jon F. Grant
Battenkill Technologies Inc.
3429 Richville Road, Suite C, Manchester Center, VT 05255 USA
Edward J. Lemieux
Naval Research Laboratory
Code 6136, PO Box 1739, Key West, FL 33040 USA
Wayne B. Hyland
Azimuth Technical Consultants
c/o Naval Research Laboratory
Code 6136, PO Box 1739, Key West, FL 33040 USA

The Environmental Protection Agency's Environmental Testing Verification (ETV) developed the ETV protocol, which provides experimental guidelines for the testing of Ballast Water Treatment (BWT) equipment. The Naval Research Laboratory in Key West, Florida, under sponsorship of the United States Coast Guard, has constructed a full-scale Ballast Water Treatment Test Facility to perform verification testing according to the ETV protocol.

Since the summer and fall of 2006, instrumentation was added to the test facility, and modifications were made to the biological procedures to implement the requirements of the ETV criteria. To ensure continued biological rigor by limiting organism mortality, decreasing variability of biological measurements, and acquiring representative organic and inorganic samples, validation tests were conducted on the newly added instrumentation and modified analytical procedures. The validation experiments were conducted prior to full-scale BWT equipment verification testing. The validation tests consisted of 1) quantifying the effects of pneumatic diaphragm pumps on the mortality of test organisms (here, the crustacean *Artemia franciscana*), 2) examining the effects of the treatment agent, chlorine, on the phytoplankton cell labeling by a fluorescent stain, SYTOX® Green, and 3) comparing CO_2 and low-acidity vinegar as de-mobilization agents of motile phytoplankton (de-mobilization is necessary to generate representative measurements).

The results of the pneumatic diaphragm pump validation test indicated no mortality loss of *A. franciscana.* Likewise, the chlorine did not inhibit the labeling of phytoplankton cells by the dead stain SYTOX® Green. Surprisingly, it was determined that using low acidity vinegar as a demobilization agent drastically decreased variability when performing phytoplankton analyses on a Sedgewick Rafter slide. The CO_2 treatment, in contrast, caused cell displacement due to bubbles being produced and trapped within the slide chamber of the Sedgewick Rafter.

NOTES

Pilot Environmental Technology Verification (ETV) Test Report of the Severn Trent DeNora BalPure™ Ballast Water Treatment System

Jonathan Grant
Battenkill Technologies Inc.
3429 Richville Road, Suite C, Manchester Center, VT 05255 USA

Edward J. Lemieux
Naval Research Laboratory
Code 6136, PO Box 1739, Key West, FL 33040 USA

Timothy Wier
Science and Engineering Technologies, Inc.
c/o Naval Research Laboratory
Code 6136, PO Box 1739, Key West, FL 33040 USA

Stephanie Robbins, Scott Riley and Luke Davis
Science Applications International Corporation
c/o Naval Research Laboratory
Code 6136, PO Box 1739, Key West, FL 33040 USA

Wayne Hyland and Bob Brown
Azimuth Technical Consultants
c/o Naval Research Laboratory
Code 6136, PO Box 1739, Key West, FL 33040 USA

Richard A. Everett
U.S. Coast Guard, Environmental Standards Division (CG-5224)
2100 2nd Street SW, Washington, DC 20593 USA

The first test of a ballast water treatment system in accordance with the Environmental Protection Agency's Environmental Technology Verification (ETV) Program Generic Protocol for the Verification of Ballast Water Treatment Technologies is reported. This document presents the technical data and results regarding the performance of the Severn Trent DeNora BalPure™ ballast water treatment system as conducted with the ETV Draft Protocol completed at the Naval Research Laboratory's Marine Corrosion Facility in Key West, FL (NRLKW) between October 2006 and February 2007. The objective of this testing was to evaluate both the engineering/operational and biological performance of the BalPure™ system. Biological performance was assessed through four test cycles using marine conditions and a determination of ambient organism concentrations in treated discharges and overall mortality of surrogate and ambient populations. Concurrently, additional test cycles were conducted for a total treated volume of 100,000 gallons to assess lifecycle engineering properties.

NOTES

Concentrating High Densities of Ambient Plankton for Use in Ballast Water Treatment Testing

Mia Steinberg *and Edward J. Lemieux*
Naval Research Laboratory
Code 6136, PO Box 1739, Key West, FL 33040 USA

Scott Riley
Science Applications International Corporation
c/o Naval Research Laboratory
Code 6136, PO Box 1739, Key West, FL 33040 USA

In 2004, the International Maritime Organization (IMO) adopted an international convention for the control and management of ships' ballast water. Among other things, this convention set standards for the performance of ballast water treatment and management systems. As part of the United States Environmental Protection Agency's Environmental Technology Verification (ETV) program, the Naval Research Laboratory in Key West, in partnership with the US Coast Guard, has created a Ballast Water Treatment Test Facility (BWTTF) for the purpose of evaluating ballast water treatment systems.

The ETV Protocol for evaluating ballast water management systems sets biological and physical conditions for the "challenge water," which is then treated by the system in question. These criteria include minimum organism concentrations and organism diversity broken down by size class: >50 µm and 10-50 µm. In addition, ambient species must comprise at least 75% of the total organisms in the challenge water. This latter requirement poses a problem at the BWTTF in Key West, Florida, where the surrounding waters are classified as oligotrophic.

Here we present a method to concentrate ambient plankton >50 µm using an *in situ* mesocosm. To meet ETV challenge water criteria, plankton in this size class must be injected into the experiment with a final concentration of at least 100 organisms l^{-1}. Our goal is to concentrate an adequate number of plankton for use in the ballast water treatment tests while also maintaining maximum viability and health of the organisms.

Initial plankton sampling shows mean summer densities of 108 organisms l^{-1}; however we must factor in potential mortality due to handling and/or injection into the system. Planning for a concentration of 200 organisms l^{-1}, we estimate 3 h of concentration will be necessary given the specifications of the pump on site. Another matter we address is accurately estimating the abundance of rare species in the concentrated plankton. This aspect is important, as ETV requirements dictate at least five species spanning at least three phyla be represented in the ambient size class.

NOTES

Overview of the Naval Research Laboratory's Phytoplankton Enumeration Experiment Workshop

Bruce N. Nelson
Battenkill Technologies Inc.
3429 Richville Road, Suite C, Manchester Center, VT 05255 USA

Scott Riley
Science Applications International Corporation
c/o Naval Research Laboratory
Code 6136, PO Box 1739, Key West, FL 33041-1739 USA

Tim Weir
Science and Engineering Technologies, Inc.
c/o Naval Research Laboratory
Code 6136, PO Box 1739, Key West, FL 33041-1739 USA

Edward J. Lemieux
Naval Research Laboratory
Code 6136, PO Box 1739, Key West, FL 33040 USA

J. Penny Herring
U.S. Coast Guard, Research & Development Center
1 Chelsea Place, New London, CT 06320 USA

Standardized testing of Ballast Water Treatment Equipment necessitates the complete characterization of the challenge water used to evaluate the efficacy of the equipment. Characterization of basic water quality parameters such as pH, total dissolved solids, salinity and other parameters will validate compliance with water chemistry parameters that are called out in the standardized test protocols. To document biological treatment performance, concentrations and viability of both indigenous (ambient) and surrogate (challenge) phytoplankton and zooplankton must be determined before and after treatment. In support of these types of tests, the enumeration and viability classification of phytoplankton has proven to be particularly difficult. This is primarily a result of the very low number of viable cells that should remain in successfully treated ballast water samples.

To evaluate the efficacy of various methods for enumerating and classifying phytoplankton, the Naval Research Laboratory and US Coast Guard sponsored a Phytoplankton Enumeration Experiment Workshop. The workshop was conducted at the Naval Research Laboratory Key West from January 6 to January 16, 2008. This workshop brought together groups from the Woods Hole Oceanographic Institute (sample concentration through filtration, vital stains and manual microscopy), the Moss Landing Marine Laboratory (flow cytometry with vital stains), the Naval Research Laboratory (vital stains and manual microscopy) and a Naval Research Laboratory/Fluid Imaging Technologies Team (vital stains and FlowCAM®). During the course of the workshop, each of these groups evaluated a variety of relatively complex test samples that contained varying concentrations of live and dead phytoplankton.

The presentation will first provide a description of the methods that were used to prepare the samples that were evaluated by each of the workshop participants. This will be followed by a brief description of the various technologies that each group employed as well as a description of the methods that were used to process the data and to generate enumeration and classification results. Comparisons of each of the group's measurements will next be presented for the seven workshop test samples. These comparisons clearly show that there was significant consistency across all of the methods that were used to enumerate and classify the phytoplankton in the test samples. The paper will conclude with a summary of the workshop's conclusions on the efficacy of the various methods for enumerating and determining the viability of phytoplankton cells in complex ballast water test samples.

Determination of Accuracy and Precision in Plankton Enumeration Methods in Ballast Water Treatment System Testing

Stephanie Robbins and Scott Riley
Science Applications International Corporation
c/o Naval Research Laboratory
Code 6136, PO Box 1739, Key West, FL 33041-1739 USA

***Edward J. Lemieux** and Sophia Ratcliff*
Naval Research Laboratory
Code 6136, PO Box 1739, Key West, FL 33040 USA

J. Penny Herring
U.S. Coast Guard, Research & Development Center
1 Chelsea Place, New London, CT 06320 USA

Determining how to effectively sample sparse populations remains a challenge in ballast water testing. At the Naval Research Laboratory in Key West, Florida, in an effort to quantify variability in counting planktonic organisms, a series of experiments that eliminated as much variability as possible was conducted. Suitably sized microbeads—to represent various densities of phytoplankton and zooplankton—were added to artificial seawater. Concentrations were based on the U.S. Environmental Protection Agency's Environmental Test Verification protocol, the International Martime Organization standards and guidelines as well as proposed domestic legislation, all of which involve sparse populations. Ten μm-diameter beads in densities of 1, 5, 10, 50, 100, 500 and 1000 beads mL^{-1} were used to represent phytoplankton, while 150 μm-diameter beads in densities of 10, 30, 60, 100, 200, 300 and 600 beads in 500 mLs of seawater represented zooplankton.

The bead densities were created in flasks to represent different sample volumes exposed to varying levels of concentration prior to final analysis. The accuracy and precision of the collection and processing combinations were evaluated along with observer bias. For phytoplankton analysis, polymer, microsphere beads were subsampled in 1-mL increments, placed on a Sedgwick-Rafter slide, and viewed using a stereomicroscope at 20X magnification. For zooplankton analysis, colored, polymer microshere beads were subsampled in 1 mL volumes, placed into multiwell plates, and viewed using a stereo-dissection scope.

The results showed that for phytoplankton beads, the concentrations of 50, 100 and 1000 beads ml^{-1} did not have significantly different precision, and all had coefficients of variation that fell below an acceptable benchmark of 20%. Accuracy, in terms of the variability between the observed and expected counts, stabilized at 4 mLs of subsample analyzed.

The zooplankton concentration of 600 beads per 0.5 liters was also below the 20% benchmark for precision, while the 10, 30, 60 and 100 concentrations showed poor precision (CV > 20%). Analysis of the 200 and 300 bead concentrations will be completed to provide precision and accuracy measurements between the 100 and 600 bead range. In both experiments, no significant differences between observers' counts were found.

NOTES

Computation Fluid Dynamics Characterization of Inline Sampling for Ballast Water Discharges

Edward J. Lemieux
Naval Research Laboratory
Code 6136, PO Box 1739, Key West, FL 33040 USA

Jonathan Grant
Battenkill Technologies Inc.
3429 Richville Road, Suite C, Manchester Center, VT 05255 USA

Roy Richards
Science Applications International Corporation
c/o Naval Research Laboratory
Code 6136, PO Box 1739, Key West, FL 33040 USA

Analytical methods and computational fluid dynamics are used to describe flow conditions encountered at Naval Research Laboratory's Ballast Water Treatment Test Facility. Design tradeoffs are examined in the engineering of sample ports for the collection of biological organisms in water samples, and criteria provided for sample port installation in shipboard piping systems. Results of this work show the ideal geometry for biological sampling is from the centerline of a straight vertical, upward flowing pipe with a sample port diameter between 1.5 and 2.0 the basic isokinetic diameter as defined in this report. Sample ports should use ball valves for isolation purposes, and diaphragm or venturi valves for flow control, should be located as close to the overboard outlet as possible, and positioned as far from upstream obstructions and fittings as possible. On the basis of the presented data, guidelines are recommended for the design, positioning and operation of shipboard sampling ports.

NOTES

Effect of Invasive Bivalves *Dreissena polymorpha* and *Limnoperna fortunei* on Benthic Communities

Lyubov E. Burlakova *and Alexander Y. Karatayev*
Buffalo State College, Great Lakes Center
261 Science Building, 1300 Elmwood Ave., Buffalo, NY 14222 USA

Vadim A. Karatayev
City Honors School
186 East North Street, Buffalo, NY 14204 USA

Invasive bivalve zebra mussel, *Dreissena polymorpha*, is known as an ecosystem engineer, capable of altering the structure and function of freshwater ecosystems. Another recent invader in South America, mytilid *Limnoperna fortunei* may have a similar effect on aquatic ecosystems. To compare the effect of both species on benthic community, we studied density, biomass and taxonomic structure of zoobenthos within mussel aggregations (druses) formed on different sediment types, and in the sediments near druses, in North America, Europe and South America. We found that the effect of both species on benthic communities was similar. Density, biomass and species richness of macroinvertebrates associated with druses was 2-6 times higher than in sediments without mussels. Both bivalves made significant changes in benthic community structure in druses compared to those in adjacent sediments. Taxonomic structure of macroinvertebrates' community within druses was significantly different from those in sediments near druses. Most taxonomic groups (e.g., Chironomidae, Trichoptera, Ephemeroptera, Isopoda, Amphipoda, Hirudinea, etc.) were 3-13 times more abundant in druses, while Bivalvia and Oligochaeta were more abundant outside druses. Regardless of the type of sediment where druses were formed, benthic community within druses (excluding mussel) was always remarkably similar and dominated by amphipods, leaches, midges, and mayflies. In contrast, the density of zoobenthos and dominant species in bare sediments differed significantly depending on the substrate type. The trophic structure of druse communities was also significantly different from those formed on sediments near druses. All functional feeding groups, increased their biomass in druses from 3 to over 1000 times when we included mussels into the analysis. The benthic structure of druse communities (including invasive mussels) became dominated by one trophic group – filterers (99% of the total biomass), and therefore the filtration efficiency of the benthic community and its ability to effect benthic-pelagic coupling dramatically increases. By forming druses on various substrates, both *D. polymorpha* and *L. fortunei* create new multi-dimensional habitat colonized by invertebrates that are generally uncommon in fine sediments, increasing the local biodiversity and heterogeneity of benthic communities.

NOTES

Effects of the Presence and Density of Conspecifics on Settling Juveniles of the Invasive Bivalve *Limnoperna fortunei*

Paula Sardiña
Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)
and Museo Argentino de Ciencias Naturales "Bernardino Rivadavia"
Av. Angel Gallardo 470, C1405DJR Buenos Aires, Argentina

Daniel H. Cataldo and Demetrio Boltovskoy
Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET),
Museo Argentino de Ciencias Naturales "Bernardino Rivadavia"
and Universidad de Buenos Aires, Facultad de Ciencias Exactas y Naturales
Pabellón 2 de Ciudad Universitaria, C1428EHA Buenos Aires, Argentina

The golden mussel *Limnoperna fortunei* was introduced in the Río de la Plata watershed in the 1990s swiftly becoming the sole dominant macrobenthic component on hard substrates, reaching densities of up to 200,000 ind. m^{-2}. We conducted a field experiment to assess the influence of conspecific adults on recruitment success of *Limnoperna fortunei*. Tiles of ca. 0,025 m^2 in surface were used as artificial substrates in four treatments: control (blank tiles), low (800 mussels m^{-2}), medium (4000 mussels m^{-2}) and high (12000 mussels m^{-2}) density treatments. Results obtained indicate that recruitment is strongly affected by the presence and density of conspecifics on the substrate: after one and three months of exposure numbers of recruits were significantly higher on tiles with conspecific adults than on blank tiles, and there was a positive and significant correlation between the number of recruits and the number of adults in the three treatments assayed. On the other hand, after three months of exposure recruits in the medium and high density treatments were smaller than recruits in the low density treatment. These results suggest that while conspecific adults have a positive effect on recruitment success (through chemical cues released by the adults, enhanced food supply, protection from predators, etc.), they also hinder growth of the newly settled juveniles.

NOTES

Colonization Pattern and Population Density of Invasive Bivalve *Limnoperna fortunei* in a Reservoir in Central Argentina

Demetrio Boltovskoy and Daniel Cataldo
University of Buenos Aires, School of Exact and Natural Sciences, Department of Ecology, Genetics and Evolution
C1428EHA Buenos Aires, Argentina

Alexander Y. Karatayev *and Lyubov E. Burlakova*
Buffalo State College, Great Lakes Center
1300 Elmwood Avenue, Buffalo, NY 14222, USA

Vadim A. Karatayev
City Honors School
186 East North Street, Buffalo, NY 14204, USA

Francisco Sylvester
University of Windsor, Great Lakes Institute for Environmental Research
401 Sunset Avenue, Windsor, ON, N9B 3P4 Canada

The freshwater bivalve *Limnoperna fortunei*, native to Southeast Asia, was introduced into Argentina around 1990, swiftly spreading throughout the entire Río de la Plata-Paraná watershed and becoming the dominant macrobenthic organism on hard substrates. At present, the mussel is a major nuisance for industrial and power plants that use raw river or lake water for their processes, and several important effects on the biota have been described (enhancement of nutrient cycling, plankton gazing and invertebrate densities, modification of trophic interactions, etc.). Mussel densities in excess of 200,000 ind. m^2 have been mentioned, but abundances over large areas have not been estimated. In December 2006 we performed a detailed study of the densities of *L. fortunei* in Embalse de Río Tercero, a medium-sized (54 km^2) reservoir in central Argentina where the mussel was first discovered in 1998. Abundances were assessed on the basis of 109 diver-collected 0.25 m^2 samples distributed among 25 transects. Mussel beds were clearly associated with the type of substrate. At the sampling time, most (85%) of the mussels were adult individuals (>13 mm in total length). Mean densities on bedrock and boulders (4867 ind. m^{-2}) were over one order of magnitude higher than those on silt (339 ind. m^{-2}), where it only occurred on isolated hard objects, such as wood debris. Other bottom types (gravel, sand) hosted intermediate values. Conversely, variability was highest on silt, gradually decreasing on harder and coarser substrates. Most substrate-associated population density differences were statistically significant. The reservoir hosts somewhat over 3×10^{10} mussels; over 90% of them at depths <10 m; deeper areas were almost invariably covered by a thick layer of silt. Thus, sandy and rocky areas, which represent about 13% of the lake bottom, hosted 58% of the mussels. The mean density for the entire water body was 712 ind. m^{-2}. In terms of biomass, this represents 1262 metric tons of *Limnoperna* dry tissue, or 20,458 metric tons of whole wet *Limnoperna* mass (27 g of dry tissue, or 459 g of whole wet *Limnoperna* mass, per m^2).

NOTES

Potential Distribution of Golden Mussel (*Limnoperna fortunei*) in North America Based on Environmental Limits Observed in a Tropical Wetland of Brazil

Márcia Divina de Oliveira
Embrapa Pantanal
R. 21 de setembro, 1880, Corumbá, MS, CEP 79320900, Brazil

Stephen K. Hamilton
Michigan State University, Kellogg Biological Station and Department of Zoology
3700 E. Gull Lake Drive, Hickory Corners, MI 49060-9516 USA

The bivalve *Limnoperna fortunei* (Dunker, 1857), also called golden mussel, is native from Southeast of China. It was introduced into South America in 1991 in the La Plata River (Argentina) and quickly spread into the Parana River basin, including Paraguay River. Paraguay River which is shared by Brasil and Bolivia, is also connected with a large floodplain (~140.000 km^2) called Pantanal. Annual interaction between river and floodplain results in profound changes in water characteristics in various portions of the floodplain. Most important of the changes is the annual variation of ph and dissolved oxygen. We have observed the golden mussel under various combinations of environmental conditions and we have recorded annual mortality when the environmental limits for this species were reached. Based on knowledge about the limiting factor for golden mussel we have predicted it potential distribution in Paraguay River basin based on chemical and physical water characteristics. We used this experience to predict the potential dispersion of golden mussels in the North American watersheds in the event it is introduced. Due to the great tolerance of *Limnoperna* to low dissolved oxygen and more modest requirement for calcium than *Dreissena*, we anticipate wide distribution of this species throughout North America.

NOTES

Sex Ratio as One of the Major Factors Promoting the Invasion of the Round Goby (*Neogobius melanostomus*) in the Gulf of Gdańsk

Mariusz R. Sapota
University of Gdańsk, Institute of Oceanography
Al. M. Pilsudskiego 46, 81-378 Gdynia, Poland

Konrad Dąbrowski
The Ohio State University, College of Food, Agricultural, and Environmental Sciences
210 Kottman Hall, 2021 Coffey Rd., Columbus, OH 43210 USA

Konrad Ocalewicz
University of Warmia and Mazury in Olsztyn, Department of Ichthyology
ul. Oczapowskiego 5, 10-957 Olsztyn, Poland

Invasion by the round goby (*Neogobius melanostomus*), the Ponto-Caspian fish, has been observed in the Gulf of Gdańsk from 1990. Gobies were of small importance during the first few years of the invasion, but soon they became the dominant of the shallow water fish community. The invasion in this area involves a number of different species and a stable and complex ecosystem.

Ecologically important invader is studied carefully. Most of population features are the same as in the native regions of occurrence. One of the most prominent differences is the sex ratio. In the Gulf of Gdańsk number of males is much higher than the number of females. Currently observed, sex ratio is two or three males to one female.

The round goby spawns in waters of depth down to twenty meters, mostly in the shallowest areas. Males guard eggs attached to hard elements of bottom. In the area of native occurrence, the Ponto-Caspian region, effectiveness of reproduction is correlated with sex ratio in the spawning population. When number of females is greater then number of males the effectiveness falls down. Nests are big, many females lay eggs into one nest (round gobies are multiple spawners). Guarding and ventilation of nests is difficult, a lot of developing eggs die. In native areas, the numbers of males and females are mostly equal and spawning success is excessive. Reproduction takes place during all warm periods of the year. In the Gulf of Gdańsk, spawn usually prolongs from the mid of April to the end of September. Due to the domination of males in number, the nests are small. Their guarding effectiveness is high. It results in the highest, ever observed, reproduction success. It promotes the successful invasion.

The sex ratio in fish population might be influenced by internal (genetic) or external (i.e., temperature, salinity, pH) factors. Performed investigations showed that temperature has the biggest influence on sex ratio in investigated population. Despite this in all temperatures from 10 to 20°C males were dominating among successfully hatched fish. It is worth to point out that in 10°C embryogenesis takes over two months while in 20°C only two weeks. In environment, the probability of successful finish of embryos development, in temperatures around 10°C, is very low. Male during all period of embryos development guards nest and does not eat. Its death before the end of embryogenesis is highly possible.

Investigations on genetic factors determining sex in round goby are in progress.

Taking into account frequent invasions of the round goby in various European and North American regions, presented data may be employed for prediction of invasion potential in early stage of settlement. Domination of males in numbers results in high reproduction effectiveness and successful invasion. Too low water temperature prevents effective reproduction.

NOTES

Status of the Non-native Gobiids in Fish Communities and Food Webs of the Lower Vistula River (Central Poland) 3-5 Years After their Appearance

Tomasz Kakareko, *Dariusz Płąchocki Janusz Żbikowski and Katarzyna Reszkowska*
Nicolaus Copernicus University, Institute of Ecology and Environmental Protection
Gagarina 9, 87-100 Toruń, Poland

Jarosław Kobak and Małgorzata Poznańska
Nicolaus Copernicus University, Institute of General and Molecular Biology
Gagarina 9, 87-100 Toruń, Poland

In the years 2000-2001, specimens of two Ponto-Caspian gobiids (racer goby *Neogobius gymnotrachelus* and monkey goby *Apollonia fluviatilis*) were recorded for the first time in the lower Vistula River, which is a part of the central inland corridor used by Ponto-Caspian species to migrate in Europe. After 3-5 years (2004-2005), we studied 1) the relative abundance of goby species, 2) their role as a prey in the diet of carnivorous fish and 3) their feeding habits in various habitats in the invaded areas. Samples were taken from the freely flowing Vistula as well from its dammed section (Włocławek Reservoir). To study the feeding habits of gobiids, parallel samples of fish and invertebrates were collected from the sites located along the 1.9 km wide cross-section profile of the dam reservoir, from depths of 0.5-2.5 m (nearshore zone), 4-5 m (open water areas) and 10-12 m (main channel). Small fish were sampled using seine netting, trapping and electrofishing while predatory fish were collected randomly from commercial catches. Altogether 7291 specimens (10 - 340 mm total length), belonging to 18 species were recorded in 84 samples and the diet of 20 pikeperch (63-72 cm body length) and 32 pike (8.9-70.0) specimens from the river as well as 26 pikeperch (32-70) specimens and ca. 350 gobiids from the reservoir were recorded.

Monkey goby was one of the subdominant (18.1% by number) fish species in the nearshore zone of the river together with bleak *Alburnus alburnus*, roach *Rutilus rutilus* and tree-spined stickleback *Gasterosteus aculaetus*. Racer goby was less abundant (4.7%) but also quite common (frequency of occurrence: 33%), similarly to common bream/silver bream *Abramis brama/Abramis bjoekrna*, European perch *Perca fluviatilis*, dace *Leuciscus leuciscus* and European bitterling *Rhodeus sericeus amarus.* In the dam reservoir, racer goby was more numerous (15.3 % of total fish number) then monkey goby (< 1%).

The gobiids constituted one of the most important items in the diet of pike and pikeperch in the river (by volume, 39.4 and 22.5%, respectively) as well as of pikeperch in the reservoir (56.2%). However, their percentage share in the diet decreased with increasing predator size.

The study of the gobiids diet is currently in progress. The preliminary results suggest that racer goby seems to select for chironomid larvae and avoid oligochaetes. The role of other prey (e.g., molluscs, amphipods) in the feeding habits seems to be intermediate. Invertebrates specific for the nearshore zone were not found in the guts of fish sampled at the offshore sites. Thus, fish probably did not explore large areas during foraging.

We can conclude that a considerable explosion of the two Ponto-Caspian gobiid populations took place in the lower Vistula River within 3-4 years (from 2000-2001 to 2004). Our results show that in the years 2004-2005 they became a numerous species in the nearshore fish communities and stimulated considerable changes in the local food webs. However, other aspects of its impact on the local fish community are yet to be assessed in the future studies.

NOTES

Present Status of the North American *Umbra pygmaea* (Eastern Mudminnow) in Flanders (Belgium) and in Europe

Hugo Verreycken *and Claude Belpaire*
Research Institute for Nature and Forest (INBO)
Duboislaan 14, B-1560 Hoeilaart, Belgium

The eastern mudminnow *Umbra pygmaea* (DeKay, 1842) originates from the eastern part of the United States of America and was transferred to Europe already at the beginning of the 20th century. In Belgium (Flanders), Germany, the Netherlands and France it was probably introduced around 1910 – 1920 while first occurrences of *U. pygmaea* were reported for Denmark and Poland only in the late 1980s and early 1990s.

Fish data for Flanders were extracted from the on-line fish stock assessment database 'VIS' of the Research Institute for Nature and Forest (INBO), which compiles data from fisheries surveys undertaken between 1993 and 2008 at over 2100 locations (on rivers, canals and public stagnant waters) throughout Flanders.

Eastern mudminnow is established in Flanders, but the species was only found on 75 locations over the last 15 years. Its distribution is confined to the northeastern part of Flanders.

The abundance of the eastern mudminnow in relation to the presence of other fish species (specifically predatory species) is discussed and the length frequency distribution, the length-weight relation and Fulton's condition of the Flemish populations are analysed. These data are compared with published data of introduced populations in other European countries and of autochthonous populations.

U. pygmaea is also assessed on its potential invasiveness and the scores are rather low indicating a low capacity to become invasive when introduced. Considering the long period since its introduction in Europe, the species colonized only few countries, and its distribution is usually confined to restricted areas. Despite this, the eastern mudminnow manages to maintain viable, self-reproducing populations in Europe for over 100 years now.

NOTES

Impacts of Introduced Aquatic Alien Species in European Aquaculture Initiatives

Stephan Gollasch
GoConsult
Grosse Brunnenstr. 61, 22763 Hamburg, Germany

Ian Cowx, Laurence Miossec, Ed Peeler, Sylvie Lapegue, Andy Nunn, Robert Britton, Glyn Jones and Esther Areikin

Exotic species are in use for aquaculture efforts since a long time. This talk summarises the impact of alien species and at the same time highlights the need to follow existing instruments to reduce adverse effects when importing alien species. The European Commission has emphasised the need for a thorough evaluation of the potential impact of non-indigenous species in aquaculture and it has also promoted the application of the 'ICES Code of Practice on Introduction and Transfers of Marine Organisms' as well as the 'EIFAC Code of Practice and Manual of Procedures for Considerations and Transfers of Marine and Freshwater Organisms'. To address the concerns raised by various expert groups, since January 1st 2009 a new EU Regulation is in place which was implemented to avoid unwanted impacts of alien species in aquaculture use. This instrument and the suggested measures are briefly introduced and it is hoped that this new EU instrument will considerably reduce unwanted impacts by alien species in European aquaculture efforts. Results from the recently terminated EU-funded research programme *Environmental impacts of alien species in aquaculture* (IMPASSE) to assess the impacts of introductions and translocations in aquaculture and for aquaculture based restocking in Europe since the 1970s will be presented.

NOTES

Life History Traits of Invasive Topmouth Gudgeon (*Pseudorasbora parva*) from Europe

Eva Záhorská *and Vladimír Kováč*
Comenius University, Department of Ecology
Mlynská dolina 842 15 Bratislava, Slovakia

Topmouth gudgeon, *Pseudorasbora parva* (Temminck & Schlegel, 1842), is a highly invasive species in Europe. It appears to be a good example of a successful invader with such attributes as short generation time, high reproductive effort and parental care, as well as wide physiological tolerance. The high level of dietary overlap with indigenous species and a voracious appetite for fish oocytes of other fish species indicates a high potential for interspecific interactions. A recently discovered infectious disease transmitted by topmouth gudgeon may explain why the populations of this species often replace native cyprinids.

This study represents a summary of our project devoted to life-history traits of invasive topmouth gudgeon populations. Therefore, ontogenetic patterns, external morphology, fecundity, sexual dimorphism, age, growth and body weight of several invasive populations from various European regions (England, France, Slovakia, Romania) and from various environments (from ponds to large rivers), are summed and discussed.

In general, topmouth gudgeon was found to be a species with a high flexibility in life-history traits. Apart from that, great phenotypic variability was observed, being expressed not only in the formation of different definite phenotypes but also in the manner by which the phenotypes are achieved. Thus, both the definite phenotype and the patterns of development in invasive topmouth gudgeon may be highly influenced by environmental conditions. Such great morphological (phenotypic) variability is likely to be one of the attributes that make this species such a successful invader.

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NOTES

How Will Climate Change Factors, Such as Increased Temperature and River Discharge, Affect the Growth, Reproduction and Dispersal of Non-native Freshwater Fishes in UK Waters?

Julien Cucherousset and J. Robert Britton
Bournemouth University, Centre for Conservation Ecology, School of Conservation Sciences
Fern Barrow, Poole, Dorset, BH12 5BB UK

Michael J. Godard, Ian C. Russell and ***Gordon H. Copp***
Centre for Environment, Fisheries and Aquaculture Science
Pakefield Road, Lowestoft, Suffolk NR33 0HT UK

Climate change predictions suggest that by 2080, there is a high probability of significant increases in mean air temperatures of up to 3.2˚C in some areas of the UK, with corresponding shifts in rainfall patterns resulting in reduced precipitation in summer but increased in winter. However, the frequency of extreme storm events in summer is also likely to be increased. Whilst there are already a number of invasive fishes in the UK that have been able to establish and disperse in the current climatic regime, there are further non-native fishes present that are currently constrained by the temperate climate. Species such as the European catfish *Silurus glanis*, common carp *Cyprinus carpio*, pumpkinseed *Lepomis gibbosus* and largemouth bass *Micropterus salmoides* have all proved to be highly invasive when introduced into inland waters in areas such as Southern Europe, yet remain relatively benign when introduced into UK waters, with relatively slow growth and only occasional reproduction that rarely results in successful recruitment. Thus, for species such as *S. glanis* and *C. carpio*, there has been a relatively relaxed attitude by relevant regulatory authorities to their introduction into enclosed inland waters due their opportunity to establish being climatically constrained. This has resulted in these particular species achieving a relatively wide distribution through human assistance.

Whilst this policy of enabling introductions of non-native fishes into enclosed waters that are unlikely to be able to establish in today's UK climate may appear pragmatic and facilitate the development and diversification of recreational fisheries, we discuss that it may be less suitable for tomorrow's climate. Through case-study, we identify those non-native fishes already in UK waters that are likely to benefit from these climate-change related shifts in temperature and rainfall patterns through analysis of their life-history traits, thermal optima and current distribution. The likely consequences of these outputs for the ecology and management of inland waters in the UK are discussed.

NOTES

Do Native Predators Feed on Exotic Preys? An Answer for Round Goby in a Multi-Species Assemblage of Piscivorous Fish (St. Lawrence River, Canada)

Yorick Reyjol, *Philippe Brodeur, Yves Mailhot, Marc Mingelbier and Pierre Dumont*
Ministère des Ressources Naturelles et de la Faune du Québec
201, Place Charles-Le Moyne, 4.05, Longueuil, QC J4K 2T5 Canada

Within the last 200 years, up to 163 aquatic species were introduced in the Great Lakes-St. Lawrence River system. Among them, the round goby, a Ponto-Caspian invader transferred in the Great Lakes by the ballast waters of commercial ships in the 1990s, has rapidly spread throughout the system. This study aimed to evaluate the importance of the round goby as a potential prey resource for seven native potential fish predators in the largest fluvial lake of the St. Lawrence River, Lake St. Pierre. Because predator-prey relationships for fish are mediated by size, the effect of predators length on round goby probability of predation was also tested. Fish were collected between August 27th and October 2nd 2007 in 111 sampling sites, using experimental gillnets. A total number of 900 fish were examined. Among them, 49 smallmouth bass, 89 northern pike, 101 sauger, 129 brown bullhead, 129 channel catfish, 154 walleye and 249 yellow perch. Among the fish, which fed, the occurrence of the goby in the stomach contents was very low for the brown bullhead (2.3%) and the channel catfish (4.8%), while being higher for the other species, varying between 21% (yellow perch) and 64% (sauger). For the five most efficient predators, logistic regressions revealed that the probability of occurrence of goby in stomachs increased with total length for the "small" predator species (sauger, smallmouth bass and yellow perch), while the opposite trend was found for the "large" ones (northern pike and walleye). For sauger and walleye, ANCOVA also indicated that there was a positive relationship between the total length of the gobies eaten and the total length of the predators. Results are discussed with regard to the habitat preferences of the predators, behavioural habits and fish size.

NOTES

Volunteer-based Early Detection and Rapid Response; Examples of Successful Partnerships Addressing Non-native Finfish in the Tropical Western Atlantic

J. Lad Akins
Reef Environmental Education Foundation
98300 Overseas Hwy, Key Largo, FL 33037 USA

James A. Morris, Jr.
National Oceanic and Atmospheric Administration, National Ocean Service, National Centers for Coastal Ocean Science
101 Pivers Island Road, Beaufort, NC 28516 USA

Volunteer divers and snorkelers are the eyes and ears of the coral reef environment. Thousand of divers enter the water each day to witness the beauty and marine life of coral reef systems. The Reef Environmental Education Foundation (REEF), a U.S. based NGO, trains these marine enthusiasts in identification and survey techniques and provides materials for them to report their sightings to a central, publicly accessible, database (www.reef.org). This continuously updated dataset currently contains over 96,000 fish surveys from the Tropical Western Atlantic and over 120,000 surveys from throughout REEF's survey regions. These data provide a valuable baseline resource and allow trend and impact analysis over large temporal and spatial scales. REEF, working with research partners, local dive operators and volunteers has developed methods and materials for outreach, detection, reporting and response which can serve as a model for addressing sporadic non-native releases or predicted invasions. For non-native species, such as lionfish, trained volunteers may be the first line of defense in early detection. The use of volunteers in early detection and rapid response may provide significant aid in slowing expansions and controlling non-native species populations at key locations of high priority.

More than 20 different species of non-native marine fish have been documented in southeast Florida waters. Lionfish (*Pterois volitans/miles*) are the first of these non-natives to become established. Their recent and rapid invasion now includes populations along the eastern coast of the U.S., Bermuda and the north central Caribbean and Bahamas. A nearly perfect invader, these fish are causing significant impacts on native marine systems and moving rapidly towards region-wide establishment. REEF, working in partnership with NOAA and researchers from Simon Fraser University, has utilized volunteers to document the spread of the lionfish invasion and gather critical field research data and samples from throughout the Bahamas. Since January 2007, REEF has conducted 16 week-long lionfish projects in the Bahamas. Over 200 volunteers have participated in these projects, helping to gather over 1700 specimens for researchers. Results indicate that volunteers can play a vital role in early detection, rapid response, and continued monitoring and control of non-native species.

NOTES

Standardizing Sampling Techniques for *Potamopyrgus antipodarum* (New Zealand Mudsnail) to Establish Early Detection and Monitoring Programs

***Jill M. Hardiman**, Timothy D. Counihan, Christopher E. Walker and Amy L. Puls*
U.S. Geological Survey, Western Fisheries Research Center
5501a Cook-Underwood Road, Cook, WA 98605 USA

Early detection, prevention, and eradication are the keys to reducing the effects of invasive species; however eradication can be extremely difficult and costly once a species is established. Thus, standardized survey techniques for early detection, monitoring, and baseline surveys are the logical first steps towards understanding variables that promote colonization and spread of invasive species. The *Potamopyrgus antipodarum* (New Zealand mudsnail) is an invasive non-indigenous species which has been spreading rapidly in the last 20 years throughout the Western United States and British Columbia. It is a parthenogenic live bearer having the ability to rapidly clone itself and has reached population densities as high as 300,000 snails/m^2. The New Zealand mudsnail (NZMS) has significant potential to alter ecosystem functions in rivers such as food web structure by competing with native macroinvertebrate fauna. Due to the ability of this mudsnail to achieve high densities and potentially alter ecosystems it is important to focus on early detection and prevention of colonization to new streams and rivers.

During 2007 and 2008, we conducted an assessment of survey techniques to determine the presence or absence of adult NZMS in the Klickitat River, Washington. We will present pilot survey techniques to assess early detection of NZMS at very low densities ($\leq 0.1/m^2$) to allow for early detection and prioritizing areas for outreach and management. We will further provide an evaluation of sampling techniques and intensity levels necessary to detect varying densities of NZMS in different habitats. Measures of sampling intensity include evaluation of the plot size sampled, number of plots sampled, and the search efficiency within plots on our ability to detect populations at varying densities and habitats. To determine an appropriate study design, variables to consider are the desired power of detection, the monetary cost per sample, detection at density levels for eradication, and search efficiency. We used previously established power curves for detecting rare species as a guideline for our initial sampling effort. Using this design approach we are able to state NZMS were detected or not detected given the specific sampling effort and search efficiency. We will evaluate and present sampling designs for different densities, detection powers, search efficiencies, and areas sampled. These sample designs once established could be used for early detection of NZMS and potentially other aquatic invasive species, and to monitor for population changes.

NOTES

The Adirondack Park: A Region of Opportunities for Successful Aquatic Invasive Species Spread Prevention and Management

Hilary A. Smith
The Nature Conservancy-Adirondack Chapter
Adirondack Park Invasive Plant Program
PO Box 65 Keene Valley, New York 12943 USA

The Adirondack Park Invasive Plant Program (APIPP) is a regional partnership program operating in the 2.4 million hectare Adirondack Park in upstate New York. Initiated in 1998 as a grass-roots effort, the program aims to protect the Adirondack region from the negative impacts of non-native invasive species and focuses on prevention, early detection, rapid response, management, and education.

Invasive species management is most effective when addressed at the landscape level with the synergy of diverse partnerships. A coalition of more than 30 cooperating organizations, the APIPP has successfully incorporated this strategy by utilizing the strengths of each partner, organizing hundreds of volunteers and approaching the daunting issue of invasive species in a comprehensive, systematic, and cooperative manner that has produced real on-the-ground results.

The program's successes include developing a regional volunteer monitoring program to detect aquatic invasive plants; designing a regional database to store and track invasive plant distribution information; recruiting and training 350 staff and citizen volunteers to survey more than 219 lakes and ponds; engaging partner groups and volunteers to inventory, map, and control hundreds of invasive plant infestations; identifying research needs and pursuing projects to meet those needs; developing educational materials to increase public awareness and a website www.adkinvasives.com to facilitate information exchange; promoting innovative spread prevention programs such as boat launch stewards; reaching more than 12,000 individuals through presentations since 2004; and, leveraging $1,100,000 in grant awards and partner contributions since the program's inception. Continuing to work towards a complete and effective invasive species program, APIPP recently proposed its plans for formalizing regional response teams to control new invasions in the Adirondack region.

The program has received two national awards from the United States Federal Highway Administration and a state award in Environmental Excellence from the New York State Department of Environmental Conservation and serves as the model partnership for seven regional partnerships across the state. This presentation will discuss program goals, strategies, and activities and highlight ways in which partnerships and coordination are essential to effective program implementation.

NOTES

Developing and Implementing a Citizen Volunteer Lake Water Quality Monitoring Program on 20 Northwestern Montana Lakes for Early Aquatic Nuisance Species (ANS) Detection

John L. Wachsmuth
Montana Fish, Wildlife & Parks
490 N. Meridian Rd., Kalispell, MT 59901 USA

Mike Koopal
Whitefish Lake Institute
635 Denver Street, Whitefish, MT 59937 USA

With continual budget cuts to natural resource management agencies, under staffed work forces and the need to do public outreach programs in regards to ANS issues and concerns the involvement of citizen volunteers can prove to be useful and effective in the fight for ANS prevention and detection.

The Whitefish to Eureka Volunteer Lake Monitoring Program is a cooperative partnership between the Montana Department of Fish, Wildlife and Parks (MFWP) Region 1, and the Whitefish Lake Institute (WLI). The goal of this project is to collect long-term trend data on select lakes. The data will be used by management agencies to make informed decisions and to create public awareness of lake issues. The primary responsibility of FWP will be as a funding source for the project ($4,500 FY07-FY09) whereas the WLI will be responsible to implement the program. This project has been modeled after the Flathead Basin Commission (FBC) volunteer lake monitoring effort. FBC has been consulted to avoid any duplication in lake monitoring.

The focus of this effort is to coordinate and facilitate local volunteer "lake watchers" and provide them with the training and equipment necessary to collect basic limnological data and also to do visual observation for such ANS species as Eurasian watermillfoil (*Myriophyllum spicatum*), zebra mussel (*Dreissena polymorpha*), quagga mussel (*Dreissena rostriformis bugensis*) and the New Zealand mudsnail (*Potamopyrgus antipodarum*). Monitors are given training prior to starting the program and also given color photo handouts with the ANS species of concern in this program and area. These monitors will provide a first alert if you will to any new infestations that may have occurred in these lakes. This then can provide the proper agencies a more effective rapid response to a possible infestation.

Data for lake monitoring includes secchi disk readings, water temperature profiles, dissolved oxygen readings and filling out a visual observation card which was designed by the United States Environmental Protection Agency (USEPA) for water quality monitoring programs in the U.S. This data will be collected in a consistent and reproducible format.

The collected information will then be incorporated into a database housed by WLI where it will be available to management agencies and the public. A biennial report will be prepared to evaluate the data and to establish lake trends and provide baseline data and evaluations regarding any new ANS infestations for the 20 lakes in northwestern Montana volunteer lake monitoring program.

NOTES

Biological Synopsis of Selected Phytoplankton New to the Bay of Fundy

Jennifer L. Martin
Fisheries and Oceans Canada, Biological Station
531 Brandy Cove Road, St. Andrews, NB E5B 2L9 Canada

Georgia Klein and Irena Kacsmarska
Mount Allison University, Department of Biology
63B York St., Sackville, NB E4L 1G7 Canada

A monitoring program was initiated in 1987 to study phytoplankton populations in the Western Isles region of the Bay of Fundy, southwest New Brunswick. Samples are collected weekly from May through October, and monthly during the remaining months for phytoplankton distribution and abundance at Brandy Cove, Lime Kiln Bay, Deadmans Harbour, the Wolves Islands and mid-Passamaquoddy Bay. Since the programme was initiated a number of new species have been observed suggesting the introduction of new species. In order to determine species non-indigenous to the Bay of Fundy waters, we have taken a conservative approach and list species that have been observed since 1995. Those new species include the following : (dinoflagellates) *Alexandrium pseudogonyaulax*, *Amphidinium carterae*, *Amphidinium sphenoides*, *Ceratium macroceros*, *Polykrikos schwartzi.*, *Preperidinium meunieri*, *Protoperidinium crassipes*, and *Pyrocystis lunata,* and (diatoms) *Attheya septentrionalis*, *Attheya longicornis*, *Chaetoceros radicans*, *Cylindrotheca gracilis*, *Grammatophora serpentina*, *Lithodesmium undulatum*, *Mediopyxis helysia, Membraneis challengeri, Neodenticula seminae*, *Odontella sinensis*, *Proboscia eumorpha*, *Pseudo-nitzschia subpacifica*, *Pseudo-nitzschia fraudulenta* and *Thalassiosira punctigera*.

Phytoplankton transport and relocation to other regions of the world are a major concern as are the effects of establishment on the new environment. Several of the species recently detected in the Bay of Fundy are being focused on, considering phytoplankton species that could be a potential risk to both coasts, to formulate a biological synopsis to evaluate potential risk for introduction to the major ports in Canada. Available information on these phytoplankton species, including biological characteristics, distributions and harmful/invasive potential, will be discussed.

NOTES

Green Marine's Environmental Program

David Bolduc
Green Marine
P.271, de l'Estuaire, Quebec, QC G1K 8S8 Canada

Green Marine is an environmental partnership between the St. Lawrence and Great Lakes which brings together eight associations from the Canadian and U.S. marine industries. Green Marine's objective is to implement an environmental program which requires a voluntary commitment from participating companies to tangibly and measurably strengthen their environmental performance with respect to six priority issues:

- Aquatic invasive species
- Pollutant air emissions
- Greenhouse gases
- Cargo residues
- Oily waters
- Conflicts of use in ports and terminals

Since coming into effect on January 1, 2008, the environmental program has attracted 44 participants, 16 partners, and 20 supporters, making it a true reference source on sustainable development within the industry. The program's participants are required to self-evaluate their environmental performance for 2008 with respect to six environmental issues, using a scale that ranges from regulatory compliance to demonstrating excellence in their practices. From 2009 onwards (i.e., as of the second year of the program's implementation), participants' self-evaluations will be audited by a third party.

The Green Marine coordinator will make a presentation on aquatic invasive species (which is one of the six priority issues covered by the environmental program), with particular focus on the performance indicator linked to this issue.

NOTES

Frameworks and Tools for Risk Analysis of Non-indigenous Species

David M. Lodge
University of Notre Dame, Center for Aquatic Conservation
P.O. Box 369, Notre Dame, IN 46556 USA

In the last two decades, citizens, industries, governments and scientists around the globe have realized the urgent need for better risk analysis to guide voluntary or mandatory policies and management efforts to reduce the number of harmful biological invasions. In response to this growing demand, the number and variety of tools for risk analysis has grown rapidly. The ways in which these tools are implemented often differ among countries, economic sectors, and different kinds of organisms. Nevertheless, the basic conceptual framework for risk analysis remains as follows. Every biological invasion consists of a sequence of probabilistic transitions: with some probability, a species is entrained in a pathway; transported and released alive; establishes a self-sustaining population; spreads; and causes harm to ecosystems, human health or the economy. Risk assessment consists of determining the probability of each transition that is relevant to a given application, and may include determining those probabilities under different scenarios of potential risk management. The probability of harm is the product of all the probabilities in the entire sequence of transitions. For any specific voluntary or regulatory case, a final decision about what level of risk management is appropriate is determined by comparing the probability of harm estimated by risk assessment to a pre-determined threshold of maximum acceptable probability of harm. While the implementation of this framework may necessarily differ when considering different pathways of invasion (e.g., the risk of harm from ships' ballast water relative to a species proposed for importation in the pet trade), many of the new tools for risk assessment are relevant to both. For example, environmental niche modeling, spread modeling, and trait-based modeling—and the variety of approaches within each class of these approaches—are increasingly accurate and appropriate to incorporate in risk assessment. Using a framework that was adopted with the support and concurrence of the Secretariat of the Convention on Biological Diversity (CBD), and officially recognized in 2008 by the CBD COP 9 Decision IX/4, I will illustrate how these tools may be employed in an overall risk analysis framework. This framework will also be used to introduce the rest of the talks in this session.

NOTES

Practical Applications of Risk Assessments in an Aquatic Invasive Species Program

Becky Cudmore
Fisheries and Oceans Canada, Centre of Expertise for Aquatic Risk Assessment
867 Lakeshore Road, Burlington ON L7R 4A6 Canada

Protecting biodiversity from aquatic invasive species is a priority for the Government of Canada and a national action plan has been implemented to address this threat. Risk assessments are being completed more frequently as a preventative tool. The general framework on which biological risk assessments are based assesses the probability of an introduction of an aquatic invasive species and the magnitude of the consequences of that introduction to conclude an overall statement of risk. Risk assessments provide valuable information which can be applied to many areas of an aquatic invasive species program. A key component and first step to any aquatic invasive species program is the development of prevention strategies. Risk assessments identify those species of greatest risk and the pathways these species use. This enables aquatic invasive species decision makers and managers to set up 'road blocks', such as the development of legislation, to prevent the species' movement into an area of concern. Risk assessments can also provide information for other preventative strategies, such as education and public outreach initiatives. During the risk assessment process, identification of knowledge gaps can provide direction for an aquatic invasive species research program, rapid response plans and inform managers on control or eradication options. Monitoring and early detection programs can also be informed from information derived during a risk assessment process by identifying geographic locations and gear selection. Specific examples from risk assessments conducted by Fisheries and Oceans Canada will be used to highlight the practical application of risk assessment results within its aquatic invasive species program.

NOTES

The Role of Domestic Shipping as a Vector for Introduction and Spread of Aquatic Non-indigenous Species in the Great Lakes

Sarah Bailey *and Michael Rup*
Fisheries and Oceans Canada
867 Lakeshore Road, Box 5050, Burlington, ON L7R 4A6 Canada
and
University of Windsor, Great Lakes Institute for Environmental Research
401 Sunset Avenue, Windsor, ON N9B 3P4 Canada

Christopher J. Wiley
Fisheries and Oceans Canada/Transport Canada – Ontario Region
100 Front Street South, Sarnia, ON N7T 2M4 Canada

Mark Minton, Whitman Miller and Greg Ruiz
Smithsonian Environmental Research Center
PO Box 28, Edgewater, Maryland 21037 USA

Hugh MacIsaac
University of Windsor, Great Lakes Institute for Environmental Research
401 Sunset Avenue, Windsor, ON N9B 3P4 Canada

Domestic commercial ships ('Lakers') move more than 60 million metric tonnes of ballast water within the Laurentian Great Lakes annually – approximately 60 times the amount of ballast introduced by foreign vessels each year. Due to the vast volume and area of the Great Lakes, our ability to detect the initial introduction of new aquatic nonindigenous species (ANS) is overshadowed by the rate of spread, or secondary transfer, to new locations in the basin. Secondary vectors, such as Lakers, have the potential to spread ANS at rates many orders of magnitude greater than would be expected by natural mechanisms (such as downstream drift). Here we have conducted the first detailed analysis of the movement of ballast water by Lakers operating at 135 ports between Duluth, Minnesota and Sept Iles, Quebec. More than 200 million metric tonnes of ballast water was moved during >30,000 vessel transits over a three year period (2005-2007). In addition, we report results of ballast water samples taken from >50 domestic ship transits in 2007 and 2008. We report on the presence and abundance of established ANS, and native taxa with restricted distributions, being transported in domestic ballast water. Detailed knowledge of the major ballast water donor and recipient ports, as well as the taxa likely to be entrained in tanks, will be valuable for future targeted monitoring and management strategies.

NOTES

Brine as an Alternative Treatment of Water Ballast Tanks for Non-compliant Ships Wishing to Enter the St. Lawrence Seaway

Philip T. Jenkins
Philip T Jenkins & Associates Ltd.
1 Forest Hill Crescent, Fonthill, ON L0S 1E1 Canada

The concept of using brine, and specifically sodium chloride brine to treat low salinity residuals in water ballast tanks of ships proceeding into the Great Lakes that report no ballast on board (NOBOB) as they enter the Gulf of St. Lawrence is a natural progression from the current regulatory emphasis.

The objective to eventually eliminate a threat to the fresh water ecosystem from adults, larvae and resting stages of the many taxa that may have originated from foreign ports and be capable of establishing colonies which has been thoroughly researched and documented by bi-national research teams in studies conducted between 2000 and 2006. The current emphasis is on shipboard management practices, a salinity shock by the introduction of deep ocean water and flushing offending tanks during the transoceanic passage, to ensure a residual salinity of at least 30 ppt stems from that research.

However it is recognized that circumstances may make that operation impossible on certain passages, and thus the need exists for an alternate form of treatment that could be applied after the ships arrival. These ships are all carrying import cargoes, many loaded to their full ocean load line will have to discharge initially below the Seaway entrance, and others will be loaded so as to arrive at that entrance at the maximum permitted Seaway draft in effect at the time of arrival.

While despite the fact that most tanks where residuals are likely to exist will not be readily accessible for internal examination, it is quite feasible to establish both the quantity and salinity of those residuals from a pre entry inspection process, which is already in place. It is equally as feasible to apply a liquid treatment to those tanks, although the quantity needed to be applied may preclude carrying out that treatment until the ship reaches the first port of cargo discharge, or a location above the Welland Canal where it is no longer constrained by draft. Wherever the choice of location, it must be agreed with the Master/Owners before entry into the system is permitted, and it must be applied before the ship takes fresh water ballast into the offending tanks.

Brine at a salinity of 230 ppt is readily available throughout the Great Lakes basin, where it is used for anti icing in winter road management, and much of the infrastructure for manufacturing and storing that brine lies idle during the period when ocean ships are trading into the Great Lakes. There are, in addition, independent suppliers who manufacture brine on demand throughout the year, and a feasibility study performed for Transport Canada in 2007 established that both sources could be readily available to the shipping industry.

This recommended approach recognizes concerns amongst the shipping industry regarding not only the direct cost of treatment, but the potential for disruption of the commercial voyage and the related legalities and costs of deviation and/or delays. This form of treatment is foreseen as one that would be used infrequently, if at all, on individual tanks or on individual ships, which have non-compliant tanks, as a practical and cost effective means of providing an immediate but temporary solution to a complex problem. While scientific studies are being completed to establish appropriate salinity concentration(s) and related hang times post application, full scale field trials will be conducted in the fall 2008 to confirm the practicality of application processes, fully identify any application shortcomings, while at the same time confirming efficacy in a real world setting. The trials will be conducted under the auspices and scrutiny of both Transport Canada and Fisheries and Oceans Canada, and the rationale of the treatment process and outcomes from these trials will be the subject of this proposed presentation.

NOTES

Brine Treatment for Limiting Spread of Non-indigenous Species via Ballast Water

Johanna Bradie *and Hugh MacIsaac*
CAISN, University of Windsor, Great Lakes Institute for Environmental Research
401 Sunset Avenue, Windsor, ON N9B 3P4 Canada

Sarah Bailey
Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences
867 Lakeshore Road, Box 5050, Burlington, ON L7R 4A6 Canada

Christopher J. Wiley
Fisheries and Oceans Canada/Transport Canada – Ontario Region
100 Front Street South, Sarnia, ON N7T 2M4 Canada

David F. Reid
National Oceanic and Atmospheric Administration, GLERL
4840 S State Rd, Ann Arbor, MI 48108-9719 USA

Thomas H. Johengen
University of Michigan, CILER
2205 Commonwealth Blvd., Ann Arbor, MI 48105 USA

Scott Santagata and Gregory Ruiz
Smithsonian Environmental Research Center
647 Contees Wharf Road, Edgewater, MD USA

Voluntary exchange of ballast water at sea for transoceanic vessels operating on the North American Great Lakes was first recommended under Canadian regulations in 1989 (later made mandatory by U.S. Coast Guard in 1993). In 2005, Canada amended its Ballast Water Control and Management Regulations to include management of residual ballast carried by vessels declaring 'no ballast on board' (NOBOB) status.

The addition of NaCl brine has been proposed as a treatment solution for management of non-compliant NOBOB ballast tanks. Seawater (≥30 ppt salinity) used in flushing and exchange practices can effectively reduce viability of fresh- and brackish-water taxa, but mortality does not always reach 100%. Brine (up to 230 ppt NaCl) is expected to provide greater protection by achieving complete mortality against most, if not all taxa in the tanks, but will be dependent on exposure time and concentration.

Several studies have been completed to evaluate the biological efficacy of brine treatment. Experiments were conducted to determine the brine concentration required to achieve mortality of aquatic invertebrates collected from exchanged ballast tanks and also from several freshwater and estuarine habitats. The latter experiments were aimed at halotolerant taxa, including high-risk invertebrates (i.e., species with wide salinity tolerance with an invasion history in ballast water in European habitats) collected from major European ports. All taxa were subjected to a range of brine concentrations, with survival measured at discrete time intervals. Brine concentration/exposure time combinations required for complete extermination of the taxa were identified. Successful implementation of this treatment can further enhance protection of the Great Lakes from aquatic invasive species.

NOTES

Great Lakes Shipping, Trade and AIS: A Report from the U.S. Transportation Research Board

Hugh MacIsaac
U.S. National Academy of Sciences
c/o University of Windsor, Great Lakes Institute for Environmental Research
401 Sunset Avenue, Windsor, ON N9B 3P4 Canada

A. U.S. National Academy of Science committee – with broad representation of American and Canadian investigators from transportation, economics, shipping, ecology, and invasive species sectors – delivered a report in June 2008 that made a series of recommendations regarding shipping into the Great Lakes basin. The objectives of the study were to enhance the region's potential for global trade and to eliminate further introductions of AIS into the Great Lakes by vessels utilizing the St. Lawrence Seaway. The committee rejected closure of the Seaway because doing so would not enhance the potential for global trade and because it would be impractical from a political perspective. Elimination of transoceanic shipping was rejected because it could not be implemented in a timely fashion, because of adverse environmental impacts, because of possible reprisals from trading partners, because of increase costs associated with moving goods, and because it would possibly threaten the long-term viability of the Seaway. Instead, the committee recommended that the Seaway remain open with a suite of prevention measures that would evolve over time in response to lessons learned and development of new technologies. First, all transoceanic and coastal vessels should be required to flush or exchange ballast with saltwater to remove and/or kill organisms in ballast tanks. Strict enforcement, and remediation options for non-compliant arriving vessels, are needed. New ships designs should optimize ballast water management, and vessels should explore use of 'black box' technologies for remote monitoring of compliance. Third, the committee recommends exploration of shipboard ballast water treatment technologies using the IMO D-2 standard as a starting point. Fourth, a binational, science-based surveillance program should be established to monitor presence of 'hot species' and 'hot spots' in the Great Lakes to inform adaptive management. Fifth, methods of containment, control and possible eradication need to be developed. The committee recommended an adaptive management process to ensure that policy measures remain updated and reflect practical experiences, knowledge gained through research, technological developments, and changes in sources of invaders. Collectively, our identified measures come closer to the two project criteria than any of the other options identified.

NOTES

Is the South Australian Invasion of *Caulerpa taxifolia* Inconsequential?

Marty R. Deveney, *Keith P. Rowling, Kathryn H. Wiltshire, Clare E. Manning, Milena B. Fernandes, Greg J. Collings and Jason E. Tanner*

South Australian Research and Development Institute, Aquatic Sciences

P.O. Box 120, Henley Beach SA, 5022, Australia

Caulerpa taxifolia was detected in West Lakes, a man-made saline estuary in suburban Adelaide, South Australia in 2002. In 2003 the population there was eradicated by diverting stormwater to reduce the salinity in the lake, but a population that established in the Port River could not be eradicated and has been spreading since 2003.

As part of a broader environmental risk assessment and spatial modelling of risk, we examined the environmental effects of the *C. taxifolia* invasion in South Australia. At four sites: two infested with *C. taxifolia* and two with cover of native *Zostera* sp. we examined infauna and epifauna communities and analysed the physical structure and chemistry of sediments.

Both *C. taxifolia* and *Zostera* contained an abundant and diverse fauna, however, there were substantial differences between them.

The chemistry of sediments under meadows of *C. taxifolia* is altered in comparison to those under seagrass. Seagrasses trap more sediment, retaining nitrogen and carbon and their sediments contain more water than those under *C. taxifolia* meadows, which develop anaerobic conditions and release ammonium and sulfides, contributing to decreased water quality and environmental change.

It is likely that these differences mean that *C. taxifolia* meadows do not support the same critical ecosystem processes as seagrasses, with attendant potential effects on fisheries recruitment and maintenance of marine biodiversity.

NOTES

Patterns of Invasion in Western Europe: Can We Predict Which Aquatic Invaders to Expect in Britain and Ireland?

Philine S.E. zu Ermgassen *and David C. Aldridge*
University of Cambridge, Department of Zoology
Downing Street, Cambridge CB2 3EJ UK

Rob S.E.W. Leuven
Radboud University Nijmegen, Institute for Wetland and Water Research, Department of Environmental Science
PO Box 9010, 6500 ED Nijmegen, The Netherlands

Dan Minchin
Marine Organism Investigations
Ballina, Killaloe, Co Clare, Ireland

Reuben P. Keller
University of Notre Dame, Department of Biological Sciences
Notre Dame, IN 6556, USA

Gerard van der Velde
Radboud University Nijmegen, Institute for Wetland and Water Research, Department of Animal Ecology and Ecophysiology
PO Box 9010, 6500 ED Nijmegen, The Netherlands and
National Natural History Museum Naturalis
PO Box 9517, 2300 RA Leiden, The Netherlands

Aquatic invasions are often both economically and ecologically damaging. The rate of invasion is increasing as the result of a globalised society. Despite considerable evidence that preventing an invasive species from establishing or arriving is less costly than controlling it once it is established, this approach is rarely taken. This is in part due to the lack of a specific knowledge regarding which species are likely to arrive.

Here we present a systematic approach to non-native species horizon scanning by comparing the invasion history of the Netherlands, Britain and Ireland. We demonstrate that international collaboration and exchange of data sets can provide accurate predictions for new arrivals into the island regions of Great Britain and Ireland, as well as indicators of their mode of arrival, which may in turn be of great use to policy makers.

We also present an overview of invasions in all three regions, and discuss potential socio-economic reasons for some of the patterns observed, along with their implications for predicting future invaders.

NOTES

Statewide Risk Analysis for the Spread of Zebra and Quagga Mussels in Colorado, USA

Jonathan M. Bossenbroek
University of Toledo, Lake Erie Center and Department of Environmental Sciences
6200 Bayshore Rd., Oregon, OH 43618 USA

Alexei Potapov
University of Alberta, Department of Mathematical and Statistical Sciences
Edmonton, AB T6G 2G1 Canada

Lake Pueblo and Lake Granby are the first lakes to become infested with dreissenid mussels (i.e., zebra and quagga mussels, respectively) in the state of Colorado, USA. To aid in the management of the water bodies of Colorado we developed models to predict the spread and population growth of dreissenid mussels, specifically we: 1) Predicted the potential densities of zebra mussels in Lake Pueblo and other water bodies in Colorado by using the water quality of these lakes and comparing these values to known lakes with zebra mussels and existing density models, 2) Assessed the feasibility of developing a population growth model of zebra mussels within Lake Pueblo, and 3) Developed a dispersal model of dreissenid mussels based on the movement of recreational boaters and river and canal/pipe connections. Our results suggest that most of the reservoirs east of the continental divide are considered suitable for zebra mussels. West of the divide is more variable. The central mountain region is the primary area where zebra mussels are not expected to be able to establish. There are very little data on the current zebra mussel abundance in Pueblo reservoir making accurate predictions of population growth improbably. However, based on the available data and in particular from the shape of the North Marina bay (where zebra mussels were first found), two major scenarios may be suggested. First, if there is little water exchange between North Marina bay and the main reservoir there will be explosive population growth within the bay. Then the larvae production will be very intense, and the spread around the lake will begin. Second, if there is intensive water exchange between the bay and the main reservoir body it may take several years before explosive growth will start. Our gravity model results predict that Neenoshe Reservoir has the highest probability of being invested with dreissenid mussels due to overland transport, while John Martin Reservoir is most at risk to downstream dispersal. Our model also predicts that the zip codes of Grand Junction, Pueblo and Colorado Springs have a probability of spreading zebra mussels between lakes. This is particularly true for Pueblo, which is near the infested Pueblo Reservoir and for Grand Junction, which is relatively close to the Colorado River reservoirs of Powell, Mead, etc., which are infested with quagga mussels. These model results will be continually updated as more data about the current state of dreissenids in Colorado becomes clear. These results are currently being used to develop the State of Colorado's management plan.

NOTES

Hung Out to Dry: Fitness Loss Due to Desiccation of Eurasian Watermilfoil (*Myriophyllum spicatum*) and Implications for Efficient Risk Management

***Matthew A. Barnes**, Christopher L. Jerde, Anna Noveroske, Elise K. DeBuysser and David M. Lodge*
University of Notre Dame, Department of Biological Sciences
Center for Aquatic Conservation, PO Box 369, Notre Dame, IN 46556 USA

W. Lindsay Chadderton
The Nature Conservancy
c/o University of Notre Dame, Department of Biological Sciences
Center for Aquatic Conservation, PO Box 369, Notre Dame, IN 46556 USA

The ability to undergo vegetative reproduction contributes to the invasive success of many aquatic invasive plants. In addition to aiding dispersal via natural pathways, vegetative reproduction promotes human-mediated dispersal as plant fragments can "hitchhike" between water bodies by attaching to boats and trailers. Therefore, the inspection of boats entering and leaving water bodies represents an important risk management strategy for preventing the spread of nonindigenous plants. However, even without inspection efforts, desiccation of plant fragments may reduce fitness (survival and reproductive capability), and consequently, transport of fragments over distances with increasing exposure may decrease the risk of initiating new invasions. Nevertheless, current lake-to-lake transport models of invasive species, such as gravity models, do not directly consider fitness loss in the transport pathway. This can lead to inefficient management at locations that receive propagule pressure but have no risk of invasion due to fitness loss. Here, we estimate fitness loss as a function of desiccation exposure for Eurasian watermilfoil, *Myriophyllum spicatum* (EWM). EWM is invasive throughout North America, and known for producing thick vegetative mats which interfere with hydrology, displace native aquatic plants, and adversely impact many other organisms, including sport fish. In this experiment, we air-dried EWM fragments of varying lengths (3-23 cm) for a range of time periods (0-24 hours). Following desiccation, we returned fragments into a tank of water in individual jars and monitored recovery, survival, and the formation of roots over 18 weeks. We assessed differences between desiccation treatments using time-to-event survival analysis. For control fragments, which received no desiccation treatment, survival and root production readily occurred across all fragment lengths, and the expected waiting time for root production was less than two weeks. In contrast, fragments that experienced desiccation for more than 24 hours posed little or no risk of surviving or initiating root production. We believe these results and similar analyses on other aquatic invasive species, such as *Hydrilla verticillata* in the United States and Canada, can increase the effectiveness of management efforts by considering fitness loss in the transport pathway.

NOTES

Investigating Patterns of Risk Activity Within an Invasion Pathway

Andrew Drake *and Harold H. Harvey*
CAISN, University of Toronto, Department of Ecology and Evolutionary Biology
25 Willcocks Street, Toronto, ON M5S 3B2 Canada

Nicholas E. Mandrak
Fisheries and Oceans Canada, Centre of Expertise for Aquatic Risk Assessment
867 Lakeshore Road, Burlington, ON L7R 4A6 Canada

Risk assessments of invasion pathways often determine the likelihood of occurrence of risk activities (e.g., bait-bucket release) throughout multiple pathway steps, which, when taken collectively, cumulate an overall probability that represents the occurrence of a primary risk event (e.g., the probability of introduction of aquatic invasive species). Because the occurrence of risk activities is typically rare, yet with high consequence, models that incorporate individualistic behavior provide novel tools to determine the likelihood of species introductions by identifying patterns of high-impact vectors. We used multivariate ordination techniques to describe risky angler behaviour within Ontario's baitfish pathway to assess whether risk activities are distributed uniformly among vectors, or whether certain vectors disproportionately support the majority of risk activities. Results indicated that most pathway vectors participated in relatively benign activities; whereas, at least two or greater risk activities occurred within a small sub-set of sampled vectors, emphasizing the importance of individual variation leading to primary risk events within the pathway. These results suggest that future pathway risk assessments should incorporate patterns of individual variation to determine the distribution of risk activities among vectors, which in-turn can be used to guide appropriate management and prevention strategies.

NOTES

Predicting the Secondary Spread of *Bythotrephes longimanus* (Spiny Waterflea) in the 2EB Watershed in Ontario

Erin L. Gertzen *and Brian Leung*
CAISN, McGill University Department of Biology
1205 rue Docteur Penfield, Montreal QC H3A 1B1 Canada

The secondary spread of *Bythotrephes longimanus* (spiny waterflea) from the Great Lakes into other inland lakes in Ontario has caused great alarm. This spread likely occurs mainly via recreational boating traffic, but may also occur via other vectors of spread. In efforts to understand and prevent the further spread of aquatic non-indigenous species such as *B. longimanus*, researchers have stressed the importance of developing predictive tools. Such tools help in understanding where and when invasions will occur so that limited resources can be focused in high-risk areas. Spatial spread models, in particular production-constrained gravity models, have been shown to be a powerful means of predicting the secondary spread of aquatic non-indigenous species, specifically by overland human-mediated dispersal. However, the relative contribution of natural versus anthropogenic dispersal has not been integrated in models. Further, the data available to construct these models are often incomplete. Here, we develop a production-constrained gravity model to predict the spread of *B. longimanus* in lakes of the 2EB watershed in Ontario. We extend the model to incorporate both human-mediated dispersal by boating traffic and natural fluvial dispersal, and compare the relative contributions of each vector of spread. We make use of data on invaded and uninvaded lakes in the 2EB watershed from large-scale survey of 300 lakes for *B. longimanus* and develop techniques for sparse data to extend our analysis to the roughly 1200 unsampled lakes. This theoretical model allows us to test the effects of propagule pressure on the spread of *B. longimanus* over a large spatial scale using metrics of natural and anthropogenic propagule pressure and sparse data.

NOTES

An Alternative Hypothesis for Invasional Meltdown: General Facilitation by *Dreissena*

Kristen M. DeVanna, *Betsy L. Bodamer, Erin Hammer, Colleen G. Wellington, Jonathan M. Bossenbroek and Christine M. Mayer*
University of Toledo, Lake Erie Center and Department of Environmental Sciences
6200 Bayshore Road, Oregon, OH 43618 USA

Biological invasions occur naturally, but the rate has been rapidly increasing, leading to the collapse of biogeographical barriers and a loss of regional biotic distinctiveness. One proposed reason is that early invaders alter environmental conditions in a way that makes the environment more suitable for later species to establish and grow. The idea of facilitation has been expanded to the concept of 'invasional meltdown', where an organism modifies the habitat to favor non-indigenous over native species. The Laurentian Great Lakes have been used as an example of invasion meltdown; however, we suggest an alternative explanation for the observed trend. We hypothesized that strong interactors, such as *Dreissena* spp. (i.e., zebra and quagga mussels) modify the environment, resulting in population level changes in both native and non- indigenous species. Literature reviews were conducted on native and non-indigenous species of benthic invertebrates, fish, macrophytes, and phytoplankton that have known interactions with *Dreissena* and determined if the interactions were positive, negative, or no effect. There was little conclusive evidence that *Dreissena* are strong facilitators of fish or are strongly facilitated by non-indigenous phytoplankton. *Dreissena* strongly facilitated macrophytes and benthic invertebrates; however there was no difference between native and non-indigenous species. Also, the establishment of a species cannot be facilitated by a species that is not yet present at the time of introduction. Therefore, the invasional meltdown theory can only be supported when a 'facilitating' species is introduced prior to the species being facilitated. We examined the year of introduction of each species aiding in the establishment of another invasive species. The order of introduction of the species appears to be random. This analysis further suggested that true 'invasional meltdown' interactions are possible in only about ~50% of the cases analyzed. Although *Dreissena* do facilitate the population growth and expansion of non-indigenous species, we have shown that *Dreissena* proportionally facilitate as many native species as non-native species. We suggest that *Dreissena* cause strong interactions and change the benthos in a way that facilitates many organisms, but that invasional meltdown is not occurring in the Great Lakes.

NOTES

Alien Invasive Species at the Romanian Black Sea Coast – Present and Perspectives

Marius Skolka *and Cristina Preda*
University "Ovidius" of Constantza, Natural Sciences Faculty, Department of Biology – Ecology
Mamaia Avenue 142, 900527, Constantza, Romania

The Black Sea has unique morphological and structural characteristics (a young brackish sea that lacks vertical currents) and is one of the most affected seas by biologic invasions. From a total number of approximately 750 alien invasive species reported from Romania, only 68 (9.05%) are marine species. Nevertheless, this small number of species had major impacts on native ecosystems.

Started in the first decades of the 20th century, the process of acclimatization of alien species became more and more evident, especially in the 1970-1990, due to the increasing of commercial changes. In ballast water or fouling, an important number of microalgae, hydrozoans, jelly-fishes, mollusks, crustaceans – copepods, barnacles, crabs, bryozoans and other invertebrates became established in the Black Sea. They originate from different areas: 10% are indo-pacific species, 47% are atlanto-mediterranean species, 22% are north Atlantic and 14% are species with uncertain origin.

Some of these species, like the indo-pacific gastropod *Rapana venosa* (veined rapa whelk), the north Atlantic bivalve *Mya arenaria* (soft-shelled clam), *Balanus improvisus* (barnacle), the indo-pacific bivalve *Anadara inaequivalvis*, the east Atlantic crab *Rhithropanopeus harrisii* (estuarine mud crab), north Atlantic ctenophores *Mnemiopsis leidyi* (lobate comb-jelly) and *Beroe ovata* produced large scale changes in the local ecosystems, replacing native species and affecting the biodiversity of local plankton or benthos associations.

The invasive process continued, and after 2000, new species were mentioned from Romanian Black Sea Coast – like *Musculista senhousia* (Asian mussel), and *Molgula manhattensis* (common sea grape).

The perspective is even worse. The development of the Constantza Harbor and the increasing of the commercial activities in the area represent further opportunities for other marine invasive species, already reported from other parts of Europe.

In these conditions, species like the Asian mussel – a successful immigrant in the Pacific, Atlantic and Mediterranean, cirripeds like *Balanus amphitrite* (striped barnacle) or *Balanus crenatus* (common barnacle) – both of them very common in fouling association, southern Pacific small barnacle *Elimnius modestus*, very common now in western Europe, *Hemigrapsus sanguineus* (Asian shore crab), indo-pacific isopod *Sphaeroma walkeri* etc, are potential invasive species in the Black Sea.

NOTES

Genetic Structure of Native and Introduced Populations of the Charru Mussel *Mytella charruana*

Nancy K. Gillis, Linda J. Walters and ***Eric A. Hoffman***
University of Central Florida, Department of Biology
4000 University Blvd., Orlando, FL 32816 USA

Mytella charruana (the charru mussel) is a marine mussel native to the Pacific coast of Mexico south to Ecuador and the Atlantic coast of South America, and has recently been introduced to the southeast coast of North America. Close monitoring and detailed surveys have revealed a proliferation of this nonindigenous mussel along the Atlantic coast from central Florida up through northern Georgia. This species has the potential to greatly increase in numbers, as densities higher than 11,000 mussels/m^2 have been reported in native waters. The recent introduction, potential ecological threat, and rapid spread make *M. charruana* a model species to study. To understand the potential ecological impacts, routes of invasion and processes of natural selection on introduced species, it is imperative that the evolutionary history of the species be known. In the past, the prevailing view was that invasive populations would display low genetic diversity due to founder effects and bottlenecks. However, researchers have recently documented successful invasions without bottleneck. Thus, the role of admixture versus bottleneck during species' invasion is still debated. In this study we sought to investigate the genetic structure of *M. charruana* and compare variation from nonnative populations to variation found within natural populations from Ecuador and Colombia. Specifically, we analyzed levels of genetic diversity to determine the frequency and size of introductions (i.e., propagule pressure) and the pattern of spread of *M. charruana*. We sequenced 722 bp of the mitochondrial cytochrome oxidase I *(COI)* gene from multiple individuals and sites in the introduced and native ranges. We found higher levels of nucleotide diversity in introduced populations than in native populations, although the number of haplotypes was greater in the native populations. Additionally, mismatch distribution analyses resulted in ragged, multimodal distributions for the introduced populations, a pattern indicative of population admixture. Conversely, mismatch distributions of native populations formed smooth, unimodal distributions, a pattern indicative of populations in static equilibrium. Our data present compelling evidence that the *M. charruana* invasion resulted from admixture of three populations, which combined to form higher levels of genetic diversity in invasive populations. Moreover, our data suggest that one of these populations originated from the Caribbean coast of South America, likely transported in the ballast water of oil tankers. The constant influx of ships dumping ballast water from South America into North American ports in combination with high genetic diversity due to admixture provide ideal conditions for *M. charruana* to further adapt and spread throughout their new environment.

NOTES

Invasion Genetics of the Round Goby (*Neogobius melanostomus=Apollonia melanotstoma*): Founding Sources, Spatial Patterns, and Temporal Changes

***Carol A. Stepien**, Joshua E. Brown, Emily Sopkovich, Douglas Murphy*
University of Toledo, Great Lakes Genetics Laboratory, Lake Erie Center
6200 Bayshore Road, Toledo, OH 43618 USA

The genetic composition and diversity of an exotic introduction are believed to be fundamentally important to its ecological success in new habitats. This study examines these genetic factors for the invasion of the Eurasian round goby *Neogobius melanostomus (=Apollonia melanostoma*), which entered the Lake St. Clair region of the Great Lakes in 1990 via ballast water. The round goby quickly spread and is now one of the most abundant benthic fishes in the lower Great Lakes. We test the central hypothesis of whether the population genetic composition and genetic diversity of the exotic round goby has changed over the invasion's time course or remained static, in addition to analyzing its spatial structure and identifying its likely founding source(s). We sequenced the mitochondrial cytochrome *b* gene and analyze 8 nuclear microsatellite loci for 1300+ round gobies from 25 North American and 22 Eurasian locations, and additionally test temporal patterns from 2-3 time periods (1993-2007) at 5 locations in Lakes St. Clair (including the original invasion site), Erie, and Michigan (subsequent areas of spread). Genetic relationships are evaluated using F_{ST} analogs, neighbor-joining trees, haplotype networks, Bayesian assignment tests, Monmonier barrier analysis, and 3-dimensional factorial correspondence analysis.

Invasion genetic findings for the round goby invasion show: 1) the southern Dnieper River at the port of Kherson in Ukraine was the primary donor population, supplemented by others, 2) the invasion has high genetic diversity and no founder effect, 3) high spatial genetic structuring, 4) some fringe areas fit a "leading edge" model with less genetic variability, whereas others have high diversity with unique alleles from other donor sources, and 5) peripheral sites changed significantly over the invasion's time course, towards a net gain of alleles, whereas the original sites remained stable. In conclusion, the exotic round goby invasion exhibits significant genetic structure, high genetic diversity (with no founder effect), and has undergone temporal change with overall gain of alleles. High genetic diversity and divergence across its invasive range have likely enhanced the round goby's ecological success in the Great Lakes. In addition, spatial genetic structure among the different locations likely reflects both differential introduction histories and local genetic predominance of established colonists. Genetic data thus aid our understanding of the ecological adaptations underlying the round goby's invasion success.

Additional information can be found at http://www.lakeerie.utoledo.edu

NOTES

Biological Invasions in Aquatic Ecosystems of the Lake Baikal Basin

*N.M. Pronin and **Dimitriy V. Matafonov***
Institute of General and Experimental Biology
SD RAS, Ulan-Ude, Buryatia Republic 670047 Russia

B.B. Bazarova
Institute of Natural Resources, Ecology and Cryology
SD RAS, Chita, Russia

Baikal is the oldest and purest freshwater lake with an exceptional diversity of fauna and flora (above 5,000 species), which was declared by UNESCO as a World Natural Heritage Site in 1996. Since the second half of the 20th century, there were an extreme rising number of invasions in Lake Baikal and its basin (Pronin, 1982; Kozhova & Izhboldina, 1993; Mills et al., 1999; Pronin & Bolonev, 2006; Matafonov et al., 2006; Bazarova & Pronin, 2006). Amur sleeper *Percottus glenii* and Canadian waterweed *Elodea canadensis* represent the major invasive species here. By 2002–2005 *E. canadensis* penetrated from the Lake Baikal – Yenisei River basin into the upper tributaries of Lena River and reached the Amur River basin (the border of the World Watershed of Artic and Pacific oceans), as well as *P. glenii* penetrated into the Mongolia area while spreading along the Selenga River invasion corridor. The results of our investigations on biological invasions in the Lake Baikal basin are summarized as the following statements:

- Lake Baikal basin can be considered as the arena of spreading and naturalization of North-American and East-Asian origin species such as *E. canadensis*, muskrat *Ondatra zibethicus* and *P. glenii*, included in the metalist of "Invasive and potentially invasive alien species in Europe" (2007) of Bern Convention (1979). On the other hand, Lake Baikal itself is the source for dispersion of potentially invasive species both westwards and towards Pacific Ocean through the Amur River basin (e.g., Baikalian subendemic species of amphipods *Gmelinoides fasciatus* and *Micruropus wohli*);
- The intentional introduction of alien aquatic animals for fishery was a main vector of invasions in the Lake Baikal basin last century. The unintentional invasions owing to fishing and recreation, as well as self-settling invasive species along aquatic corridors, are vectors of its spreading at present;
- The expansion of alien species has a significant negative impact on the regional economics by decreasing of fish resources and recreational potential of aquatic ecosystems. The clear positive economical effect is observed only from the naturalization of muskrat *O. zibethicus;*
- The naturalization of alien species has a major ecological impact on the simple ecosystems, where such species have not enemies and can essentially change communities. Accordingly, the impact of alien species on aquatic ecosystems with higher diversity of species and complex structure of communities, especially phytocenoses, is negligible;
- The alien species of aquatic plants (*E. canadensis*) are able to modify the environment by making habitats suitable for phytophilic organisms;
- The spread and impact of alien species depend on the seasonal and long-term fluctuations of water level, natural and anthropogenic eutrophication of water bodies;
- Watershed of Arctic and Pacific oceans at the territory of Baikalian Siberia is a weak barrier for biological invasions.

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NOTES

Introduction of Aquatic Organisms to Thailand Via Aquarium Trade

Suchana Chavanich *and Voranop Viyakarn*
Chulalongkorn University, Faculty of Science, Department of Marine Science
Bangkok 10330, Thailand

Visut Baimai
Biodiversity Research and Training Program, NSTDA Building
Rama VI Road, Rajdhevee, Bangkok 10400 Thailand

The purpose of this study was to investigate the species of aquatic animals that were introduced to Thailand for the aquarium trade purpose, and to assess the possible impact that may be caused by this introduction pathway. The study was done by using questionnaire surveys distributed to owners or employees of shops around Chatujak area and aquarium shops located in Bangkok. The results from the surveys and questionnaires showed that most marine organisms were imported from overseas while most freshwater organisms were from Thailand. Even though, majority of freshwater organisms sold were originally from other countries, at present, most of them can be cultured in Thailand. The results from the surveys also showed that if marine aquarium organisms could not be sold for a long time, they would be kept in shops until they could be sold since their prices were high. In contrast, some freshwater organisms were release to natural habitats if they were not sold for a long time due to low prices and lack of spaces. Therefore, the freshwater aquarium organisms tend to have higher impact on the natural habitats compared to the marine aquarium organisms. In addition, the results from the surveys showed that majority of the aquarium traders do not know the meaning of the word "introduced species". Therefore, more education and awareness of the introduced species are needed.

NOTES

Overview of U.S. Bureau of Reclamation Water Systems and Their Invasion by Quagga and Zebra Mussels

Fred L. Nibling, Jr.
U.S. Bureau of Reclamation, Technical Service Center
P.O. Box 25007 (86-68220), Denver, CO 80225-0007 USA

The Bureau of Reclamation is the largest supplier of water in the United States, delivering ten trillion gallons annually. Over 10.6 billion dollars (USD) have been spent on Reclamation projects since its origin in 1902. The agency has constructed over 500 dams, 52 hydropower plants, 68,400 miles of canals and other conveyance and distribution facilities, and hundreds of recreational and environmental enhancement/protection facilities. Virtually none of these structures was built with design considerations necessary to contend with biofoulers having the capabilities of quagga and zebra mussels. Quagga mussels were first discovered in Lake Mead on the Colorado River in January 2007. Since then, both quagga and zebra mussels have been found in a number of other Reclamation facilities. Major problems in Western water facilities with the arrival of these mussels can be grouped into three categories: physical obstruction (ranging from friction or roughening to complete blockage of water flow), chemical degradation (corrosion), and deterioration of ecosystems (food chain depletion and altered water quality). The water systems in the West are in many ways quite different from those which have been affected by the zebra mussel in the eastern United States, and it is likely that new problems will arise which will require new approaches and techniques for solving them. The discussion will include Reclamation's ongoing response to this developing problem and associated issues.

NOTES

The Quagga Mussel: Dealing with an Invasive Species

Leonard Willett
U.S. Bureau of Reclamation, Lower Colorado Dams Office
LCD-2300, PO Box 60400, Boulder City, NV 89006-0400 USA

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

Response of Southern Nevada Water Authority to the Quagga Mussel Invasion of Lake Mead

Peggy Roefer
Southern Nevada Water Authority
PO Box 99954, Las Vegas, NV 89193-9954 USA

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.

Response by local, state, and federal agencies to the presence of quagga mussels was immediate. All impacted agencies began inspections of their infrastructure for quagga mussels. The extent of the infestation was evaluated visually by weeks of continuous diver surveys and by collection of water samples in search of veligers, the free-floating form of quagga mussels. Numerous regional and local meetings, that included expert scientists and resource managers, were held to develop a response plan to this potentially disastrous invasion.

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.

This presentation will focus on the response by Southern Nevada Water Authority to this invasion. It will discuss the proactive steps take to protect the SNWA assets, cooperation with other stakeholder on Lake Mead and future plans for quagga mussel control.

NOTES

Salt River Project and the Threat of Dreissenid Invasion in the Southwest

Lesly Swanson
Salt River Project Environmental Services
Mail Station PAB352, PO Box 52025, Phoenix, AZ 85072-2025 USA

Quagga and zebra mussels have recently crossed the continental divide. Salt River Project (SRP) manages a system of six reservoirs and over 1100 miles of canals in the desert southwest. These desert lakes are located within easy driving distance of existing invasions. The lakes provide a source of water recreation for the local cities and towns and habitat for a number of wildlife species and are the primary source of water for the metropolitan Phoenix area.

SRP is 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 920,000 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 infected 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.

SRP has undertaken a comprehensive risk assessment project to evaluate the likelihood of dreissenids establishment in the various portions of their system and to determine the potential impact dreissenids may have on SRP facilities. The assessment is examining all facilities, which have a direct surface water connection, the series of reservoirs, dams, electrical generating facilities and canals operated by SRP.

This presentation will describe the process and the outcome of this risk assessment as well as the public outreach SRP is doing to help prevent further infestations.

NOTES

Exercise Those Mussels: Building Dreissenid Response Readiness Through Mock Drills

Paul Heimowitz
US Fish and Wildlife Service, Region 1
911 NE 11th Ave., Portland, OR 97232-4181 USA

Stephen Phillips
Pacific States Marine Fisheries Commission
205 SE Spokane Street, Suite 100, Portland, OR 97202 USA

Recognizing that no prevention method is fool-proof, many jurisdictions are investing in rapid response planning as an important second-line of defense. Response plans can significantly enhance the capacity for agencies to make timely decisions after discovery of a new aquatic invasive species. However, these plans are not worth much if they are simply shelved after completion. As with fires, oil spills, and other emergency incidents, AIS plans need to be tested and exercised regularly. This presentation will focus on a new exercise program developed to build rapid response preparedness for zebra and quagga mussels in the Columbia River Basin (CRB).

The CRB Team of the 100th Meridian Initiative held an innovative exercise in October 2007 to help guide completion of the *Columbia River Basin Interagency Invasive Species Response Plan: Zebra Mussels and other Dreissenid Species.* Beyond stimulating changes to the plan and other preparedness actions, this event generated useful lessons about general tactics for AIS response exercises. Those lessons have been applied to create a five-year exercise strategy for the Columbia Basin. This strategy addresses a number of objectives, such as building response team relationships, enhancing capacity to make decisions on eradication and pathway management, testing notification effectiveness, and evaluating response at specific high-risk water bodies. Each exercise will focus on a subset of these objectives with the intent to collectively test all of them over the five-year cycle (recognizing that an actual introduction into the CRB will end that path). Although most objectives will be met via "table-top" drill formats, some actual personnel and equipment deployment is also planned. A multiagency ad hoc work group relevant to the individual scenario will design and organize each exercise. Ultimately, this approach will not only raise awareness and build preparedness regarding the threat posed by dreissenid mussels to the Pacific Northwest, but should also benefit geographic-based rapid response planning for any invasive species.

NOTES

Quagga and Zebra Mussels: Are They a Major Cause of the Botulism E Epidemic? Could it Happen Out West?

Daniel P. Molloy*, Kimi C. Nishikawa, and Denise A. Mayer*
New York State Museum, Division of Research and Collections
51 Fish Hatchery Road, Albany, NY 12230 USA

Over the last decade, an epidemic of botulism type E has caused the deaths of thousands of fish and birds in the Great Lakes. The botulinum E neurotoxin is secreted during normal metabolism of the anaerobic bacterium *Clostridium botulinum* and can cause paralysis and death upon ingestion. The exact mechanisms causing this outbreak remain unknown. A popular theory holds that *Dreissena* spp. (quagga and zebra mussels) have played a major role in causing the epidemic, and although there is some evidence to support this theory, conclusive proof has yet to be provided. Two primary mechanisms of mussel involvement have been proposed by researchers:

1) Habitat Alteration: The presence of dreissenid populations may result in an increase in oxygen-deprived benthic sediments, thereby providing the anaerobic conditions leading to increased *C. botulinum* densities. It is well documented that the filter feeding of dreissenids promotes the growth of benthic algae (e.g., *Cladophora*), and it has been suggested that the autumn algal die-off may create the anoxic benthic conditions needed for *C. botulinum* population growth.

2) Food Web Contamination: Filter feeding by dreissenids may lead to their contamination with *C. botulinum* and/or the neurotoxin itself, and consumption of the dreissenids by fish, primarily round gobies, may thus be a primary path leading to intoxication of the fish themselves and also the birds that prey on these fish. There is clear evidence that *C. botulinum* is present in dreissenids. Whether dreissenids are essential for passing the neurotoxin up the food web, however, has yet to be determined since *C. botulinum* has been detected in many benthic aquatic invertebrates that are potential prey for fish.

One or both of these mechanisms might be responsible for the epidemic, but far more comprehensive data are required to clearly validate these hypotheses. Such data, however, will be difficult to obtain without a breakthrough in development of a detection assay for botulism toxin E. A rapid, sensitive, and inexpensive assay for quantification of this toxin will be crucial for tracking its transmission pathway through the aquatic ecosystem. For detection of the toxin before it becomes concentrated at the upper levels of the food web (e.g., dying birds), this assay should ideally have a higher sensitivity than the mouse assay the current "gold standard" test for botulism toxin. The new assay would also have to be much more cost-effective than the mouse assay, whose expense currently prohibits its large-scale use to quantify the toxin from the hundreds of field samples (e.g., sediments, invertebrates, vertebrates) that would be required in a comprehensive toxin transmission pathway study. Unfortunately, other quantification assays in current use are also limited by expense or poor sensitivity. Thus, the development of a rapid, sensitive, and inexpensive assay for quantifying botulinum E toxin in environmental samples is a very high priority. Its establishment will be critical for accurately delineating the role dreissenids play in this outbreak.

Until the complex events responsible for causing this epidemic are better understood, there can be little confidence in predicting the location and severity of these botulism E outbreaks. This epidemic has been thus far confined to the Great Lakes region, but because its causes are so poorly understood, the likelihood of its spread to other regions of North America also can not be accurately predicted.

NOTES

The Wilh. Wilhelmsen Group Ballast Water Treatment Initiative

Iver Iversen
Wilhelmsen Ships Equipment
PO Box 33, Oslo, Lysaker, NO-1324 Norway

Wilhelmsen Ships Equipment (WSE), part of Wilhelmsen Maritime Services and a Wilh. Wilhelmsen group (WW) company, is introducing a ballast water treatment (BWT) system in the marine market. The system is currently going through IMO testing procedures.

The paper will describe the process of technology selection and the process of testing the system. Included is a description of land based testing scheduled for summer 2008 and testing onboard the WW ro-ro vessel MV ”Toronto” in late summer, after the system is installed during dry-docking in July.

The paper will also discuss: selection criteria, system description. features and benefits, test results from land based testing, experience gained from the retrofit installation on MV ”Toronto” and results from ship board testing. The system utilizes a combination of ultrasonic cavitation, low level ozonation and chlorination. Key design features are compact size, flexible installation, low energy consumption and full scalability.

Wilhelmsen Ships Equipment is a world class marine equipment provider with over 60 years of experience in supplying safety, environmental and thermal insulation systems for new builds and retrofits in the marine and offshore markets. The company is the largest of its kind and is a global market leader, present in all the major shipping and shipbuilding markets. Wilhelmsen Ships Equipment always demands excellence in qualities and services. All products are tested and accepted by major international Classification Societies. The company provides after sales service through its associate, Wilhelmsen Ships Service with local expertise at 390 sites and serving 2200 ports in 116 countries. Our organization has for a long time been involved in evaluating and now developing Ballast Treatment Systems, and would like to use this opportunity to present our position and our experience: Trust us to protect your people, your assets and the marine environment.

NOTES

Continuous Treatment (UV or UV Advanced Oxidation Plus Filtration) of Ballast Water in Closed-loop Processing Proves Viable

Linda Sealey, *William Cairns and Brian Petri*
Trojan Technologies
3020 Gore Road, London, ON N5V 4T7 Canada

This project was completed with the support of Transport Canada and with large contributions from Trojan Technologies, Dalhousie University, BallastSafe™ Filtration Company and Balaena Dynamics Ltd. Full-scale testing was completed from May through November, 2007 at the Aquatron Facility, Dalhousie University in Halifax, Nova Scotia. Test protocols were in keeping with International Marine Organization (IMO) guidelines for full-scale land-based testing of Ballast Water Treatment Technologies, IMO guidance document G8.

Two and three-unit processes including a BallastSafe™ 40 µm filtration system and a TrojanUV Swiftsc™ low pressure disinfection system, with and without hydrogen peroxide (advanced oxidation), were tested to determine the benefits of various closed-loop treatments for the removal or inactivation of a wide range of organisms in ballast water.

Testing was performed with both salt and fresh-water seeded zooplankton and phytoplankton, as well as various bacteria and a bacteriophage (5 fresh and 6 marine organisms). All biological analyses were performed by third party laboratories and consultants.

Closed-loop treatment was shown to be a viable and potentially more cost effective solution than single-pass treatment. Advanced models developed during the study allowed accurate prediction of the performance of closed-loop treatment, which in turn allows effective design, monitoring and control of treatment and makes meeting regulatory compliance feasible. Recirculation offers complimentary benefits for ballast water treatment (BWT), which can meet or potentially exceed IMO requirements.

NOTES

Methods for Measuring the Impact of UVC Treatments on Marine Phytoplankton

Charles G. Trick
Schulich School of Medicine and Dentistry, Ecosystem Health
London, ON N6A 5C1 Canada

Brian Petri and Linda Sealey
Trojan Technologies
3020 Gore Road, London ON N5V 4T7 Canada

***Benjamin F.N. Beall** and André Morson*
University of Western Ontario, Department of Biology
1151 Richmond Street, London, ON, N6A 3K7 Canada

The introduction of aquatic invasive species through the discharge of ballast water creates serious environmental and ecological changes. Among the various classes of organisms that are possible ballast water invaders, phytoplankton are not easily removed in conventional filters. We set out to investigate the ability of UVC radiation to act on phytoplankton.

Our first goal was to develop the proper metrics for measuring the effect of treatment. It is important to recognize that for preventing the establishment of a new species, cell death may not be necessary, rather the prevention of replication is sufficient. Metrics that evaluate living versus non-living organisms, or presence versus absence, have the potential to mask the effectiveness of a treatment, as was the case for early evaluations of UV on *Cryptosporidium*. Studies using vital dyes concluded that extremely high UV doses were required, while later infectivity studies showed that extremely low UV doses were sufficient to prevent replication and thus prevent infections, leading to the widespread adoption of UV for treating municipal drinking water at very economical levels.

Recognizing this principle is important for determining a suitable metric of treatment impact for phytoplankton. The most reliable metric/method, is to attempt to grow treated phytoplankton, and measure the growth in some manner. The most probable number (MPN) method, that examines replicate dilutions of a sample for growth or no growth, is a simple and reliable technique but requires a lengthy grow out period and is highly labour intensive. We used MPN as a basis for comparison and examined multiple flow-cytometry-based criteria of viability, such as number of intact cells, DNA-replication rates and cell membrane permeability. These methods were chosen to be sensitive to not only complete cell death, but to intermediate states of reduced cell viability.

The different metrics captured different aspects of the germicidal activity of UV, as well as differences between phytoplankton species from different taxonomic lines. High UV doses, particularly with the polychromatic collimated beam, resulted in significant increases in the proportion of phytoplankton cells with damaged cell envelopes. The most-probable-number dilution series metric, on the other hand, indicated non-viable subpopulations within the UV-exposed cultures that were cryptic in terms of membrane integrity or morphology when compared to viable cells, but were unable to grow in optimized culture conditions. Furthermore, there were significant differences in the germicidal effects of UV exposure among the four examined phytoplankton species from distinct taxonomic lines, both in proportion of cells with damaged cell envelopes and in the number of viable cells estimated from the most-probable-number dilution experiments.

NOTES

Differences in the Responses of Marine Phytoplankton to Monochromatic and Polychromatic UVC

Benjamin F.N. Beall
University of Western Ontario, Department of Biology
1151 Richmond Street, London, Ontario, Canada, N6A 3K7

Brian Petri and Linda Sealey
Trojan Technologies
3020 Gore Road, London ON N5V 4T7 Canada

Charles G. Trick and ***André Morson***
Schulich School of Medicine and Dentistry, Ecosystem Health
London, ON N6A 5C1 Canada

Untreated ballast waters contain a diverse community of many taxonomic groups. UV is a potential treatment technology for phytoplankton in ballast water, but there is an absence of UV dose-response information. Within the phytoplankton community there will be many species from evolutionarily disparate classifications – spanning the prokaryotic and eukaryotic division – and each species has a potential of invasion and ecological change. Different phytoplankton groups will likely vary in their sensitivity to UV treatment, which has significant consequences for the design and operation of ballast water treatment devices.

In this study we developed monochromatic (254 nm) and polychromatic UVC dose-response curves for phytoplankton. We examined four different phytoplankton species from four different taxonomic groups (cyanobacteria, Class Raphidophyceae, Class Bacillariophyceae, Class Prymnesiophyceae). The key comparisons in this study were eukaryotic vs. prokaryotic species and flagellates vs. diatoms, in order to examine if the germicidal effects of UV exposure were similar across the major phytoplankton taxonomic groups.

Cells were exposed to monochromatic 254 nm UVC and polychromatic UVC, using low pressure and medium pressure UV collimated beams respectively. Germicidal action was examined using flow cytometry based metrics of cell viability (FACS Calibur flow cytometer with the cell-permeable SYTOX stain; and FlowCam image particle analyzer with viable cell marker, FDA) and most probable number methods of post-treatment survivors capable of growth.

An evaluation of the health of the cells after UV collimated beam treatment confirmed that the diatom (*Thalassiosira weissflogii*) was the most sensitive to UV exposure. The cyanobacterium, *Synechococcus* strain 8101, was the most resistant to treatment, and the flagellates *Tetraselmis* (*Prymnesiophyceae*) and *Heterosigma* (*Raphidophyceaa*) were intermediate between the diatom and the cyanobacteria in terms of UV sensitivity. These findings are key knowledge required for the design of standardized germicidal treatment regimes.

NOTES

Predation as a Component of the Risk of Establishment by Rusty Crayfish in Lakes

Darren C.J. Yeo*, Christopher L. Jerde, Ashley Baldridge and David M. Lodge*
University of Notre Dame, Department of Biological Sciences
PO Box 369, Notre Dame, IN 46556 USA

Rusty crayfish (*Orconectes rusticus*) invasions greatly modify lake ecosystems through extirpation of native crayfish species and reduction of benthic macroinvertebrate, macrophyte, and panfish abundance or diversity. While predation has been shown to play an important role in the establishment of invading *O. rusticus*, the influence of depth on crayfish predation risk in lakes has yet to be examined. Using field tethering experiments, we investigated patterns of predation risk on different sizes of rusty crayfish with respect to two water depths and two littoral zone habitat types in multiple lakes in northern Wisconsin. Specifically, we tested the hypotheses that predation risk on rusty crayfish in lakes will be greater: in shallower (1.0 m depth) rather than deeper (¾ Secchi depth) sites; in vegetation rather than sand littoral habitats; and for smaller (15–18 mm carapace length) rather than larger (23–26 mm) crayfish. Using time-to event survival analysis, we evaluated the predation rate and estimated daily probability of predation across the different treatment groups in four lakes. Results indicated that crayfish in deeper sites tended to experience higher predation risk; predation among habitats appeared to be size-specific, with vegetation and sand habitats being associated with higher predation risk for smaller and larger crayfish, respectively; and smaller crayfish generally were more vulnerable to predation in some, but not all, situations, e.g., small crayfish at deep vegetated sites in Island Lake had a lower daily probability of predation (ca. 0.1 vs. 0.2) than medium crayfish at the same site. Such exceptions point to possible independent lake-specific effects, which we hypothesize to be due in part to differences in predatory fish communities as well as interactions with crayfish size and variable predation rates at different depths and habitats. Based on our findings, the model that best predicts the predation risk on rusty crayfish would include depth, habitat, and crayfish size, which in turn could serve as a useful indicator to predict the risk of establishment of rusty crayfish in a lake.

NOTES

Predicting Future Great Lakes Invaders: Global Datasets of Shipping Traffic and Environmental Conditions Identify High-Risk Shipping Routes

Reuben P. Keller*, Mark Drew and David M. Lodge*
University of Notre Dame, Department of Biological Sciences
PO Box 369, Notre Dame, IN 46556 USA

John M. Drake
University of Georgia, Odum School of Ecology
Athens, GA 30602 USA

The North American Great Lakes are one of the most highly invaded ecosystems in the world. Additionally, the Great Lakes have served as a beachhead for a broader invasion of North American waterways by several invaders. Preventing further ship-borne invasions of the Great Lakes from shipping is thus a priority for protecting the Great Lakes and all North American waterways. Shipping traffic connects the Great Lakes to ports around the world. The chance that an individual port will be the source of new invasions depends largely on two factors. First, the number of ships traveling from ports to the Great Lakes will be an index of propagule pressure. The higher the propagule pressure, the more likely that species from any given port will become established in the Great Lakes. Second, species are more likely to become established in the Great Lakes if they are introduced from ports that have similar environmental conditions. We have conducted a global analysis of shipping patterns and environmental similarity of ports to determine on a port-by-port basis the risk of new invasive species becoming established in the Great Lakes. First, we used a global database of individual ship movements to determine the ports that ships most commonly visit on their voyage to the Great Lakes. Over a 12 month period in 2005-06 a total of 499 ships entered the Great Lakes from 244 different ports. These ports are widely distributed around the world, but show concentrations in Western Europe and the Mediterranean, East Asia, and the East and West coasts of North America. Next, we compiled a dataset of the temperature and salinity profiles for ~6,500 global shipping ports. These range from tropical marine ports to river ports that are far inland. Principal Components Analysis was used to give a measure of environmental similarity between the Great Lakes and each of these ports. We have combined the shipping and environmental similarity datasets to identify ports most likely to be the sources of new Great Lakes invasions. This information could be used to target high-risk shipping routes for extra management, and/or to lower the management burden for ships traveling low-risk routes.

NOTES

GlobalFish: An Environmental Matching Tool for Freshwater Organisms

Nicholas E. Mandrak
Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences
867 Lakeshore Road, Burlington, ON L7R 4A6 Canada

A key element to identifying the risks of potential aquatic invasive species (AIS) is their potential distribution. There are many different statistical methods for predicting the distributions of species; however, most of these methods are time, computer resource and data intensive. There is often a need to rapidly determine the potential distribution of AIS. We have developed a tool that allows the user to rapidly predict the potential distribution of any freshwater taxa at the scale of the major watersheds of the world (~600). The tool measures the environmental match, using standardized Euclidean distance, between the specified range of a species and all other global watersheds. The match is based on readily available global datasets for climate, hydrology and topography. This approach tested favourably when compared to the native and introduced ranges of snakehead and Asian carp species. The tool has a Windows interface and provides the user the option of choosing taxa with distribution data already in the tool, or by point-and-click identification of watersheds on a map. The tool also allows the user to select the environmental variables to be used in the matching, and a map of the results. Although not a replacement for more powerful environmental modeling of species distributions, GlobalFish provides a rapid method for predicting the distributions of AIS at the broad global scale.

NOTES

Effects of an Invasive Catfish on Aquatic Macroinvertebrates

Craig Duxbury
Walt Disney International R&D
Lake Buena Vista, FL 32830 USA

Jeff Holland
RCID Environmental Services Laboratory
Bear Island Road, Lake Buena Vista, FL 32830 USA

Marianne Pluchino
Seminole County Public Works, Surface Water Quality Department
Sanford, Florida 32771 USA

There are over 100 species of nonindigenous fish in Florida. The brown hoplo (*Hoplosternum littorale*) was recently (1995) introduced into Florida, and has rapidly expanded throughout much of the state. Because of its life-history traits, and ability to tolerate extreme environmental conditions, this fish may be one of the most invasive fish species ever introduced to Florida. There is concern that this fish may impact native invertebrate populations, which could have implications to the sustainability of native fishes that feed on invertebrates, and to the accuracy and success of invertebrate-based biomonitoring programs. an approach commonly used in Florida to assess water quality.

Using a cage experiment, we tested the hypotheses that these fish may alter macroinvertebrate assemblages in a central Florida stream. We compared the assemblage of macroinvertebrates that developed on artificial substrates (AS) after placing them in cages with and without fish for 28 days. Our experimental design consisted of two treatments (fish and no-fish), and five cages per treatment. Two fish per cage were placed in the fish-treatment cages. Fish were weighed, measured, and stomach contents were identified. By comparison, macroinvertebrates from a stomach of one fish caught in the study area were also identified. Dissolved oxygen, temperature, and velocity were measured once per week.

We identified a total of 1,998 macroinvertebrates from the AS. There were about 31% fewer organisms from the fish-treatment AS, as compared to the no-fish cages. We identified a total of 16 taxa from the AS and found the diversity of macroinvertebrate taxa was reduced by about 50% in the fish-treatment AS. The three most abundant taxa were Chironomini, oligocheates, and gastropods, accounting for about 99 and 97% of the total number of organisms on the no-fish and fish-treatment AS, respectively. Multivariate analyses suggested that macroinvertebrate assemblage structure was significantly different between fish and no-fish treatments ($p=0.03$). Numbers of Chironomini were reduced by about ½ in the fish-treatments. Oligocheates were found in greater numbers in the fish-treatment AS, than the no-fish treatments. Invertebrates in stomachs from caged fish were similar to those found on the artificial substrates. The two most abundant taxa found in stomachs from caged fish were Chironomini and *Hyalla* spp., comprising 87 and 6% of the total number. By comparison, there were a greater number of macroinvertebrate taxa from the stomach of the fish caught in the study area; however, Chironomini were still dominant, accounting for about 34% of the total numbers.

It is thought these fish affected macroinvertebrates on the artificial substrates by direct predation or disturbance. The results suggest that the hoplo catfish can adversely impact native macroinvertebrate assemblages, which in turn can result in spurious biomonitoring results

NOTES

The Role of *Balanus improvisus* in the Present Macrobenthic Communities in the Gulf of Gdańsk, Southern Baltic

Anna Dziubińska *and Anna Szaniawska*
University of Gdańsk, Institute of Oceanography
Al. M. Piłsudskiego 46, 81-378 Gdynia, Poland

The barnacle *Balanus improvisus* (Darwin, 1854), native to North America, was first recorded in the Baltic Proper in 1844. As fouling communities of Southern Baltic are now dominated by *B. improvisus*, it has strong influence on the assemblages' structure and development.

The main aim of the research was to describe the role of *B. improvisus* in the succession process in marine fouling communities in the Gulf of Gdańsk.

The experimental set – up consisted of 120 PVC panels (15 x 15 x 0.3 cm thick) fixed to the rope construction. Investigations were focused on the settlement of barnacles and further development of macrobenthic communities on artificial substrate. Three panels were collected every week during the season of barnacles intense recruitment. The fouling process on natural hard bottom in the Gulf of Gdańsk was checked, too.

Green algae *Cladophora rupestris* firstly settled on the panels. The barnacle *B. improvisus* settled, respectively. It became the most abundant species and dominated communities by the end of the study. During the last phase of the experiment, the blue mussel *Mytilus trossulus* increased in abundance (from 0 – 5 % to > 60 % of community) and strongly competed with *B. improvisus* (> 60 % of community). *M. trossulus* appeared later on the settlement substrata than *B. improvisus,* but quickly formed a compact layer covering the already – established barnacles.

Three stages of the community development, with focus on the relationship between barnacles and blue mussels, can be distinguished: competition for space, coexistence, competition for food. As a result, mussels hindered the nourishment of *B. improvisus* as they covered barnacles completely. The investigations of natural hard substrate, i.e., rocks and hydrotechnical constructions, also revealed the double – layer character of communities which mainly consists of barnacles and blue mussels.

The study proved that the layer of barnacle shells is a good substrate for *M. trossulus* and therefore, for the further development of macrobenthic community. It is also known that empty shells of the barnacle serve as new microhabitats for small annelids, crustaceans and chironomids.

NOTES

Vectors of Introduction, Spread and Potential Impacts of Exotic Freshwater Gastropods in Southern U.S.

Alexander Y. Karatayev, *Lyubov E. Burlakova*
Buffalo State College, Great Lakes Center
1300 Elmwood Avenue, Buffalo, NY 14222 USA

Vadim A. Karatayev
City Honors School
186 East North Street, Buffalo, NY 14204 USA

Dianna K. Padilla
Stony Brook University, Department of Ecology and Evolution
Room 678 Life Sciences, Stony Brook, NY 11794-5245 USA

Although ballast water is the main vector of initial introduction of exotic species in coastal regions of the North America and their connected waterways, other important vectors, such as the aquarium and ornamental trade and associated activities, could be more important in areas far from ports with ballast water and in warm climates suitable for many subtropical and tropical plants and animals typically found in the aquarium and ornamental trade. These vectors are likely to result in different patterns of introduction than ballast water, and the ecological impacts of exotic species introduced by aquarium and ornamental trade may also be different from those introduced by ballast water. In addition, the set of species introduced through aquarium and ornamental trade is usually quite different than that of ballast water introductions, especially for freshwater species. We examined the distribution, vectors of introduction, and potential ecological impacts of freshwater exotic gastropods in Texas over the last 45 years, and suggest that they may be indicative of freshwater invertebrates in general introduced through the aquarium trade and related activities. A total of 9 species of gastropods are reported to have been introduced into the freshwaters of Texas. Of these, only five species currently have currently active populations: channeled-type applesnail (*Pomacea insularum*), red-rim melania (*Melanoides tuberculatus*), quilted melania (*Tarebia granifera*), giant rams-horn snail (*Marisa cornuarietis*), and Chinese mysterysnail (*Cipangopaludina chinensis*). All of these species were introduced through activities associated with the aquarium and ornamental trade. The rate of spread of these exotic gastropods in Texas varied in several orders of magnitude and varied from a typical exponential expansion to virtually no spread through time. Presently, all exotic gastropods in Texas, with the exception of *P. insularum*, are found in thermally stable aquifer-fed springs and spring-fed rivers and ponds, which contain numerous endemic and endangered species, and thus pose serious environmental threats to these fragile habitats and the species they contain. Negative ecological impacts of these exotics are likely to include competitive exclusion of natives, and the introduction of parasites that can imperil fish and birds, including federally-protected species. These results highlight the importance of aquarium and ornamental trade and associated activities as important sources of freshwater invaders, as well as the need of both regulation and public education to reduce the negative consequences of future introductions and the spread of exotic species.

NOTES

Is the Chinese Mitten Crab *Eriocheir sinensis* Threatening Baltic Coastal Ecosystem?

Monika Normant *and Anna Szaniawska*
University of Gdańsk, Institute of Oceanography
Al. Marszałka J. Piłsudskiego 46, 81-378 Gdynia, Poland

The Chinese mitten crab *Eriocheir sinensis* a species that originated from eastern Asia is one of two brachyuran immigrants to the Baltic Sea, where its occurrence was recorded for the first time almost eighty years ago. Although the low salinity of the Baltic waters is the factor limiting larval development in this species the rapid increase in its abundance has been observed during the last several years. Unlike the data on occurrence, distribution and specimen characteristic still little is known concerning functioning and the impact of this species on the Baltic ecosystem. Therefore we studied some aspects of ecology and physiology of this species to supply missing information and to help in estimation of *E. sinensis* influence on the native communities.

Large crabs which occur in the coastal waters of this reservoir (carapace width 3.5-8.8 cm) might be the serious threat to local biodiversity. *E. sinensis* is an omnivore which does not have natural enemies. Analyses of stomachs of 59 adult mitten crabs (carapace width 4.3-8.2 mm) collected in years 2005-2007 have shown that bivalves, followed by crustaceans, gastropods, fishes and polychaetes were the most abundant among animal items. Vegetable matter was found in stomachs of only 12% of crabs. Results of laboratory experiments on food preferences were in agreement with field data: blue mussel *Mytilus trossulus* was the most consumed food item among four offered. According to the carapace width (5.4-6.8 mm) *E. sinensis* consumed from 0.24 to 0.72 g of the blue mussel soft tissue dry mass per day (T=12˚C, S=7psu). Starved crabs (carapace width 5.4-6.8 cm) consume oxygen and excrete ammonia in the rates of 80.4 ± 48.1 μmol O_2 h^{-1} and 3.3 ± 0.6 μmol NH_4 h^{-1}, respectively (T=12˚C, S=7psu). In fed animals both rates increase few times according to quantity and quality of consumed food.

Recent studies showed that *E. sinensis* influences Baltic Sea biodiversity not only through the throphic interactions. Crabs themselves offer habitat for many epibionts, which cover their massive carapaces (barnacles, bryozoans, bivalves, algae) and inhabit dense setal patches on the chelipeds (crustaceans, arachnids, insects, nematodes, bivalves, gastropods). As the Chinese mitten crab can migrate long distances, it might play a role in the transport of native and non-native species to new habitats via its mittened claws.

NOTES

Factors Affecting the Dominance of an Invasive Amphipod (*Echinogammarus ischnus*) in the St. Lawrence River: Interactions with Other Introduced Species

Åsa M. Kestrup *and Anthony Ricciardi*
CAISN, McGill University, Redpath Museum
859 Sherbrooke Street West, Montreal, QC H3A 2K6 Canada

The local abundance of an invader may vary greatly across sites due to positive and negative interactions with resident species, including competitors and predators. An invader's vulnerability to predation may be influenced by both its evolutionary experience with the predator and its ability to compete for refugia.

In the lower Great Lakes, a Ponto-Caspian amphipod (*Echinogammarus ischnus*) has replaced a native amphipod (*Gammarus fasciatus*) on substrates colonized by dreissenid mussels, which provide interstitial habitat that may serve as refugia for small invertebrates. We explored the hypothesis that selective predation by the round goby (*Neogobius melanostomus*), a Ponto-Caspian fish that invaded the Great Lakes in the early 1990s and has recently colonized the St. Lawrence River, facilitates the replacement of *G. fasciatus* by *E. ischnus*.

In laboratory experiments, we tested if *E. ischnus* excludes *G. fasciatus* from mussel patches, and if the vulnerability of the native amphipod to predation by gobies is increased in the presence of the exotic amphipod. The laboratory experiments showed no major differences between the amphipod species in their use of mussel patches, either when alone or in each other's presence. Both species were equally vulnerable to predation by gobies.

In field experiments, we tested if gobies exert a stronger negative impact than native benthivorous fishes on the relative abundance of the two amphipods.

Our results suggest that *E. ischnus* is more vulnerable than *G. fasciatus* to native predators, whereas gobies expose amphipods to a higher predation pressure but do not have a differential impact on the native species. We conclude that competition with *E. ischnus* for space does not increase the vulnerability of *G. fasciatus* to goby predation. Therefore, continued colonization of the St. Lawrence River by the round goby will probably not drive the replacement of *G. fasciatus* by *E. ischnus*.

NOTES

Derivation of ‘Functional Responses’ as a Predictive Tool in Invasion Biology: Comparison of Invader *vs* Native Functional Responses and the Effects of Parasitism

Jaimie T.A. Dick
Queen’s University Belfast, Medical and Biological Centre
97 Lisburn Road, Belfast BT9 7BL, Northern Ireland, UK

A ‘holy grail’ of invasion biology is the development of effective methodologies for predicting the identities of future invaders and their impacts on recipient communities. However, predictive methodologies have had limited success, particularly with regard to identification of potentially new and damaging invaders that are still in their native ranges. Invasion history and propagule pressure have proved useful in predicting invasion success, but generally for known invaders and existing impacts. Other methodologies, such as niche modelling, may help predict invasive species spread, but cannot tell us what species are likely to become invasive. Also, with recognized invasion ‘donor hotspots’, such as the Ponto-Caspian, how do we recognize sub-sets of potential new invaders from the thousands of candidates? I argue that a common denominator of many invasive species and their impacts is their pattern of resource use, this often bringing them into competition with natives and/or preying directly on them. Deriving the ‘functional response’, the relationship between resource (e.g., prey) density and consumption rate (e.g., predator efficiency at consuming prey) may be a useful assay to determine future invader identities and impacts. This is because functional responses: 1) can be derived quickly in simple laboratory settings; 2) can be compared within and between natives and invaders, with existing evidence that higher functional responses are associated with invasive potential; and 3) may be conserved within a species in both native and introduced ranges (unlike many traits that differ, e.g., body size), such that functional responses in the native range may predict behaviour and impacts in invasive ranges. Further, functional responses can be used to examine factors that may alter the behaviour of consumers and thus the impact of invasive species. For example, the ‘enemy release’ hypothesis posits that release from predators/pathogens/parasites gives invasive species competitive advantages in their introduced ranges. Invading species may indeed lose parasites during translocations and/or selection may favour parasite resistance during invasion. There has, however, been debate on the credibility of evidence supporting the ‘enemy release’ hypothesis. Further, invaders may bring parasites with them or become infected with native parasites. I used the functional response method to test the effects of parasites on the consumption (predatory) behaviour of native and invasive species. Counter to the ‘enemy release’ hypothesis, parasitized individuals of an invasive species had significantly higher functional responses that unparasitized individuals. Thus, parasites may enhance some invader impacts. Overall, I conclude that, while examination of specific traits of invaders versus natives has proved unsatisfactory in predicting invaders, and any single trait cannot be universally useful in this regard, the generality of using functional responses in predictive invasion biology warrants further examination.

NOTES

Plasticity of Sexual Reproductive Size in Amphipods as a Strong Survival Mechanism During Invasions. A Case Study in a Dutch Lake

Dirk Platvoet
University of Amsterdam, Zoological Museum
Mauritskade 57, 1092 AD Amsterdam, The Netherlands

Gerard van der Velde
Radboud University Nijmegen, Institute for Water and Wetland Research
PO Box 9010, 6500 GL Nijmegen, The Netherlands and
National Natural History Museum Naturalis
PO Box 9517, 2300 RA Leiden, The Netherlands

In Lake Gouwzee, a shallow Dutch freshwater lake, the indigenous amphipod *Gammarus duebeni* and the settled North-American species *Gammarus tigrinus* have been replaced from the stony banks of the lake by the recent Ponto-Caspian invader *Dikerogammarus villosus*. *G. tigrinus* reaches sexual maturity at a small body-size (males 8 mm, females 4 mm body-length), which allows the species to survive in large numbers in the small spaces within the lake bottom. The substrate consists of a combination of sand, gravel, and shell debris. *G.duebeni*, however, matures at a much larger size and for this species no refuge was available, leading to a complete disappearance from the lake.

In neighbouring areas with comparable physico-chemical conditions, where *D. villosus* has not (yet) been found, healthy populations of *G. tigrinus* exist. The average body-size within these populations is much larger than in Lake Gouwzee populations and therefore the assumption seems legitimate that the arrival of *D. villosus* played a major role in the reduction of body-length of *Gammarus tigrinus* in Lake Gouwzee with consequence for their reproductive capacity. A case study of this will be presented.

NOTES

Interference Competition Between Invasive and Native Gammaridean Amphipods, a Matter of Shelter or Intraguild Predation?

Gerard van der Velde
Radboud University Nijmegen, Institute for Water and Wetland Research
PO Box 9010, 6500 GL Nijmegen, The Netherlands and
National Natural History Museum Naturalis
PO Box 9517, 2300 RA Leiden, The Netherlands

Dirk Platvoet
University of Amsterdam, Zoological Museum
Mauritskade 57, 1092 AD Amsterdam, The Netherlands

Rob S.E.W. Leuven
Radboud University Nijmegen, Institute for Water and Wetland Research
PO Box 9010, 6500 GL Nijmegen, The Netherlands

Interactions between gammaridean species are demonstrated in a series of species. The outcome of these interactions between alien invasive and native species as well as between different alien invasive species is frequently ascribed to intraguild predation (IGP) in which a difference in mutual predation is considered the major factor.

However, is this the only factor determining the outcome of competition for food or space between gammaridean species from various origin? Competition for shelter space at day time preceding IGP is perhaps much more important as it determines size dependent distribution, which in itself determines the mechanism to avoid being preyed upon, possibilities of co-existence etc. This is a much faster and more fundamental mechanism determining the outcome of competition between various species than IGP in itself.

This hypothesis is tested by laboratory experiments with invasive as well as native gammaridean species.

NOTES

Testing and Verification of Ballast Water Management Systems

Tor Gunnar Jantsch
Norwegian Institute for Water Research
Gaustadalléen 21, N-0349 Oslo, Norway

Helge Liltved
Norwegian Institute for Water Research
Branch Office South, Televeien 3, N-4879 Grimstad, Norway

NIVA has since 2005 conducted testing of ballast water management systems in accordance with the IMO G8 and G9 requirements for land based and shipboard testing. Tests in full scale have been completed for three vendors utilising different principles for ballast water treatment. The requirements of the IMO guidelines have posed a number of challenges with regards to the physical infrastructure of a land based test facility, including size (>200 m^3/h flow and 5 day storage for >200 m^3 treated and control water), the chemical and biological water quality of test water (salinity, content of particulate and organic matter, and high densities of algae and zooplankton), and analysis of viability of organisms (differentiation of living and dead organisms). Analysis of disinfection by-products and evaluating the environmental risk of treated ballast water using various toxicity-test, bioassays and risk assessments have been important tools to describe and evaluate the potential risk of treated ballast water to the environment upon discharge. The presentation will give an overview of the practical experiences gained with full-scale land based and shipboard testing according to IMO requirements.

NOTES

Shipboard Trials of a Ballast Water Treatment System for U.S. and IMO Approval – A Case Study

David A. Wright
University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory
PO Box 38, Solomons, MD 20688 USA

Marcel Veldhuis and Frank Fuhr
Royal Netherlands Institute for Sea Research
PO Box 59, 1790 AB, Den Burg, TEXEL, The Netherlands

Regulations for the mitigation of aquatic nuisance species introductions via ballast water differ significantly among International Marine Organization (IMO) guidelines and recently enacted U.S legislation at the federal and state level. The April 2008 U.S. Coast Guard authorization Act (HR 2830) contains treatment standards considerably more stringent than IMO G8 standards, and even more stringent standards were adopted in January 2008 by the state of California. Shipboard testing of ballast water treatment systems is mandated by both IMO under G8 (and G9) guidelines, and by the U.S. Coast Guard under the auspices of the Shipboard Technology Evaluation Program (STEP).

We report here on the 'lead-off' STEP trial conducted simultaneously with a shipboard trial for G8 approval submitted to the UK Maritime and Coastguard Agency (MCA) via Lloyds Register, MCA's designated technical representative. Shipboard trials form a supplementary component of the G8 approval process, which relies primarily on a comprehensive matrix of land-based tests. The system chosen for these trials was a combination filtration and UV ballast water treatment system marketed by Hyde Marine Inc. of Cleveland Ohio, U.S. All land-based tests were conducted by the Netherlands Institute of Oceanography, Texel, Netherlands. Shipboard trials were conducted aboard the cruise ship M/V *Coral Princess* under normal operating conditions during the vessel's winter schedule in the Caribbean and the summer schedule in Alaskan and British Columbian waters.

Test results from both land-based and shipboard trials will be presented as part of a case study illustrating the difficulties of dealing with different standards and jurisdictions, as well as the pros and cons of shipboard testing and implications for future compliance testing. The importance of sampling design will also be considered. Data will be discussed within the context of differing international standards and will be used to illustrate some of the remaining inconsistencies in biological endpoint determination and reporting.

NOTES

Land-based and Shipboard Testing of the SEDNA®-System According to the IMO Guidelines

Matthias Voigt
Hamann AG
An der Lehmkuhle 4, D-21279 Hollenstedt, Germany

The SEDNA®-System is one of the few ballast water treatment systems with full IMO approval that make use of an active substance. Basic Approval has been granted to the active substance, PERACLEAN® Ocean by Evonik-Degussa GmbH, during MEPC 54 (March, 2006) and Final Approval has been given to the SEDNA®-System using PERACLEAN® Ocean during MEPC 57 (April, 2008). Furthermore, Type Approval has been granted by the German administration in June, 2008. Land-based tests under guideline G8 were carried out at the Royal Netherlands Institute for Sea Research (NIOZ). The shipboard tests were done on a container feeder in short sea traffic in the Baltic Sea and North Sea.

Moreover, his paper presents the results obtained during the approval process and discusses the experiences made during the testing period. The mechanical performance and the biological efficiency of the SEDNA®-System will be discussed, including the practical experiences gained during 18 months of onboard operation.

NOTES

Chlorine Dioxide as a Treatment For Ballast Water to Control Invasive Species: Shipboard Testing

***Lucie Maranda**, Robert G. Campbell, Annie M. Cox and David C. Smith*
University of Rhode Island, Graduate School of Oceanography
South Ferry Road, Narragansett, RI 02882 USA

Among human-mediated vectors of species introduction into coastal ecosystems, the discharge of foreign ballast water from large ships constitutes a major threat to the integrity of local environments. One approach to treating ballast water is the use of a biocide to eradicate potentially invasive species. We have determined the efficacy of chlorine dioxide (ClO_2) at eliminating organisms present in estuarine ballast water of a RORO containership under actual operating conditions along the US east coast, by comparing the survival of planktonic assemblages present in waters of two treated and two control tanks. We employed two different sampling protocols. Four separate time-series experiments encompassing a range of environmental conditions were conducted where we followed the abundance and viability of organisms in three size classes (< 10 µm, 10 to 50 µm and > 50 µm) over a five-day period. In a separate series of nine experiments, we sampled only at the endpoints, five days after treatment (just prior to de-ballasting). Chlorine dioxide was generated on site and delivered directly to the incoming gravity-fed ballast water at a calibrated rate of 5 $mg \cdot L^{-1}$, and without pre-filtration of the water. We first sample ballast water for bacterial abundance and growth, then we collect water for measurements of dissolved and particulate organic carbon, size-fractionated ATP and chlorophyll *a*, and phytoplankton potential for growth (Most Probable Number approach). Phytoplankton and zooplankton are collected with 10 and 50-µm mesh nets, respectively, and evaluated for viability by microscopy.

The addition of 5 $mg \cdot L^{-1}$ ClO_2 to the ballast water immediately reduces bacterial abundance to non-detectable levels, whereas bacteria proliferate in the untreated tanks used as controls. No bacterial growth is observed for days, especially during winter. Regardless of temperature, ClO_2 is very effective in its lethality to phytoplankton (predominantly diatoms), the effect is immediate, with no resurgence, at least for five days after treatment. The > 50-µm fraction represents mostly zooplankton, dominated by copepods: *Acartia hudsonica* in winter and *A. tonsa* during the summer. Generally zooplankton do not survive the 5 $mg \cdot L^{-1}$ ClO_2 treatment, except for occasional barnacle cyprinid larvae at abundances that do not violate IMO permitted levels. However in March 2007, recently hatched *Eurytemora* sp. nauplii were observed in the treatment tanks; eggs had apparently survived the treatment and hatched.

Under actual operating conditions aboard a commercial vessel, the treatment of ballast water with 5 $mg \cdot L^{-1}$ ClO_2 is generally effective against planktonic assemblages, but the effect on bacteria does not persist for more than a few days and some organisms in the > 50-µm fraction may pose a special challenge to the application, especially those able to find refuge within a protective coating (e.g., cysts, resting eggs, and shells).

NOTES

Bacterial Response Following Chlorine Dioxide Treatment of Ballast Water

***Annie Cox**, Lucie Maranda and David C. Smith*
University of Rhode Island, Graduate School of Oceanography
South Ferry Road, Narragansett, RI 02882 USA

Federal and international regulations requiring the treatment of ballast water in an effort to stop the introduction of invasive species will go into effect in the near future and all ships will be required to comply. The use of chlorine dioxide (ClO_2) gas has demonstrated potential as a biocide for this purpose. We tested a 5 ppm ClO_2 concentration aboard a commercial vessel, the M/V Atlantic Compass and measured bacterial abundance using culture media (Marine Agar and IDEXX Enterolert and Colilert technology) and bacterial growth using 3H-leucine incorporation. Results indicate that at first bacteria appear to be eliminated by ClO_2, however, after ~100 hours during the winter and ~40 hours during the summer, bacterial growth is observed. The seemingly 100% original efficacy of ClO_2 on the bacterial community does not last beyond a few days. The consequences of the transport and release of bacteria from ballast water into coastal ecosystems is largely unstudied. However, if a few or even only one deleterious bacterial species were to grow back in large numbers, the release of this ballast water into coastal waters could provide a large enough inoculum to have ecosystem level effects and possible health consequences. We used Terminal Restriction Fragment Length Polymorphism (T-RFLP) to determine whether the bacterial community that grows back after treatment is similar to the initial community, a small subset, one select species, or a new bacterial assemblage. This method generates a community fingerprint of gene fragments (in this case 16S rDNA) from bacteria present before and after ClO_2 treatment to determine the number of species and whether the same or different species are present. Bacterial growth subsequent to treatment likely results from bacteria that are not exposed to the treatment by virtue of being protected from ClO_2 contact. Such refuges probably are in sediments and biofilms, but others might exist. Both copepods and phytoplankton are known to harbor internal bacteria and in the case of copepods, also within their carapace. The extent to which 5 ppm ClO_2 or other biocides can eliminate bacteria within such refuges is unknown. Results on the outcome of ClO2 treatment on bacteria in shipboard ballast tanks will be presented.

NOTES

Testing Ballast Water Treatments on Microorganisms at the Great Ships Initiative Land-based Facility

Euan D. Reavie
University of Minnesota-Duluth
1900 East Camp Street, Ely, MN 55731 USA

Mary D. Balcer
University of Wisconsin-Superior
PO Box 2000, Superior, WI 54880 USA

Allegra A. Cangelosi
Northeast-Midwest Institute
50 F Street, NW, Suite 950, Washington, DC 20001 USA

Ballast water discharge from commercial vessels is a significant source for the introduction and spread of aquatic invasive species. The Great Ships Initiative (GSI) is evaluating candidate shipboard treatment systems for their ability to prevent the introduction of freshwater nuisance species. Potential treatments, including physical, chemical and biological applications, are evaluated at the pilot scale at a land-based test facility in Duluth/Superior Harbor (Lake Superior). The land-based facility meets International Maritime Organization (IMO) guidelines and is the only system dedicated to testing ballast water treatment applications on freshwater organisms. Numbers of surviving ambient organisms in treated discharge are sampled and assessed using an array of methods appropriate to each significant size class. Specific GSI methods for sampling and assessing live plankton in size classes relevant to the IMO standards will be detailed. The 10-50 micron size class (largely algae and protists) is assessed using high-resolution microscopy and fluorescent-metabolic stains, and the >50 micron size class (zooplankton) is assessed using lower resolution microscopy and movement detection of organisms. Lessons learned during the methods development process, and outstanding issues still to be resolved, will be presented. GSI test findings will support the development of shipboard treatment systems that meet and surpass IMO standards for preventing species introductions.

NOTES

A Comparison and Evaluation of Qualitative Approaches to the Assessment of Risk from Invasive Species

Marten A. Koops
Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences
867 Lakeshore Road, Burlington, ON, L7R 4A6 Canada

Becky Cudmore
Fisheries and Oceans Canada, Centre of Expertise for Aquatic Risk Assessment
867 Lakeshore Road, Burlington, ON, L7R 4A6 Canada

Risk assessment is an important decision tool to use in the preventative management of invasive species due to the uncertain nature of the science. A lack of information about many potentially invasive species has led to concerns about the data demands of quantitative methods and a preference for qualitative risk assessment methods. Many government agencies conduct risk assessments of potentially invasive species, each with their own agency guidelines that present their preferred qualitative approach. All of these approaches involve one or more categorical probabilities (likelihoods) and impacts (consequences) which are then combined through a risk matrix to generate an overall risk score. However, to date, none of these qualitative approaches have been evaluated. To provide guidance in the development of a national standard for conducting biological risk assessments on aquatic invasive species, we reviewed the various qualitative approaches used to conduct risk assessments on invasive species, compared the features of these approaches, and evaluated their performance relative to a quantitative risk assessment methodology. We found that some approaches have less accuracy or more bias in their performance under many conditions. The results of our evaluation will serve to provide recommendations to strengthen the use, and development, of qualitative risk assessments.

NOTES

Development of the Canadian 'GloBallast' System

Matthyw Thomas *and Andrew Kendrick*
BMT Fleet Technology Ltd.
311 Legget Drive, Ottawa, ON K2K 1Z8 Canada

Christopher J. Wiley
Transport Canada – Ontario Region
100 Front Street, Sarnia, ON N7T 2M4 Canada

Some years ago the International Maritime Organization initiated the development of a tool to assess the risk of transfer of non-indigenous species in ships' ballast water. This tool, GloBallast, used environmental parameters and species matching between donor and recipient ports to assess the probable viability of invasive species. A pilot project generated detailed information for a small set of ports around the world; however, limited use was made of this version of the tool and development efforts lapsed.

With the increased attention focusing on ballast water transfer of invasive species throughout North America, Transport Canada selected the GloBallast approach as the basis for its own risk-based tool. BMT Fleet Technology was contracted to upgrade and update the IMO system, and to collect the necessary information for Canadian ports and waterways in order to populate the system database.

This paper presents the various elements of the project, including the system architecture and risk assessment methodology. It demonstrates how the tool is now being used by Transport Canada inspectors to assess the risk levels represented by inbound vessels, based on their previous voyage history, methods and location of ballast water exchange, and other key indicators. Finally, the paper discusses how the use of this type of approach can be enhanced through adoption by other countries under IMO or regional leadership.

NOTES

Irelands Most Unwanted - Risk Assessment and Prioritisation of Invasive Species for Management

*Caitriona M. Maguire, **John Kelly** and Peter Cosgrove*
EnviroCentre
10 Upper Crescent, Belfast, BT7 1NT Northern Ireland

Christine A. Maggs and Jaimie T.A. Dick
School of Biological Sciences, Queens University Belfast
97 Lisburn Road, Belfast, BT9 7BL Northern Ireland

In developing and implementing national invasive species management programmes, Governments are faced with literally thousands of established and potential invasive species but which of these are most likely to have damaging effects on ecosystems and native species and which can be successfully managed? A thorough and transparent process of risk assessment and prioritisation is needed to ensure the most effective use of limited resources. The Invasive Species in Ireland project developed a risk assessment framework for potential and established invasive species which takes a systematic approach to identifying species of most concern enabling prioritisation of actions.

The first step was clearly defining the objectives to ensure that the framework was fit for purpose and would enable the risk assessments and prioritisation to be carried out within the available timeframe of six months. The objectives in this case were to put in place a framework that was straightforward to use; classified species as high, medium and low risk; reflected that the species of greatest concern to the nature conservation agencies were species that would affect compliance with European legislative obligations; that could inform the prioritisation of species and allocation of resources to management actions.

The risk assessment framework has two stages with questions that relate to factors such as 1) invasion history, 2) vectors and pathways, 3) suitability of Irish habitats, 4) propagule pressure, 5) establishment success, 6) spread potential, 7) ecological impacts, 8) economic impacts, 9) effect on EU legislative obligations, and 10) feasibility of control/eradication. The scoring system takes into account uncertainty and is weighted to prioritise those species, which have major ecological impacts, a relatively restricted distribution and are amenable to control and containment measures.

The first stage of the risk assessment enables a relatively rapid assessment of a species based on ten questions that classifies species into high, medium and low risk. High risk species undergo the more detailed stage two assessments where they are ranked. A database of risk assessments has been compiled to enable updating and additional species to be added when new information becomes available ensuring that it is an iterative process. The risk assessment process also includes stakeholder involvement in peer review of the outputs and the prioritisation of species. Stakeholder groups included scientists, environmental managers, policy makers, industry and NGO's. This was vital in ensuring stakeholder engagement and support for management actions.

Selected risk assessments for high impact aquatic invasive species and the ranked list of Ireland's most unwanted invasive species will be presented. It was clear that the greatest threat to native biodiversity from invasive species in Ireland is from freshwater species. Non-native crayfish and fish species pose the greatest potential threat and of those species already established a range of ornamental pond plants pose a growing threat in inland waterways. An overview of actions undertaken to date to address these threats will be presented, including development and implementation of management plans, Codes of Practice and contingency plans for potential invaders.

NOTES

Developing Risk-based Mitigation and Remediation Procedures for Non-native Freshwater Fishes: A Case Study of *Pseudorasbora parva* in the UK

Gareth D. Davies
Bournemouth University, Centre for Conservation Ecology and Environmental Change, and Environment Agency
Bromholme Lane, Brampton, Huntingdon, PE28 4NE UK

J. Robert Britton and Rodolphe E. Gozlan
Bournemouth University, Centre for Conservation Ecology and Environmental Change
Fern Barrow, Poole, Dorset BH12 5BB UK

Matt Brazier
Environment Agency, North West Region, North Area
Penrith, Cumbria, UK

The management of introduced non-native fishes is inherently difficult. An initial problem is the difficulty of detecting introductions when the fish are still at a low level of abundance, i.e., sufficiently early in their invasion pathway to enable effective intervention. Once the introduction has been detected, there is difficulty in assessing the actual ecological and socio-economic risks to the wider environment, and a further complication is that the most effective remediation tools are lethal and usually non-host specific, so may incur considerable collateral damage in non-target species. Risk management is the cornerstone of managing introduced non-native freshwater fishes; whilst risk assessment indicates the level of risk associated with that species, risk management determines which mitigation and remediation procedures are most appropriate to manage that risk.

Using a case study of *Pseudorasbora parva* in the UK, we demonstrate that mitigation and remediation procedures for non-native freshwater fishes can be successful in controlling the invasion of a non-native fish when risk management combines risk assessment with the development of effective control techniques. The use of piscicide application, such as rotenone, has been effective at eradicating populations of *P. parva* from a number of high-risk waters, including lakes connected to river catchments that facilitate their natural dispersal into the wider environment. Its application, however, remains difficult, due to a combination of factors including high expense and the potential for collateral damage. Where the risk level of the *P. parva* population has been assessed as low, for example where the population is present in a fully-enclosed lake from which there is no opportunity of natural dispersal, less intensive control techniques present a cheaper, but perhaps less effective remediation measure. Although this demonstrates the considerable potential for developing robust, risk-based mitigation and remediation procedures for introduced non-native fishes, their use requires an increased understanding by managers and policy-makers of how these tools can improve the current management strategies for introduced non-native fishes.

NOTES

Marine Biosecurity Risk Evaluation to Protect High-Value Areas of New Zealand

Marnie L. Campbell *and Chad Hewitt*
National Centre for Marine Conservation and Resource Sustainability, Australian Maritime College
Locked Bag 1370, Newnham, 7250, Tasmania, Australia

Maria Cassidy and Brendan Gould
Biosecurity New Zealand, Ministry of Agriculture and Forestry
PO Box 2526, Wellington, New Zealand

Marine introductions variously threaten environmental, economic, social and cultural values in coastal zones throughout the world. Introductions initially occur in entry points such as ports, marinas and aquaculture farms, but natural dispersal and human mediated secondary transfer will spread these species to adjacent coastal regions. High-value areas, such as marine protected areas, have been established in most coastal zones in an effort to protect and conserve biodiversity and contribute to the sustainable management of natural resources. *Undaria pinnatifida* (the Japanese kelp) was introduced to New Zealand in the 1980s and is now widespread throughout the North and South Islands. Two recent events have increased concerns of further spread to remote high-value areas, requiring a re-evaluation of the risks posed by *Undaria* to these regions.

A qualitative risk assessment, based on expert heuristic opinion, was undertaken to re-assess the potential impacts of *Undaria* on environmental, economic and social values associated with a set of New Zealand high-value areas (Chatham Islands, Hauraki Gulf, Fiordland, the Poor Knights, the Sub-Antarctic Islands, and the Three Kings), with the intent to provide salient, credible and legitimate information to decision-makers in a transparent manner because direct impact data is limited and uncertain.

From a biological perspective, biodiversity, habitat and trophic interactions were deemed to be at high to extreme risk and vulnerable to introduced species impacts. Yet, few New Zealand protected species were thought to be directly impacted by the presence of *U. pinnatifida;* resulting in a low perceived risk.

From an economic perspective, vessels, moorings and aquaculture are at high to extreme risk from *Undaria* and thus management places restrictions on their movement to control these vectors. Risk to fishing varied between high-value areas based on access to fishing resources within different high-value areas. Similarly, risk posed to tourism varied based on tourism access. In general, if fishing and tourism occurred in a high-value area, then the risk posed by *Undaria* was seen as moderate to high.

Social values such as aesthetics, diving, vessels and recreational harvest are at high to extreme risk from *Undaria*. Generally, stakeholders perceived that introduced species will directly impact upon their leisure/time, or diminish an individuals pleasure, rights or usage, resulting in significant concern about any such impacts.

In conclusion, *Undaria* was found to pose an extreme risk to the stakeholders values in all evaluated high-value areas. Based on these risk outcomes, the recommendation that implementing internal borders to improve pathway and vector management within New Zealand is discussed.

NOTES

Otters, Crabs and Louisiana Crayfish in Ewaso Ng'iro River: Victory of the Natives?

Mordecai O. Ogada
Kenya Wildlife Trust
PO Box 86-00502, Nairobi, Kenya

Initial studies in 2003 on the diet of the African Clawless otter *(Aonyx capensis)* in the Ewaso Ng'iro river showed the invasive Louisiana crayfish *(Procambarus clarkii)* to have supplanted the native freshwater crab *(Potamonautes neumannii)* and become the major (60%) component of otter diet. Crab and fish formed 1% and 36% of otter diet respectively. Otters and other terrestrial and avian predators including baboons *(Papio anubis)* and herons *(Ardea melanocephala)* became highly dependent on crayfish, exerting pressure on the crayfish population. The impact of crayfish caused an 80% decline in otter population density in 2003-2004 and 75% decline in diversity of aquatic macrofauna during the same period. The previous study therefore predicted a local extinction of otters by October 2006 based on the trends at the time. However, surveys in 2007- 2008 in the same study area show otters to persist in the area and the major component of their diet to have shifted to crab (47%) followed by crayfish (32%) and fish (15%). Otters are opportunistic feeders, so this shift indicates a significant decline in the population of crayfish and a re-colonization by crabs from the upstream areas where crayfish were excluded by low temperatures. There has also been a shift in territorial use by otters away from the habitats that were dominated by crayfish to the rock ones dominated by crab and higher fish diversity, which will be presented graphically. Our findings thus far demonstrate the adaptability of otters as aquatic predators and their importance as indicators of aquatic ecosystem health. Ongoing studies are investigating whether this trend indicates an established invasion having been reversed by natural forces, or part of a larger cycle.

NOTES

Larval Settlement Substrate Preferences of *Balanus amphitrite* (the Striped Barnacle), a Long-established Invader on Florida's East Coast

Holly Sweat *and Kevin B. Johnson*
Florida Institute of Technology, Department of Marine and Environmental Systems
150 W. University Blvd., Melbourne, FL 32901 USA

Balanus amphitrite (the striped acorn barnacle) is a dominant fouling organism on both natural and artificial substrata worldwide, and became established as an introduced species in Florida coastal waters by 1975. *B. amphitrite* is found in large numbers on dock pilings, buoys, local bivalve shells and other hard surfaces at Ponce de Leon Inlet on Florida's east coast. Microtopography varies widely between these substrata, and may play a role in settlement preference of barnacle cyprid larvae. Substrate preferences among fouling organisms have implications for determining invasion success of non-native foulers, understanding changes in fouling community structure and preventing costly biofouling on ship hulls, intake pipes and other surfaces. We examined settlement substrate preferences of *B. amphitrite* and other native and invasive barnacles in both the field and the lab on a range of surfaces.

We deployed settlement panels featuring different types of natural and artificial surfaces of varying microtopography at Ponce de Leon Inlet. For "natural" surfaces, we used the empty shells of certain bivalve species. Specifically, we outplanted 5 panels each of plywood (medium roughness, "artificial"), PVC (smooth, artificial), *Perna viridis* (the invasive Asian green mussel; smooth, "natural"), *Geukensia demissa* (the native ribbed mussel; rough, natural), and *Crassostrea virginica* (the native oyster; rough, natural). We determined percent cover and surface density of *B. amphitrite* recruits after a 4 week period in May and June of 2008. Mean percent cover was significantly higher for plywood than all other surfaces (52% *B. amphitrite* ± 17%; $p<0.05$), whereas mean settlement densities were significantly lower on both P. viridis shells and PVC relative to other surfaces (1.8 ± 0.3 individuals/cm^2 and 1.3 ± 0.1 individuals/cm^2, respectively, compared to 3.05-3.45 individuals/cm^2 for the other substrata; $p<0.05$). PVC and *P. viridis* shells differ from the other substrata in being smooth visually and to the touch. We hypothesize that the more textured microtopography of plywood, oyster shells, and native mussel shells facilitates or attracts *B. amphitrite* settlement.

This ongoing study is also analyzing larval settlement substrate preferences in the laboratory. To maintain a uniform settlement material across the treatments, one type of substrate will be manipulated to varying degrees of roughness. Cyprid larvae of the invasive striped barnacle *B. amphitrite*, the recently invasive titan acorn barnacle, *Megabalanus coccopoma*, and the native ivory barnacle, *B. eburneus* will be exposed separately and in combination to these substrate treatments to determine settlement substrate preference based on texture and competition.

NOTES

Community-level Effects of Co-occurring Native and Exotic Ecosystem Engineers

Jessica M. Ward *and Anthony Ricciardi*
McGill University, Redpath Museum
859 Sherbrooke Street West, Montreal, QC H3A 2K6 Canada

Exotic ecosystem engineers can substantially change native biodiversity by modifying the physical structure of habitats. In the Great Lakes–St. Lawrence River system, dreissenid mussels (*Dreissena polymorpha* and *D. bugensis*) appear to have promoted the growth of native benthic macroalgae, particularly *Cladophora*. Both *Dreissena* and *Cladophora* act as ecosystem engineers by increasing substrate complexity and providing interstitial habitat for benthic macroinvertebrates. In a 3-year study, we manipulated the patch size and topology of dreissenid mussel shells at sites in the St. Lawrence River. Experimental substrates were differentially colonized by *Cladophora*, allowing us to examine (i) how *Dreissena* patch topology affects benthic macroinvertebrate diversity, and (ii) whether the effects of *Dreissena* are altered by the presence of *Cladophora*.

Our results show that both engineers can significantly re-structure benthic communities. Macroinvertebrate responses to patches of *Dreissena* and *Cladophora* varied among functional feeding groups. The density of collector-gatherers was not affected by *Dreissena* or *Cladophora*, contrary to previous studies. The density of suspension feeders increased when *Cladophora* was abundant, but did not vary significantly across *Dreissena* shell treatments. In contrast, predators and benthic grazers responded positively to *Dreissena* shells, but were not significantly affected by *Cladophora*. Furthermore, *Cladophora* appeared to alter the effect of *Dreissena* patches on native and exotic amphipods. Native amphipods (*Gammarus fasciatus*) responded positively to *Dreissena* shells when *Cladophora* was at low abundance, but were not affected by the presence of *Dreissena* when *Cladophora* was at high abundance. Surprisingly, exotic amphipods (*Echinogamarus ischnus*) showed the opposite pattern: they responded to *Dreissena* shells only when *Cladophora* was abundant.

These findings demonstrate that the interactions of habitat-modifying species can complicate efforts to predict the community-level effects of invasion.

NOTES

The Ecology of Invasive Hydroids on Man-made Structures in Port Phillip Bay, Australia

Isla Fitridge
University of Melbourne, Department of Zoology
Parkville, Victoria, 3010, Australia

Hydroids (Cnidaria:Hydrozoa) are an important, and frequently abundant component of marine sessile communities associated with natural and artificial habitats. Many non-indigenous hydroids are known to exhibit 'invasive' behaviour and have the potential for economic impacts through extensive fouling of piles, pontoons, mariculture installations, aquaculture facilities, power stations and vessel hulls. Their success as fouling species is partly due to their rapid, indeterminate growth and longevity, as well as the ability of some species to regenerate. Unfortunately, they are often overlooked in ecological studies.

My PhD research examines the hydroid fauna associated with man-made structures in Port Phillip Bay (PPB), Victoria, Australia. PPB is considered to contain more invasive marine species than any other ecosystem in the Southern Hemisphere. Several non-indigenous hydroid species are resident in PPB, believed to have been introduced almost certainly by shipping. My research documents how the hydroid communities of the bay are composed (native and non-indigenous species), and how these communities change temporally and spatially with regards to larval recruitment and the presence, absence, growth and fertility of adult colonies. It represents the first documented assessment of the hydroid fauna of this region.

The study also examines the role of hydroids as fouling species within mussel culture operations. For twenty years the extensive, clean waters of the bay have supported a thriving marine aquaculture industry, cultivating mainly blue mussels (*Mytilus sp.*). Filamentous materials such as hydroids are known to provide an attractive settlement surface for juvenile mussels (spat), and the presence of a non-indigenous hydroid *(Obelia dichotoma)* on mussel ropes in the bay has been noted to substantially increase mussel spat yields. Ironically, another non-indigenous hydroid (*Pinauay crocea*) is emerging as problematic to local farmers by heavily fouling mussel ropes and the shells of adult mussel stock. The economic losses for farmers in the bay could be substantial in terms of lost stock (due to the weight of the hydroid fouling pulling mussels from the dropper lines), increased operating costs (due to the extra cleaning required to remove the hydroids from adult mussel shells) and the inability to catch adequate spat (due to the hydroid competing for space on the mussel ropes, or using the mussel larvae as a food source).

The detrimental effect of hydroid fouling within mussel culture operations has been documented in New Zealand and the USA, yet there remains little research on the nature of the relationship between hydroids and juvenile/adult mussels, nor of their ecology and role as fouling and aquatic invasive species. My research will provide the scientific community with some important knowledge of both native and non-indigenous hydroids in PPB, and enable the mussel industry to better understand and manage fouling species such as hydroids within mussel culture operations.

Preliminary data are presented that illustrate the spatial and temporal variation in resident adult hydroid colonies and larval recruitment around PPB, the dominance of non-indigenous hydroid species within the population and the implication of this on local aquaculture facilities.

NOTES

Aquatic Invaders as a Vector of Spread of Parasites and their Potential Effect on Invaded Ecosystems

Sergey E. Mastitsky, *Alexander Y. Karatayev and Lyubov E. Burlakova*
Buffalo State College, Great Lakes Center
261 Science Building, 1300 Elmwood Avenue, Buffalo, NY 14222 USA

Daniel P. Molloy
New York State Museum, Division of Research and Collections
51 Fish Hatchery Road, Albany, NY 12230 USA

While spreading, aquatic non-indigenous species (NIS) may serve as vectors of spread for parasites and may also become hosts for aboriginal parasitic organisms. Although the ecological consequences of these introductions have gained little attention in invasion biology, they may have serious negative effect on invaded ecosystem.

The number of commensals and parasites that can be co-introduced with a NIS directly correlates with their diversity and abundance in the donor region. Usually, species richness of exotic parasites in invaded areas is much lower than in their native range because: 1) the introduced propagules of a NIS are always a subsample of its population and, thus, are highly unlikely to harbor all possible parasites occurring within the native range; 2) exotic parasites with complex life cycles fail to establish due to the absence of proper intermediate hosts in the invaded ecosystem; and 3) the appropriate (infected) host life stage was not transported to new environment.

Local parasites and pathogens can use NIS as their hosts, especially when invaders create high population densities in invaded communities. For example, round gobies (*Neogobius melanostomus)* that invaded the Gulf of Gdańsk (Baltic Sea, Poland) were found to host several aboriginal parasites, but no exotic ones (Kvach and Skóra 2007).

Exotic parasites co-introduced with NIS can switch to indigenous hosts. The swimbladder nematode (*Anguillicola crassus)* was vectored to three continents (Eurasia, Africa and North America) by the Far Eastern eel (*Anguilla japonica)* with subsequent infection in naive, indigenous eel species (Taraschewski 2006). Introduced NIS and their specific parasites may then cause epizootics that can have serious, negative ecological and economic impacts. For instance, the crayfish plague (*Aphanomyces astaci*) was introduced into Europe with the North American spiny-cheek crayfish (*Orconectes limosus)* and caused devastating effects resulting in local extirpations and fragmentation of previously uniform European indigenous crayfish populations, as well as significant declines in the commercial catches (Westman 2002).

NOTES

Pathway to Invasion: From Artificial Structure to Rocky Reef

Katherine A. Dafforn *and Emma L. Johnston*
University of New South Wales, School of Biological, Earth and Environmental Sciences,
Evolution and Ecology Research Centre
Sydney, NSW 2052 Australia

Tim M. Glasby
NSW Department of Primary Industries, Port Stephens Fisheries Centre
Locked Bag 1, Nelson Bay, NSW 2315 Australia

Artificial structures differ from natural rocky reefs due to their physical characteristics. Most jetties and pontoons present large areas of vertical substrata and are relatively shaded, which reduces competition from many algal species and allows the development of assemblages dominated by sessile invertebrates. They are also regularly disturbed by cleaning and maintenance and this may play a role in providing a foothold for arriving invaders. In contrast, natural habitats are thought to provide barriers to invasion through the biotic resistance of native residents.

We compared hard-substrate assemblages on pilings, pontoons and rocky reef in Sydney Harbour. We found greater non-indigenous diversity and dominance on piers and pilings relative to rocky reef. However, some non-indigenous invertebrates and algae were present on the reef. We tested the hypothesis that the ability to invade natural rocky reef is influenced by shading, orientation and biotic resistance. Experiments were deployed simultaneously at two rocky reef areas in Sydney Harbour. Sandstone plates were subjected to shading treatments and were positioned vertically or horizontally. Half the plates were bare at deployment and half had one-year old assemblages present (65-90% cover of *Sargassum* sp.). The plates were deployed for seven months and then algal canopy was removed and weighed, and the remaining assemblage censused live. Exotic species were better able to invade vertical substrate and were advantaged by the availability of bare space. These findings suggest that management efforts should be targeting reefs where vertical walls are prevalent and areas exposed to high levels of physical disturbance.

NOTES

Application of a Lower Food Web Productivity Model to Investigate Ecosystem Level Changes Resulting from Aquatic Invasive Species in Lake Michigan

David H. Miller *and Russell G. Kreis, Jr.*
U.S. Environmental Protection Agency, Mid-Continent Ecology Division, Large Lakes Research Station
9311 Groh, Grosse Ile, MI 48138 USA

Wei-Chuang Huang
U.S. Naval Research Laboratory
429 East Bowen, Stop 4011, China Lake, CA 93555 USA

Xiangsheng Xia
Computer Sciences Corporation
9311 Groh, Grosse Ile, MI 48138 USA

A Lake Michigan Ecosystem Model (LM-Eco) that includes a detailed description of trophic levels and their interactions was developed for Lake Michigan. The LM-Eco model construct has been applied in two phases to investigate ecosystem-level responses and effects corresponding with aquatic invasive species within the lower food web of the lake. 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 during the 1994-1995 Lake Michigan Mass Balance Study. Field data collected at 15 sampling stations within Lake Michigan over a series of 8 sampling cruises throughout a two-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. Model simulations allowed for examination of interactions between the invader *Bythotrephes* and native zooplankton groups 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. Further, the LM-Eco model was utilized in conjunction with more recent field data collected from 1998 through 2004 to forecast population dynamics of *Bythotrephes* and zooplankton in Lake Michigan throughout a 15-year period beyond the 1994-1995 LMMBP. The 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.

NOTES

Resting Egg Bank and Yearly Recruitment Potential of the Fishhook Waterflea (*Cercopagis pengoi*) in Different Areas of the Baltic Sea

Tarja Katajisto *and Maiju Lehtiniemi*
Finnish Institute of Marine Research, Tvärminne Zoological Station
PO Box 2, FI-00561 Helsinki, Finland

The cladoceran *Cercopagis pengoi* was first recorded in the Baltic Sea in 1992 after which it has spread rapidly and formed permanent populations. In late summer it can attain high abundances by parthenogenetic reproduction, but during most of the year the environmental conditions are unfavourable for the species and it survives as sexually produced resting eggs in the bottom sediments. The yearly recruitment is thus dependent on the survival and hatching of these eggs.

The aim of this study was to estimate the yearly recruitment potential of *C. pengoi* from resting eggs in different parts of the Baltic Sea. Distribution of the egg bank was assessed in the Gulf of Finland (May 2007) as well as in the Gulf of Bothnia and the Baltic Proper (June 2008) during two cruises on R/V Aranda. Altogether 15 sites of varying depths (48–189m) and oxygen conditions were sampled with a gravity corer and sliced in 1 cm intervals to 2 to 20 cm depths, depending on the sediment properties. Eggs were extracted from the samples, counted and incubated to reveal their hatching success. In addition, an experiment was performed to reveal the temperature dependent development rate and hatching success of the resting eggs.

There were remarkable differences in the size of the *C. pengoi* egg bank in different parts of the Baltic Sea. In the Gulf of Finland eggs were relatively abundant in most sites whereas in the Gulf of Bothnia eggs were very scarce – even in the southern parts where *C. pengoi* is abundant in the water column in late summer. In the northern Baltic Proper eggs were found in low abundance. Moreover, the eggs that were found in the Gulf of Bothnia were buried so deep in the sediment that recruitment from that area is highly improbable. The sampling was conducted in the central parts of the Gulf which may indicate that *C. pengoi* overwinters in the coastal sediments and migrates yearly to the open sea. The situation may be similar in the southern parts of the Baltic Sea. On the other hand, in the Gulf of Finland and Baltic Proper recruitment is restricted due to poor oxygen conditions – in 2008, large areas in the Baltic Proper and western Gulf of Finland suffered from anoxia. Hatching success of *Cercopagis* eggs was good (≥60%) at low temperatures (3–6°C), which prevail during summer in areas deeper than (40-50m) in northern Baltic Sea. Because development was very slow (several months to hatching) recruitment may occur at a low rate from deep areas with good oxygen conditions. In shallow bottoms summer temperatures are higher and recruitment from resting eggs may be more efficient.

NOTES

A Biochemical Approach to Understand the Invasion Success of an Exotic Amphipod

***Sophie Sroda**, Pascal Sornom and Carole Cossu-Leguille*
Université Paul Verlaine – Metz, Laboratoire des Interactions Ecotoxicologie, Biodiversité, Ecosystèmes (LIEBE)
UMR CNRS 7146, rue du Général Delestraint, 57070 Metz, Borny, France

In Eastern France, local *Gammarus pulex* and *G. fossarum* populations have been severely impacted by the invasive amphipod *Dikerogammarus villosus.* To explain its invasion success, most of the authors have focused on its bio-ecological profile (e.g., salinity and temperature tolerance, predatory behaviour, reproductive potential) but few of them have investigated ecotoxicological parameters. The goal of our study was to measure antitoxic defence capacities in *D. villosus* and *G. roeseli*, a naturalized amphipod that can be found living in sympatry with *G. pulex*. Antitoxic defence systems are present in each living species and allow organisms to face environmental perturbations, and thus could explain the acclimatization of exotic species to new environmental conditions.

In both gammarid species selenium-dependant glutathione peroxidase (SeGPx), total glutathione peroxidase (GPx tot) and catalase activities were measured as antitoxic defence parameters, when malondialdehyde level (MDA) was chosen as biomarker of toxic effects. Lipid and glycogen contents were also measured to assess the energetic status of invertebrates.

In control organisms of both gammarid species we found inter-sex differences, with females showing higher lipid and glycogen levels, and higher GPx enzymatic activities than in males. On the other hand, enzymatic activities and MDA levels were significantly different between *D. villosus* and *G. roeseli*. Surprisingly, males and females of *D. villosus* species had similar MDA levels, which were lower than in *G. roeseli*. This suggests, first, that *D. villosus* should be more tolerant to stressors than *G. roeseli* and second, that whatever the species females compared to males seem to have more robust defence systems.

An experiment performed in controlled conditions to determine acute toxicity of copper in *D. villosus* and *G. roeseli*, has demonstrated that after 48h of exposure, the male of *G. roeseli* appeared more sensitive than the females, when in *D. villosus* organisms no inter-sex differences were noted. As expected, *D. villosus* organisms were significantly more resistant to copper toxicity than *G. roeseli* ones, according to the LC50 values.

Antitoxic defence parameters and MDA as well as lipid and glycogen levels were measured in *D. villosus* and *G. roeseli* exposed for two days at sub-lethal concentrations of copper. The responses obtained for both species will be discussed and compared. Relationships between ecotoxicological parameters and behavioural traits such as swimming performance and ventilatory activity measured in the same experiment will be highlighted.

NOTES

The Swimming Performance in Native and Exotic Amphipods as a Part of Their Anti-predator Strategy

Vincent Médoc, *Pascal Sornom and Jean-Nicolas Beisel*
Université Paul Verlaine – Metz, Laboratoire des Interactions Ecotoxicologie, Biodiversité, Ecosystèmes (LIEBE)
UMR CNRS 7146, rue du Général Delestraint, 57070 Metz, Borny, France

The biotic pressure from local predators in a recipient ecosystem is a key factor in the success of organisms that moved out of their natural range. As an example, in Southern Germany, the invasive gammarid *Dikerogammarus villosus* has been found to be less preyed upon by trout and perch than the natives *Gammarus roeseli*, *G. pulex* and *G. fossarum* because of a lower activity level and a higher affinity for coarse substrate that provides an efficient refuge compared to fine substrates. In the aquatic environment, the olfactory assessment of predation risk is commonplace and benthic invertebrates adapt their behaviour in response to both predator odours and chemical signals released by injured conspecifics. The efficiency of these anti-predatory adaptations is expected to be positively correlated with the success of a potential invader.

Most of the studies devoted to anti-predatory responses in aquatic systems focused on the use of refuges and the activity level of prey organisms while their displacement abilities have rarely, not to say never, been regarded as an efficient mean to reduce predation risk. Prey however increase their conspicuousness when they leave a safety area, for example to forage, to mate or to reach another refuge. Consequently, during this short period of time, prey are under a strong selective pressure by predators that may have shaped the evolution of displacement abilities.

Thanks to an original video recording device, we investigated the swimming performance and several parameters related to refuge usage in four amphipods, the invasive *D. villosus*, the two natives *G. pulex* and *G. fossarum*, and *G. roeseli,* which is considered as naturalized in Eastern France. During single- and mixed-species experiments, gammarids were placed in cylindrical experimental units equipped with benthic refuges and filled with control or scented water. Next, gammarids were exposed to a native fish to test if the behavioural differences observed between native and exotic species affect the predation under laboratory conditions.

Counter intuitively, pre-experimental investigations demonstrated that neither the gender nor the body length of amphipods had a significant effect on the swimming speed. Overall, our results argue for a trade-off in anti-predatory behaviours in which an increase in refuge usage may compensate for a reduced swimming performance. As expected, an efficient anti-predatory response regarding the swimming performance and the use of refuges was negatively correlated with predation risk.

NOTES

Invasive Species in the Tropics: The Same Old Mistakes in a Changing World

Mordecai O. Ogada
Kenya Wildlife Trust
PO Box 86-00502, Nairobi, Kenya

The introduction of exotic aquatic fauna into Kenyan ecosystems was based mainly on the belief that there wasn't any indigenous species worth catching for sport, or that could support a commercial food fishery. The introductions were also based on the patronizing nature of colonial government and a certain measure of nostalgia for things of the 'home country'. At independence, natural resource management departments were inherited from the colonial government with these attitudes in place, and taken over by local staff trained in this manner. In all spheres of ecosystem management, we still accept exotic flora and fauna to augment fisheries and forests, control pests, and even control other invasives. International organizations still experiment with, and fund species introductions with disastrous consequences for our environment. It is particularly worrying that scientific organizations seem reluctant to change tack, probably due to fear of admitting incompetence and losing funding sources. Markets pay premiums for 'organic' produce thus advancing the biological control of pests by parasitoids, disregarding the fact that biological control is by definition, a biological invasion. In the aquatic spectrum, scientists are now struggling at great cost, to conserve Nile perch stocks in Lake Victoria for 'sustainable fish production'. Local people are regularly arrested for 'poaching trout' in highland streams or common carp in rift valley lakes. They are attempting to negate the basic ecological rule that any ecosystem dominated by a tertiary consumer cannot achieve equilibrium. It is high time that Kenya (and much of Africa) sought to sustainably manage its indigenous natural resources rather than seek short-term gain and court long-term problems through exotics.

NOTES

Ballast Water Management Moving Towards a New Phase

Dandu Pughiuc
International Maritime Organization, Marine Environment Division
4 Albert Embankment, London SE1 7SR UK

The introduction of invasive aquatic species through ships' ballast water and sediments is considered to be one of the most significant threats to the marine environment in modern times. The urgent need to take effective action cannot be overestimated. It is, therefore, not surprising that ballast water management has become an issue of the highest priority for a wide group of stakeholders, in particular, IMO Member States, the shipping industry, environmentalists, technology developers and technology test facility operators.

Since Canada first brought this matter to the attention of IMO in 1986, the Organization has been working constantly to address, meet and respond to all the associated challenges, initially through the development of two sets of guidelines and, more recently, by devising a new, legally-binding international instrument. The International Convention for the Control and Management of Ships' Ballast Water and Sediments, which was adopted in February 2004 by a Diplomatic Conference, has been ratified by 18 countries representing almost 16% of the world's merchant shipping capacity. The Convention and its associated guidelines provide the much needed framework for developing an integrated-systems approach to ballast water management. It offers the critically-needed set of management tools through which the maritime industry can be regulated in a manner that is predictable, transparent and responsive with regard to environmental benefits, technological achievability and, most importantly, international consistency.

The growing number of ratification instruments, which have been deposited with the Secretary-General of IMO during the last few months coincides with the first application date of the performance standard contained in regulation D-2 of the BWM Convention and with the development of groundbreaking technologies to remove, render harmless, or avoid the uptake or discharge of aquatic invasive species in ships' ballast water. If in the past the lack of technologies and management options used to be a matter of concern, this should not be the case any longer. The shipping industry and the international community as a whole, need to recognize that ballast water management options are currently available. Out of four ballast water management systems that have received final approval by IMO, three technologies have been certified for type approval by their national administrations and are readily available to be used on board ships, while the last one is in the final stages of the certification process.

The momentum precipitated by technology developers needs to be sustained and the fact that thirteen more ballast water management systems are currently in the approval pipeline is a confirmation of the commitment of the R&D community and the determination of the shipping industry to act decisively to address the issue of aquatic invasive species in ships' ballast waters. A healthy competition in this new market is the guarantee of increasingly higher treatment standards and lower costs.

The effectiveness and efficiency of maritime transport, and by extension IMO's work, can have a major and direct impact on the global economy and environmental sustainability.

The Organization remains, therefore, committed to reducing the negative impact of shipping's everyday operations on the environment. IMO has, once again, joined forces with the UNDP and GEF to stem the tide of invasive aquatic species in ships' ballast water and the second phase of the GloBallast Programme, named GloBallast Partnerships, is now well under way. Further confirming the importance the IMO attaches to aquatic invasions, its Marine Environment Protection Committee has initiated the development of international measures for minimizing the translocation of invasive species through biofouling of ships.

IMO will continue, through the Integrated Technical Co-operation Programme, to assist its members in their efforts towards implementation of effective measures to address aquatic invasions, however, all these efforts are hollow without the most important step, **timely entry into force of the BWM Convention**. Early ratification of this important instrument is a prerequisite of success in preventing the transfer of aquatic invasive species in ships' ballast water.

Implementing Biofouling Controls on International Shipping: The Current State of the 'Art'

John F. Polglaze
URS Australia
Level 3, 20 Terrace Road, East Perth, WA 6004 Australia

Australia, at both the national and State levels, is currently developing and progressively implementing a comprehensive suite of formalised biofouling (i.e. hull fouling) controls. These encompass both internal and external fouling of vessels and other immersible equipment (such as anchors, buoys, floating booms and similar). To date, a number of vessels have been compelled to leave Australian ports after the discovery of aquatic invasive species as hull fouling. The International Maritime Organization (IMO) has also recognised the problem and has signaled an interest in developing an international regulatory regime for biofouling.

All vessels are subject to biofouling to some extent, with the magnitude and composition of that observed influenced by a vessel's design and construction, and operations and maintenance history. Therefore, unlike ballast water, biofouling treatments and risk evaluations do not lend themselves to consideration of a neat package isolated within a ship – biofouling is unavoidably and invariably in direct contact with the surrounding water body which one may wish to protect. As a result, biofouling risk assessments and controls must contend with the fact that every vessel has biofouling of some sort and every time a vessel enters a port or coastal waters there is the possibility that there may be an inoculation by an alien species if present. Accordingly, biofouling risk evaluation and management requires a fundamentally different approach to that for ballast water, and one which is more difficult to develop and implement.

This presentation will relate how biofouling controls and risk evaluations are being undertaken by industry in response to the evolving requirements and underlying expectations of Australian national and State authorities. Based upon the experience gained in around 100 ship biofouling inspections and risk evaluations, the presentation will relate the relative merits and shortcomings of risk assessments based upon vessel type and movements and maintenance history and contrast the efficacy of in-water inspection and hull cleaning (which in many cases is the only viable response option) with cleaning and inspections in drydocks.

The presentation will also draw upon a number of projects undertaken by the author which have characterised the biofouling-related aquatic invasive species risks of a diverse range of vessel types as a precursor to the development and application of biofouling risk reduction and contingency response procedures. A particular focus of this presentation will be upon how the prevailing orthodoxy of biofouling risk assessments related to different types of vessels is inadequate to effectively describe and rank relative risks, and hence ineffective and potentially misleading as a metric for prioritising management and response efforts.

NOTES

TBT Ban – A Golden Opportunity for Alien Hitchhikers?

Sanjeevi Rajagopal *and Gerard van der Velde*
Radboud University Nijmegen, Institute for Wetland and Water Research, Department of Animal Ecology and Ecophysiology
Heyendaalseweg 135, 6525 AJ Nijmegen, The Netherlands

Alien species are those species, which are not native to a specific ecosystem (also referred to as exotic, non-native, non-indigenous). Invasive alien species can take a heavy financial toll on ecology, governments, industries, and private citizens. A recent study estimates that invasive alien species cost the United States of America more than $100 billion a year and at least this much in six other countries combined. The International Maritime Organization (IMO), Global Environmental Facility (GEF), and U.N. Development Program (UNDP) have jointly developed the GloBallast programme, a global technical cooperation program to assist developing countries to tackle the transfer of harmful aquatic organisms mediated by ship ballast water. However, there are no internationally-agreed prevention measures for hull-fouling as an invasive alien species (IAS) vector.

The main method used worldwide to control biofouling on ship hulls is by using antifouling paints. Toxic paints such as those using tributyl-tin-oxide (TBTO) have been extremely effective in controlling biofouling. In spite of their effectiveness and usefulness, they have been black-listed because of their environmental persistence and toxicity to other organisms. The IMO International Convention on the Control of Harmful Anti-Fouling Systems on Ships (2001) provides for the global phase-out of tri-butyl-tin (TBT) in paints, a ban designed to reduce chemical pollution of the marine environment. In the absence of an effective and long-lasting system to control hull fouling, it is feared that the ban could lead to a significant increase in the number of introductions of invasive species. In this context, we have started to analyze historic data on alien species invasion through literature review to see if TBT introduction had any impact on global scale mobilization of alien species and, importantly, whether the intended TBT ban will lead to an increase in exotic species introductions. The paper presents highlights from this analysis.

NOTES

IMProtector: a Novel In-water Treatment System for Vessel Biofouling

***Ashley D.M. Coutts**, D. Shields and P. Synge*
Aquenal Pty Ltd.
GPO Box 828, Hobart, 7001 Tasmania, Australia

The Commonwealth Government of Australia is proposing to implement mandatory requirements for biofouling on all vessels entering Australian waters. Inevitably there are situations where vessels entering Australian waters are contaminated with NIMS of concern and will require immediate treatment. Presently removing vessels from the water and defouling their hulls is considered the only feasible method for treating vessel biofouling. However, given most vessel maintenance facilities are in high demand, they are unlikely to accommodate emergency treatment of vessels contaminated with NIMS of concern. Contaminated vessels are known to pose a significant biosecurity risk while they remain in inshore waters until haul-out and treatment is undertaken.

To this end, Aquenal have developed a practical and inexpensive system, the "Introduced Marine Pest Protector" (IMProtector) that is capable of a) quarantining vessels *in situ* until maintenance facilities are available or b) *in situ* treatment of NIMS of concern if vessel maintenance facilities are unavailable. The present IMProtector prototype consists of a tough reinforced black PVC sheath in the form of a bag with inflatable collars that is capable of encapsulating the submerged area of vessel hulls up to 15 m in waterline length. It weighs approximately 100 kg and can be deployed from the vessel requiring treatment or a small dinghy or from an adjacent marina pontoon. For larger vessels the sheath can be extended by simply adding extension panels or be manufactured in a variety of sizes and dimensions to suit different vessels.

Two treatment methods are presently available: a) the environmentally friendly "set-n-forget" method which simply starves organisms of food and dissolved oxygen and causes complete mortality within ~4 days, or b) the addition of accelerants such as sodium hypochlorite which is capable of complete mortality within ~24 hours and the accelerant can either be neutralized prior to release into the surrounding environment or pumped from the IMProtector to holding tanks ashore.

The IMProtector has many other advantages, including: a) it is reusable: b) capable of retaining and treating mobile organisms often associated with vessel biofouling which haul-out facilities (syncrolifts, slipways and travel-lifts) release into the surrounding environment during the vessels removal from the water; c) ability to retain all defouled material after treatment for verification purposes and disposal of at an approved landfill facility; and d) ideal for treating vessels in remote locations including shark or crocodile infested waters.

Aquenal are presently refining the IMProtector prototype and undertaking efficacy trials surrounding the various treatment options and its potential to be utilized on larger vessels and infrastructure. The latest improvements to the IMProtector and results of the efficacy trials will be revealed during the presentation.

NOTES

Evaluation of the Efficacy of Hull Cleaning Methods for NIS Vector Control

Chris Woods, Oliver Floerl, Isla Fitridge, Olivia Johnston, Karen Robinson, David Rupp, Niki Davey, Nicola Rush, Matt Smith and Graeme J. Inglis
National Institute of Water and Atmospheric Research
PO Box 8602, Riccarton, Christchurch, New Zealand

Liz Jones
MAF Biosecurity New Zealand
PO Box 2526, Wellington, New Zealand

Vessel biofouling is an important pathway for the introduction and spread of non-indigenous aquatic species. Removal of biofouling from the vessel is considered the best way to mitigate risk, but variability in the operations of vessel cleaning facilities may allow some residual risk of survival and escape of unwanted organisms. We assessed the survival of fouling organisms following hull cleaning at five different facilities that incorporated three types of cleaning situations (dry dock, hardstand cleaning operations, and in-water hull cleaning), and four methods of waste treatment that involved different degrees of containment of solid and liquid wastes. We assessed the numbers and survivorship of organisms in the waste stream from each facility and compared viability of organisms removed from vessels in different seasons (summer *vs.* winter). We also modelled the theoretical residence time of liquid effluent within the waste treatment systems of each facility during summer and winter cleaning.

Results indicate that the method of hull cleaning, rather than seasonality, was the main determinant of the viability of organisms on completion of the cleaning and treatment processes. Methods used in dry dock and haul-out facilities produced fewer viable macro-fouling organisms in the solid waste than in-water cleaning. In shore-based facilities, average concentrations of intact biota were greatest in the initial runoff from the water blasting, with settlement and filtration progressively reducing the numbers of viable organisms in the liquid effluent. Mortality was a function of residence time within the freshwater liquid effluent and generally increased with the volume of the effluent treatment system relative to the volume of effluent input. Greater throughput of vessels within the facility shortens the residence time of liquid effluent within the system, thereby increasing survivorship. Modelling of the residence times of different particle sizes showed that particles with a fast settling rate (1.0 m min^{-1}) were retained by all treatment facilities. Rates of retention for particles with a settlement rate of 0.1 and 0.01 m min^{-1} varied with system capacity and water inflow rate, whilst no cleaning facility offered theoretical 100% retention for particles with slow sink rates of 0.001 or 0.0001 m min^{-1}. The liquid effluent treatment systems of most cleaning facilities studied would theoretically kill many non-indigenous marine pests based on their known salinity tolerances in relation to modelled water residence time distributions.

Our results show that maximum efficacy for treatment of effluent from hull cleaning is achieved by shore-based facilities that retain solid macro-fouling waste (disposed of to landfill) and which treat liquid effluent prior to discharge/recycling. Treatment systems that have a large volume of storage relative to effluent input and which use freshwater in the treatment system retain greater amounts of potentially viable propagules and achieve greatest mortality of them during treatment. Fine particle filtering (to a size of 10–20 µm) of treated effluent is required to minimise discharge of any surviving organism to the sea, although discharge of treated effluent into municipal sewage systems or similar extensive freshwater treatment system, or even recycling for use in water blasting, may avoid the need for filtration.

NOTES

Hull Fouling as a Vector for Introduction of Non-indigenous Species

Francisco Sylvester, *Colin van Overdijk and Hugh J. MacIsaac*
CAISN, University of Windsor, Great Lakes Institute for Environmental Research
401 Sunset Avenue, Windsor, ON N9B 3P4 Canada

Hull fouling is a well recognized vector for the introduction of aquatic non-indigenous species (NIS) worldwide, although studies in Canada are rare. During 2007-2008, we surveyed a total of 60 vessels entering ports on Canada's east and west coasts, and the Great Lakes, to assess their comparative risk of invasion from hull fouling. We collected 20x20cm scrapings from exterior vessels surfaces as well as underwater video-transects. The Great Lakes' samples yielded an average of 500 organisms per ship from more than 60 taxa, including several marine and freshwater invertebrate groups. Some samples contained established NIS such as *Cercopagis pengoi*, though it is not clear whether this species was present before the ship entered the lakes. However, in a preliminary assessment no freshwater taxa new to the Great Lakes were found. Preliminary analysis of the east and west coast samples suggest that larger numbers and greater diversity of invertebrates can be retrieved from ships entering marine ports than the Great Lakes. The comparative risk of hull fouling introductions between the coasts, as well as the potential strength of hull fouling vs. ballast water vectors, will be discussed.

NOTES

Testing the Effects of Multiple Anthropogenic Stressors on the Spread of Invasive Species: Climate Change, Urbanization and Water Hyacinth

Juliet C. Simpson *and Katherine F. Smith*
Brown University, Department of Ecology and Evolutionary Biology
80 Waterman Street, Box G-W, Providence, RI 02912 USA

Environmental stressors (e.g., increasing atmospheric CO_2 concentrations, eutrophication, salinization) can have important effects on the spread and persistance of invasive species. While these stressors are typically studied independently, they do not operate independently in the world, but often interact to produce non-additive ecological "surprises". Accurately predicting rates of growth and spread of invasive species more will require some understanding of how they will respond to combined stressors.

We are investigating the combined effects of climate and land-use change on the establishment, success and impact of *Eichhornia crassipes* (water hyacinth). We are conducting a series of of greenhouse and growth chamber studies in which we manipulate nutrient availability with daytime and nighttime temperatures and salinity to determine if eutrophication can 1) increase rates of growth at high and low temperatures; 2) increase hyacinth's ability to withstand cold and freezing nighttime temperatures; and 3) increase hyacinth's ability to tolerate short and long-term exposure to saline water. Preliminary results show that a) plants grown at higher nutrient concentrations have higher tolerance for cold night time temperatures (measured as rate of photosynthesis on days following cold nights), and recover more quickly from cold night time treatments, and b) hyacinth grown under high nutrient conditions have much higher salinity tolerances than those reported in the literature.

These results suggest that regions not currently invaded by water hyacinth may indeed be susceptible to future invasion. Knowledge of hyacinth's response to the combined effects of temperature, nutrients, and salinity will ultimately be combined with regional climate change projections to generate distribution models that will identify fresh and brackish water systems at risk of invasion.

NOTES

Effects of Global Warming and Thermal Pollution on Native and Exotic Fish Species in the Rhine

Rob S.E.W. Leuven*, N.A.H. Slooter, A.J. Hendriks, M.A.J. Huijbregts and Gerard van der Velde*
Radboud University Nijmegen, Institute for Wetland and Water Research
PO Box 9010, 6500 GL Nijmegen, The Netherlands

Several large rivers in Western Europe show rising water temperatures, due to thermal pollution and global warming. The present study analyses the influence of water temperature on fish fauna in the river Rhine. The minimum, average and maximum water temperature of this river increased with circa 5°C over the period 1908-2005. It is hypothesized that rising river water temperature is a limiting factor for recovery of native fish fauna and facilitates establishment of exotic ones.

The fish fauna of the Rhine river branches in the Netherlands shows remarkable changes from the 20th century onward. Over the period 1940-1979, the species richness of rheophilous species has declined due to habitat deterioration. In spite of recent improvements of water quality and habitat rehabilitation, native fish fauna has only partly recovered. The number of exotic species (i.e. non-native immigrants and deliberately and accidentally introduced species) has strongly increased, in particular after the opening of the Rhine-Main-Donau canal in 1992.

Species sensitivity distributions for minimum and maximum temperature tolerance show that exotic species tolerate broader ranges and higher temperatures than native ones. Using species sensitivity distributions it is predicted that a future increase in water temperature will potentially affect a higher percentage of native fish species than of exotic ones.

NOTES

Trinational Risk Assessment Guidelines for Alien Invasive Species: Test Cases for the Snakeheads (Channidae) and Armored Catfishes (Loricariidae) in North American Waters – A Common North American Approach to Risk Analysis

Roberto Mendoza
Universidad Autónoma de Nuevo León (UANL), Faculty of Biological Sciences
Aptdo. F-96, Cd. Universitaria,C.P. 66450, Monterrey, N.L., Mexico

There are few environmental issues that are as well documented as the impacts of Invasive Alien Species (IAS). The movement of people, commodities and their conveyances through international commerce has increased the risk of movement of these unwanted organisms.

Mexico, Canada and the United States all have extensive histories in addressing IAS, and --due to trade and economic implications, the CEC was seen as the appropriate venue to steward the development of a common approach to IAS.

Trinational consensus was quickly reached that two issues had to be addressed before relevant IAS work could be started under the CEC. The first (1) was to determine the gaps in the current international protection coverage and the second (2) to agree upon an evaluation process, which the CEC could use to address specific IAS.

To address the first issue a review of the major gaps in North American regulatory coverage showed that animals (those that fall outside of the jurisdiction of the animal health organizations) were serious gaps in coverage that were not currently being addressed elsewhere. To address the second issue the Trinational Working Group agreed to draft CEC Risk Guidelines. It was realized that future trinational CEC risk assessment would need a mechanism to insure that all three countries use the same risk approach, and organize and present their data in a similar way.

The focus of this type of assessment process was mainly in taking the available information and putting it into a format that could be understood and used by risk managers or policy makers. It also had the added plus of meeting the requirements of the various international trade conventions and agreements.

Agreement was reached by the Working Group that the draft CEC Risk Guidelines was ready for field testing. Based on a Canada agreed to focus on the Snakehead fishes while Mexico focused on the Sailfin Catfishes assessment. It was also agreed that the Working Group would conduct two limited economic studies on the impacts of the Sailfin Catfish. Both the Infiernillo Dam in Mexico and Peninsular Florida populations of the catfish were chosen as evaluation sites.

The purpose of the assessments and economic evaluations were to test the feasibility and basic structure of the current draft CEC Risk Guidelines. These assessments did indeed show that the draft Risk Guidelines could be adopted and adapted to the particular needs of the regulating agencies. However, it was recognized that the field of risk analysis is evolving quickly and that the CEC Risk Guidelines need to be flexible enough to accommodate new methodologies and processes when they come available.

NOTES

The Transformation of Aquatic Invasive Species into Environmental and Economic Activities at the Niger River Basin Initiative

Sylvie Trudel
Great Lakes United, Union Saint-Laurent Grands Lacs
3388 Rue Adam, Montreal, QC H1W 1Y1 Canada

The "River to River Initiative" is an environmental and economic development project on the Niger River. This project impacts 20,000 people in participating communities throughout Mali and Niger – two of the poorest countries in the world. These people are struggling to survive. The goals of this Initiative are to improve agriculture and biodiversity through soil restoration by using aquatic invasive species to improve environmental, social, health, and economic conditions of the people living in these communities.

In less than 20 years, the water hyacinth and other invasive species have invaded the Niger River choking water flows to the detriment of human health and the overall well-being of the people that live in this region. These plants have devastated the river's ecology by choking water access, preventing navigation and irrigation, and have caused a decline in the areas ability to maintain fisheries due to destabilized water chemistry. Further devastation includes invaded paddy fields, blocked hydroelectric turbines, pumping and filtration systems, and they cause water stagnation which promotes Schistosomiasis and the growth of the larvae that carry malaria. Despite the many problems and barriers we have faced, the "River to River Initiative" has been successful in turning these invaders into an economic benefit.

The "River to River Initiative" was designed to meet the sustainable development needs of the region by transforming extracted plant waste for goods to market, including compost for enhanced soil productivity, fuel briquettes to replace wood for energy, paper, soap, arts and crafts for income, and more. The water hyacinth is also used in ponds and basins as a natural filter to bring pure water to people. Using these plants makes controlling them possible. Through training and by encouraging local ownership of the initiative, we are able to ensure that the economic and educational benefits resulting from this Initiative are retained by the communities themselves, thereby supporting regional development and overall human health.

Another unique aspect of this Initiative is the development of adapted technologies such as solar cookers, solar dryers and bio fuel production. The technologies developed within the project are cost-effective and adaptable to the region and we continue to search for new uses for these plants. We are learning there are many.

For the last ten years, the "River to River" Initiative has helped the people in these communities to take these invaders from a curse and to a development opportunity. Our presence in the region provides educational and economic opportunities that have led to increased yields and produced healthier, more diverse agricultural harvests. The people participating in the Initiative are no longer in a state of malnutrition. When they embrace the initiative methodologies, their lives improve.

We would be happy to present the results of this unique and exciting initiative at the ICAIS conference. Our success is a model for other countries with this same problem.

NOTES

Source Populations and Reproductive Mode of Invasive *Cabomba caroliniana* in Canada

Andrée M. McCracken *and Brian Husband*
University of Guelph, Department of Integrative Biology
50 Stone Road East, Guelph, ON N1G 2W1 Canada

The propagule source and mode of expansion can have important effects on the extent and rate of colonization of species into a novel environment. However, such information about the history of invasion is often difficult to obtain. *Cabomba caroliniana* (fanwort) is an invasive plant that has successfully colonized environments very different from its native range. Native to the southern United States and South America, this species has spread worldwide, including to the northern United States and a single population in Canada in Kasshabog Lake near Peterborough, Ontario. The mechanism of introduction is unknown, although most non-native populations are assumed to be introductions via the aquarium trade or other commercial sources and spreading clonally. In this study, I will test the validity of these two assumptions by attempting to determine both source populations and mode of reproduction in the introduced range of this species in North America. Plants were sampled from native populations in the southern US, populations in the adventive range in the northern U.S., from the single Canadian population near Peterborough and from various commercial sources. Genetic diversity and structure was quantified using flow cytometry and Amplified Fragment Length Polymorphisms (AFLPs) to compare the genetic structure of populations from the native range, the introduced range and from the commercial suppliers. Flow cytometry was used to estimate total DNA content of each sample as preliminary data indicated there was intaspecific variation in total DNA content within the species. Networks were constructed from AFLP data to assess genetic similarities between introduced populations and the various putative sources (Northern U.S., Southern U.S., commercial sources). Indices of genetic diversity including genetic Simpson's diversity index, measures of genetic evenness and genotypic richness as well as compatability analyses were also used to evaluate the importance of sexual versus asexual recruitment in *C. caroliniana.* If a population is reproducing asexually, it is expected to contain low genetic diversity compared to populations that are reproducing sexually. The results of this study will aid in management of this species as well as provide information about the spread of aquatic invasive species in general.

NOTES

The Use of Life Cycle Traits in the Management of the Invasive Species *Lagarosiphon major* in Lough Corrib, Ireland

Stephanie Evers *and Joe M. Caffrey*
Central Fisheries Board
Swords Business Campus, Swords, Co Dublin, Ireland

Lagarosiphon major is a highly aggressive, submerged macrophyte that is currently colonising large areas of Lough Corrib, one of Ireland's Great Western Lakes. The plant was introduced to Ireland by the horticulture industry and has a relatively widespread national distribution in artificial watercourses. Lough Corrib is the only natural waterbody in the country to support expansive populations of this species. The rapid spread of the weed within the lake is resulting in significant changes to the natural lake habitat and its overall ecology.

Efforts to eradicate or control *Lagarosiphon* in the lake are ongoing but are meeting with limited success thus far. Recent studies have focused on an examination of the life cycle of the species, under Irish conditions, in order to identify potential weak links that may be specifically targeted for control. One prominent feature that has emerged from the investigations is the presence of two distinct morphological states within the lake populations. One state is represented by tall, erect and often canopy-forming plants that can grow to heights of 5 metres in the water column. The other is represented by collapsed, often leafless stems, commonly with large numbers of adventitious roots along their length. Both states can be recorded growing alongside each other in the lake.

The study explores the defining characteristics of these vegetative states and the impact that a range of environmental features within the lake might have on their expression and status. The succession of the two vegetative states through the seasons is also being monitored. The impact of various weed control measures as applied to 'collapsed' and 'erect' *Lagarosiphon* stands will be discussed.

NOTES

Invasive Aquatic Plants: Growing Solutions in Indiana

Patrice M. Charlebois *and Kristin M. TePas*
Illinois-Indiana Sea Grant/Illinois Natural History Survey
400 17th Street, Zion, IL 60035 USA

Douglas C. Keller
Indiana Department of Natural Resources, Division of Fish and Wildlife
402 W. Washington Street, RM W273, Indianapolis, IN 46204 USA

Katherine M. Glassner-Shwayder and Erika S. Jensen
Great Lakes Commission
Eisenhower Corporate Park, 2805 S. Industrial Hwy Suite 100, Ann Arbor, MI 48104 USA

Reuben Keller
University of Notre Dame, Department of Biological Sciences
PO Box 369, Notre Dame, IN 46556 USA

Invasive aquatic plants are taking root in Indiana, and posing a serious threat to the state's ecological and economic health. For example, an infestation of hydrilla (*Hydrilla verticillata*) was discovered in a 734-acre lake in Indiana in 2006, and is expected to cost the state $1.5 million to eradicate. This closely followed a Brazilian elodea (*Egeria densa*) infestation of a 109-acre impoundment, which the state eradicated at a cost of $135,000. Anglers, boaters and hunters (and the businesses that cater to them) felt additional economic and social impacts because of imposed restrictions on recreational activities on the lakes.

These infestations impelled us to comprehensively address the issue of invasive aquatic plants in Indiana. To do this most effectively, we invited relevant stakeholders in Indiana to assist us. Representatives from the aquarium trade, nursery and landscaping industry, non-governmental organizations, academia and state government volunteered for our "Aquatic Plants in Trade" working group.

Since 2007, this group has been developing solutions to the issue of invasive aquatic plants in Indiana, which include regulatory, best management and public education approaches. The most significant of these has been the development of a systematic process for evaluating aquatic plants in trade, which includes a risk assessment model for Indiana based on the New Zealand Aquatic Plant Weed Risk Assessment. These solutions, when fully implemented, will significantly reduce the introduction, and therefore the ecological and economic impact of invasive aquatic plants in Indiana.

NOTES

Status of the Water Chestnut (*Trapa natans*) Eradication Program in Quebec, Canada

Isabelle Simard
Ministère du Développement durable, de l'Environnement et des Parcs
675 boulevard René-Lévesque Est, boîte 21, Québec, QC G1R 5V7 Canada

Annie Simard
6573 du Dom-Périognon, Québec, QC G3E 1T7 Canada

Bertrand Dumas
Ministère des Ressources naturelles et de la Faune
201 Place Charles-Le Moyne, Longueil, QC J4K 2T5 Canada

Pierre Bilodeau
Ministère des Ressources naturelles et de la Faune
289 Mont-Tremblant, QC J8X 2X4 Canada

Water chestnut (*Trapa natans*) was first detected in the South River, Québec, in 1998 and has rapidly spread to the entire water course. Since then, the plant has been identified in the Brochets and Richelieu Rivers. The eradication of the water chestnut was initiated in 2000 by a non-profit organization, CIME Haut-Richelieu. By 2001, a collaboration agreement was achieved between the regional county municipality Haut-Richelieu, Ducks Unlimited Canada, CIME, Fondation de la faune du Québec and provincial ministries, in a concerting effort to eradicate the plant. The harvesting efforts of the 2002-2007 eradication campaigns have led to significant reductions of infested areas and water chestnut biomass in the South River watershed. A reduction of 81% of the surface area covered by water chestnut was observed in the highly infested zones, decreasing from 35.6 hectares in 2002 to 6.8 hectares in 2007. Biomass also declined significantly from 6.79 million of rosettes harvested in 2002 to 0.18 million in 2006. However, climatic and hydrologic conditions observed in 2007 are believed to have resulted in an increase of water chestnut productivity when 1.38 million of rosettes were harvested. In the next years, water chestnut is expected to be present in low or very low densities in the watershed. Future efforts in early detection, control and eradication are still needed over the next few years. The renewed involvement and perseverance of all the partners implicated in the eradication program is necessary, supported by a targeted education campaign. Only a strong commitment of all partners will insure the protection of Québec watersheds against major water chestnut infestations.

NOTES

Potential for Weed Biocontrol in Ireland: *Azolla filiculoides* Control by *Stenopelmus rufinasus*

Jan-Robert Baars *and C. Milar*
University College Dublin, School of Biology and Environmental Science
Belfield, Ireland

Joseph M. Caffrey
Central Fisheries Board
Swords Business Campus, Swords, Co. Dublin, Ireland

The control of the water fern *Azolla filiculoides* Lamarck (Azollaceae) by a natural enemy is the first example of aquatic weed biocontrol in Ireland. The water fern has been established as an aquatic invasive species in Ireland for nearly a century. It is found as isolated populations in ponds and slow-moving freshwater habitats over a wide geographic distribution in Ireland, but only periodically becomes troublesome. Recent surveys indicate that a natural enemy, the frond feeding weevil *Stenopelmus rufinasus,* which originates from the plants country of origin, is controlling water fern populations in Ireland. Subsequent to its discovery on an infestation of water fern in County Cork in late 2007, plant and weevil populations have been monitored monthly. Ten replicate quadrats were taken monthly, over a twelve month period. On each occasion, weevil life stages were recorded and plant biomass measured. Field monitoring indicates that the weevils over-winter as adults at low densities and only resurge in numbers after the plant proliferates at the start of the growing season. Noticeable populations of larvae and pupae were recorded in April and numbers exceeded 3000 individuals/m^2 by mid-summer (July). The water fern infestation collapsed as a result of the feeding damage and no plants were left when the site was examined in August. The weevil was recorded on all of the water fern populations that were assessed within the country, indicating that it has successfully established over a wide geographic range. The plants in each of these isolated populations were severely damaged and under complete control by mid-summer. In all instances, weevil populations subsequently collapsed as the weevils were unable to utilise the indigenous species as a food source. This is the first example of weed biocontrol in Ireland, even though it occurred as a result of the inadvertent introduction of a host specific natural enemy. This should encourage the use of biological control as an alternative method of managing the increasing threat of invasive species in Ireland.

NOTES

A Practical and Effective Approach to Bullfrog Control and Eradication

Stan A. Orchard *and Kevin Jancowski*
BullfrogControl.com Inc.
69A Burnside Road West, Victoria, BC V9A 1B6 Canada

Can anything be done to stop burgeoning and ecologically damaging populations of invasive American bullfrogs (*Rana catesbeiana* = *Aquarana catesbeiana*) in western North America and Europe? This amphibian, like many of the worst alien invasive species, is vagile – by amphibian standards - agile, fecund, and adaptable. While there is a general consensus that invasive bullfrogs should be eradicated, their rapid rates of population growth and geographical expansion have created a general impression that all prospects of success are vain.

In 2005, a program got underway on southern Vancouver Island, British Columbia, Canada, experimenting with strategies and tactics and developing innovative techniques to out-smart, out-flank, out-pace, and thus overwhelm bullfrog populations. By the end of the 2008 field season this program will have removed in excess of 8,000 juvenile and adult bullfrogs from a wide range of habitat types. New tools have emerged that are species-specific, eco-friendly, humane, cost-effective, and time-efficient. Three years of field data collected by one two-person team now strongly support the proposition that at least in north temperate climates and with the right tools and methodologies bullfrog eradication is both feasible and practical.

In the beginning the multiple goals of this program were each to varying degrees hypothetical. Additionally, the program is on-going and cannot yet claim that bullfrogs have been eradicated from the entire target region – but that is not the point. The point is that our techniques are detecting and removing bullfrogs from the environment at rates and in numbers that make the exercise well worthwhile and eradication inevitable. There is no longer any doubt that bullfrog population growth and geographical expansion can be stemmed and turned. By increasing the current effort with respect to hours invested and numbers of personnel involved the rate of populations decline can be proportionally accelerated. Success is therefore now simply a matter of logistics rather than theory and speculation and this program model is applicable throughout western North America and Europe.

NOTES

Mechanisms Behind the Successful Invasion of Bullfrogs (*Rana catesbeiana*) in the Northwest United States

Tiffany S. Garcia, *Rebbecca Hill and Benjarmin Emmert*
Oregon State University, Fisheries and Wildlife Department
104 Nash Hall, Corvallis OR 97331 USA

William C. Funk
Colorado State University, Biology Department
Fort Collins, CO 80523 USA

Understanding the mechanisms that allow populations of some species to successfully expand into novel environments is essential for developing management strategies to limit the spread and ecological impact of biological invasions. *Rana catesbeiana* (Bullfrogs) are one of the 100 worst invasive species in the world and are involved in declines of many native species, particularly other amphibians, via predation and/or competition. Our research tests three general hypotheses for the invasion success of bullfrogs: 1) local adaptation to the new environment, 2) phenotypic plasticity in response to novel environmental conditions, and 3) bullfrogs act as a disease reservoir for a fungal pathogen, *Batrachochytrium dendrobatidis* (Bd), which acts as a novel weapon in amphibian communities. These hypotheses link molecular genetics, controlled laboratory experiments, population modeling, and field surveys in a biogeographic framework in which the phenotypes and ecology of invasive bullfrogs will be compared to those of source populations in the native range. We have determined the source population of invasive bullfrogs in the Northwest United States bullfrogs using molecular markers and comparing them with populations in the bullfrog native range (Southeast United States). Analysis of 15 populations from the Northwest United States matches the genetic composition of native Bullfrog populations along the Mississippi River Valley. Locating these source populations for the Northwest United States bullfrog complex will now allow us to directly compare life history characteristics and measure trait divergence and/or plasticity in response to environmental conditions, such as water temperature, hydroperiod, and local species susceptibility to the BD pathogen.

NOTES

The American Bullfrog as Predator and Cannibal: What are the Benefits of Eating Your Own Species?

Kevin Jancowski *and Stan A. Orchard*
BullfrogControl.com Inc.
69A Burnside Road West, Victoria, BC V9A 1B6 Canada

The American bullfrog (*Rana catesbeiana* = *Aquarana catesbeiana*) is an extraordinarily prolific and aggressively predatory invasive species. The diet is extremely varied – including virtually any arthropod, fish, amphibian, reptile, mammal or bird that can be grasped and swallowed. Bullfrogs are also avowed cannibals – but why? Some biologists seem to believe that bullfrogs actually control their own population numbers by preying on their own species – and this has been used as a rationale for not killing bullfrogs. Can this be true? How could cannibalism possibly translate into bullfrog success?

An examination of stomach contents from a relatively large sample of adult American bullfrogs – all captured on southern Vancouver Island - is coupled with two years of capture results to offer an interpretation and explanation of the role of cannibalism in bullfrog survival and success.

NOTES

Bullfrog Eradication Efforts in Scotia Canyon, Huachuca Mountains, Arizona, USA

Glenn P. Frederick
U.S. Forest Service, Coronado National Forest
5990 S. Hwy 92, Hereford, AZ 85615 USA

Brooke S. Gebow
The Nature Conservancy
27 Ramsey Canyon Road, Hereford, AZ 85615 USA

Trevor Hare
Sky Island Alliance
738 North Fifth Avenue, Suite 201, Tucson, AZ 85705 USA

James C. Rorabaugh
U.S. Fish and Wildlife Service
201 N. Bonita Ave, Suite 141, Tucson, AZ 85745 USA

Thomas R. Jones
Arizona Game and Fish Department
5000 W. Carefree Hwy., Phoenix, AZ 85086 USA

Bullfrogs (*Rana catesbeiana*) are significant impediments to recovery of native aquatic amphibians and reptiles in riparian systems in the American Southwest. They appear to have invaded Scotia Canyon in the Huachuca Mountains of southeastern Arizona in the early 1980s, and soon became widely established in a 1.6 km perennial reach of the creek and in several earthen stock tanks. Native aquatic species of conservation concern, including Chiricahua leopard frog (*Rana chiricahuensis*), Sonoran tiger salamander (*Ambystoma tigrinum stebbinsi*) and Mexican garter snake (*Thamnophis eques megalops*), declined or disappeared from Scotia Canyon shortly after the bullfrogs invaded.

Following an ambitious project to breach most of the impoundments and to reestablish a natural flow regime within the canyon, the U.S. Forest Service, U.S. Fish and Wildlife Service, Arizona Game and Fish Department, The Nature Conservancy, Sky Island Alliance, and a host of volunteers began a concerted effort to eliminate bullfrogs from the system during the 2008 late spring dry season. First, likely sources of continued immigration were identified for removal. Next, the remaining spring-fed impoundment in Scotia Canyon was nearly completely drained, allowing for hand capture, dip-netting, gigging, and seining to remove most frogs and to eliminate tadpoles completely. Third, the entire perennial reach of Scotia Canyon was searched repeatedly and all bullfrogs encountered were removed. And finally, prior to and during the summer rainy season, biologists and volunteers made repeated visits to dispatch the remaining frogs by gigging and shooting.

Regardless of the apparent success, bullfrog immigration will continue to threaten aquatic habitats in Scotia Canyon. It is clear that a broad landscape approach is necessary to eliminate bullfrogs completely, while even then, careful monitoring will be necessary to ensure ultimate success.

NOTES

History and Current Affairs of VHS Virus

Gael Kurath
U.S. Geological Survey, Western Fisheries Research Center
6505 NE 65th St. Seattle, WA 98115 USA

Viral hemorrhagic septicemia virus (VHSV) is an acute pathogen of fish that has been well known since the 1950s as the cause of widespread epidemics in cultured trout in Europe. Although European VHSV (genotype I) has been studied for decades, the virus was first isolated in North America in 1988, in salmonids returning to west coast watersheds. We now know this VHSV genotype (IV) is endemic to several Pacific marine fish species and causes epidemics in wild marine fish such as herring. Most recently a variant VHSV genotype (IVb) was detected on the Northern Atlantic coast of North America, and in 2005-2007 it caused epidemics in several wild freshwater species in the extensive Great Lakes watershed. The emergence of VHSV in Great Lakes fisheries is currently an issue of great concern, requiring active surveillance and regulatory management. This overview of VHSV will explain its history, recent emergence in the Great Lakes, and how genetic typing informs our understanding of the virus.

NOTES

Development of Improved Detection Methodologies for Viral Hemorrhagic Septicemia Virus (VHSV) and their Use in the Surveillance of the Great Lakes Region of Canada

***Kyle Garver**, Laura Hawley, Sandra Edes and Jon Richard*
Fisheries Oceans Canada, Pacific Biological Station
3190 Hammond Bay Road, Nanaimo, BC V9T 6N7 Canada

VHSV is an aquatic rhabdovirus that is listed by the World Organization for Animal Health (OIE) due to its ability to cause mass mortality in numerous fish species in Europe, Asia and North America. In 2005 the virus became one of the newest invasives to the Great Lakes where it has caused multi-species epidemics involving more than 25 fish species in both US and Canadian waters, including Lake Michigan, Lake Huron, Lake St. Clair, Lake Erie, Lake Ontario and the Saint Lawrence River. Inland lakes in New York, Michigan, Wisconsin, and Ohio have also suffered outbreaks. The rapid spread of this virus into previously VHSV free water sources prompted a large-scale surveillance and monitoring program to determine the spatial extent of the virus. Currently accepted diagnostic procedures depend on virus isolation in cell culture using cell lines such as *Epithelioma papulosum* cyprinid (EPC) with subsequent agent identification by conventional RT-PCR using VHSV specific primers. While these techniques are useful in disease outbreak investigations, they are not well suited for survey, surveillance, or movement control programs as they lack high throughput and suitable turn-around times. To this end, we have developed a quantitative RT-PCR for universal VHSV detection. The qRT-PCR assay targets a conserved region of the nucleoprotein (N) gene of the virus and is highly specific and sensitive, detecting as little as 50 copies of VHSV RNA transcript per reaction. Analytical validation has also revealed the assay to be universal, in that it amplifies all four genogroups of VHSV. The assay has proven effective for detection of VHSV in infected tissues and when used in conjunction with ultra-filtration technology provides a highly sensitive methodology for quantifying viral particles in large volumes of water.

NOTES

Persistence of VHSV-GL in the Absence of Clinical Disease

*E.R. Cornwell, W.T. Heath, K.M. Hope, R.N. Casey, P.R. Bowser, G.E. Eckerlin, I. Lombardino, E. Penner, S. Owczarczak, M.B. Bain and **James W. Casey***
Cornell University, Department of Microbiology and Immunology
Ithaca NY 14850 USA

W.N. Batts and J.R. Winton
U.S. Geological Survey, Western Fisheries Research Center
6505 NE 65th St., Seattle, WA 98115 USA

Traditional assays for the identification of microbes in aquatic environments have used morphological and culture-based methods that are imprecise and slow. More recently, novel molecular approaches are providing quantitative estimates of the various microbial species present in aquatic systems. In an effort to identify risk factors for the spread of the Great Lakes strain of *Viral hemorrhagic septicemia virus* (VHSV-GL), we conducted a targeted screening program using a novel qRT-PCR assay on fish and water samples collected in the lower Great Lakes at a time in which no disease outbreak or mortality was occurring. Three classes of sites were selected: 10 commercial shipping harbors, 10 recreational harbors and 10 undeveloped (wild) sites. We targeted our samples at each site to round gobies (60 per site, 1269 acquired), which are abundant in the lower Great Lakes and highly susceptible to VHSV-GL. Tissue samples testing positive for VHSV-GL were obtained from fish at twenty-three sites, while eight sites produced positive water samples. The overall prevalence of VHSV-GL was approximately 5% and evenly distributed among all three classes of sites. The qRT-PCR levels of VHSV-GL ranged from 10^1 to 10^7 and infectious virus was isolated from selected fish using standard cell culture protocols even though no clinical signs of disease were present. Sequence analysis showed that the VHSV-GL from gobies collected in this study and from previous years were essentially identical, discounting the hypothesis that attenuation of VHSV is responsible the absence of outbreaks in the Great Lakes in 2008.

NOTES

U.S. Federal Efforts to Address VHSV and Other Aquatic Animal Pathogens

P. Gary Egrie
U.S. Department of Agriculture, Animal and Plant Health Inspection Service
4700 River Road, Unit 46, Riverdale, MD 20737 USA

In the United States, VHSV, and other pathogens of aquatic animals, are being addressed at the Federal level through the National Aquatic Animal Health Task Force (NAAHTF). The NAAHTF is comprised of the three Federal agencies with primary regulatory authority for aquatic animal health, the U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS); the U.S. Department of Commerce (DOC) National Oceanic and Atmospheric Administration (NOAA); and the U.S. Department of the Interior (DOI) Fish and Wildlife Service (FWS). The Agencies comprising the NAAHTF strive to leverage available resources and expertise in order to collaboratively and effectively address aquatic animal health issues important to both a natural resource and agriculture perspective. All stakeholders are encouraged to look internally within their own organizations to examine ongoing efforts to control aquatic animal pathogens, and to improve intra-agency communications and collaboration on aquatic animal health issues.

NOTES

Response of Great Lakes States to the Presence of the VHS Virus in the Region

Philip B. Moy
University of Wisconsin Sea Grant Institute
705 Viebahn Street, Manitowoc, WI 54220 USA

T. Bruce Lauber
Department of Natural Resources
126 Fernow Hall, Cornell University, Ithaca, NY 14853 USA

As the VHS virus (VHSv) spread through the Great Lakes region, so too did the array of recommended actions and regulations that were intended to prevent the introduction of the virus to inland lakes and protect states' fishery resources. The response to VHSv within the community of Great Lakes agencies and the shipping industry was rapid and precipitated an array of guidance and regulations. Though similar in intent, regulations and approaches to VHSv prevention differ among jurisdictions. To date we have not seen the virus spread to numerous inland lakes but one consequence of the feared infestation is better biosecurity for fish farms and hatcheries. Initial trepidation among anglers has in some cases been transformed into increased awareness of aquatic invasive species prevention strategies yet misunderstandings may still exist regarding use of live bait. This presentation will summarize and compare actions taken by the Great Lakes states to minimize the effect of VHS virus on their fish and fisheries.

NOTES

Fisheries Management Responses to the Detection of VHS (Viral Hemorrhagic Septicaemia) in Ontario

Brenda G. Koenig, *Steven J. Kerr, Mike E. Bohm and M. Elizabeth Wright*
Ontario Ministry of Natural Resources
300 Water Street, 5th Floor, North Tower, Peterborough, ON K9J 8M5

Viral hemorrhagic septicemia (VHS) was first identified in Ontario during 2005 after a die-off of fish in the Bay of Quinte, Lake Ontario. The virus has now been found in more than 25 species of fish in the Great Lakes, including walleye, yellow perch, small-mouth and large-mouth bass, muskellunge and several species of baitfish.

In January 2007, interim measures to control the harvest and transport of live baitfish were invoked. This involved the designation of management zones across the province; an infected zone, a buffer zone and a virus-free zone. Baitfish harvest from an area encompassing the lower Great Lakes was prohibited. These measures were designed to slow the spread of VHS from the Great Lakes to inland waters and had significant impacts on baitfish operators. Following this, the Ontario Ministry of Natural Resources (OMNR) met with several stakeholders to share information and gather feedback on potential management approaches for the future.

A revised one-year interim management strategy was announced in March 2007 and included a broader definition of virus-positive waters and a VHS Management Zone, The operation of fishways and existing manual transfers of fish over barriers did not change, however restrictions were placed on the use of fish, eggs and spawn collected from the VHS Management Zone. The new strategy allowed baitfish harvesters and dealers in the VHS Management Zone to resume limited operation but restricted movement of live baitfish out of the zone. Other movements of fish such as anglers moving baitfish were not restricted. The OMNR initiated an education and awareness campaign (e.g., fact sheets, website http://www.mnr.gov.on.ca/en/Business/LetsFish/2ColumnSubPage/STEL02_166029.html, slide presentations) to share information about the VHS virus, potential impacts and preventative actions that the public and stakeholders could take to help slow the spread. Another aspect of the management response included the collection of fish for VHS testing in the spring and fall of 2007.

MNR believes that there is an ongoing need for measures to slow the spread of VHS and potentially other invasive fish pathogens into Ontario waters. Early in 2008, a decision to continue the current VHS control measures and develop options for improving them, including consultation with stakeholders, was made. Currently, if new information confirms the presence of VHS beyond the current VHS Management Zone, existing controls will be applied to the new area.

NOTES

Reproductive Biology and Ecology of the Invasive Lionfishes *Pterois miles* and *Pterois volitans*

James A. Morris, Jr.
NOAA National Ocean Service, National Centers for Coastal Ocean Science
101 Pivers Island Road, Beaufort, NC 28516 USA

The Indo-Pacific lionfishes, *Pterois volitans* and *Pterois miles*, have become rapidly established in the Atlantic from Cape Hatteras, North Carolina to the Caribbean. The rapid establishment and expansion of the lionfishes demand careful examination of their biology, ecology, and ultimately their impacts on native fishes. Our observations of lionfish reproductive biology indicate that lionfish are iteroparous, asynchronous, indeterminate batch spawners with each egg batch comprised of two buoyant gelatinous egg balls. Lionfish were found to be actively spawning during each month of the calendar year from Cape Hatteras, North Carolina to the Bahamas. Laboratory experiments designed to investigate predation on juvenile lionfish indicate that some native reef fishes avoid the lionfish as prey, likely due to their venom defence. Tagging efforts indicate that lionfish exhibit site fidelity suggesting that local control at some locations, such as marine sanctuaries, may be a viable management strategy for controlling the impacts of this invader. Recent observations suggest that lionfish may be captured in traps providing an efficient removal strategy and abundance assessment. These efforts are providing new insights into the integrated biology and ecology of marine finfish invaders and further demonstrate the need for aggressive early detection and rapid response efforts in the marine environment.

NOTES

Predicting the Impact of Invasive Lionfish (*Pterois volitans* and *P. miles*) on Native Reef Fish Populations in the Caribbean

Stephanie J. Green *and I.M. Côté*
Simon Fraser University, Department of Biological Sciences
8888 University Drive, Burnaby, BC V5A 1S6 Canada

James A. Morris, Jr.
National Oceanic and Atmospheric Administration, National Ocean Service, National Centers for Coastal Ocean Science
101 Pivers Island Road, Beaufort, NC 28516 USA

J. Lad Akins
Reef Environmental Education Foundation
98300 Overseas Hwy, Key Largo, FL 33037 USA

Indo-Pacific lionfish (*Pterois volitans* and *P. miles*) have recently invaded and rapidly spread throughout Western Atlantic and Northern Caribbean habitats. These venomous fish use an ambush strategy to consume whole prey and have few predators in their introduced range.

To understand the impacts of lionfish on native fish communities and to predict their impacts on the wider Caribbean, we studied the prey and habitat preferences of lionfish on reefs along the southwest coast of New Providence, Bahamas. Prey-sized fish density, diversity and size distribution, reef complexity and topography, and lionfish density and habitat preference data were collected from 14 sites varying in habitat types, depths and lionfish densities. From January 2007 to July 2008, 500 lionfish (TL = 50 - 424 mm) were collected from these sites.

Stomach content analysis revealed that lionfish prey heavily on many species and size classes of native reef fish. Comparisons of diet to prey availability suggest preferential predation on species with behavioural characteristics and morphologies that increase encounter rate and ease of capture. Furthermore, lionfish density was positively correlated with both reef complexity and relief, and prey-sized fish density. Finally, comparing data on lionfish and prey biomass from reefs with experimental rates of prey consumption revealed that lionfish have the potential to remove prey from reefs at a rate far greater than reef fish populations can replenish themselves. Thus, lionfish have the ability to significantly impact native reef fish communities. These findings can be used in conjunction with fish community and habitat profiles from elsewhere in the Caribbean to predict the impact of lionfish as they continue to spread throughout the region.

NOTES

Dietary Habits and Feeding Ecology of Invasive Lionfish in the Tropical Western Atlantic

James A Morris, Jr.
National Oceanic and Atmospheric Administration, National Ocean Service
101 Pivers Island Road, Beaufort, NC 28516 USA

J. Lad Akins
Reef Environmental Education Foundation
98300 Overseas Hwy, Key Largo, FL 33037 USA

The invasive Indo-Pacific lionfishes (*Pterois miles* and *Pterois volitans*) are now widely distributed along the U.S. East Coast, Bahamas, and the Caribbean. It is anticipated that lionfish will impact native reef fish communities via competition for dietary resources. To investigate lionfish feeding habits in the tropical western Atlantic, we analyzed approximately 1200 lionfish stomachs sampled from various locations on the Bahamian archipelago. Our results suggest that lionfish diet is approximately 78% finfish and 15% crustaceans by percent volume. When considering the composition of finfish, we found that lionfish feed on over 20 families of fishes with the top five most important families comprising Gobidae, Labridae, Grammatidae, Apogonidae, and Pomacentridae. Of the crustaceans, we found that lionfish feed primarily on shrimps. Lionfish are considered ambush predators frequently using their large pectoral fins to corral prey. Lionfish feeding occurs primarily during the crepuscular periods of the day with peak feeding occurring during the early morning hours. The composition of finfish in lionfish diet increases at approximately 140 mm total length corresponding with the onset of sexual maturation. These results provide the first comprehensive assessment of lionfish dietary habits in the Atlantic and their native range and provide a quantitative analysis of the impacts lionfish will have on forage fishes of Atlantic reef fish communities.

NOTES

Bioenergetics and Trophic Impacts of Invasive Lionfish (*Pterois miles* and *Pterois volitans*)

David S. Cerino and ***James A. Morris, Jr.***
National Oceanic and Atmospheric Administration, National Ocean Service
101 Pivers Island Road, Beaufort, NC 28516 USA

Anthony S. Overton
East Carolina University, Department of Biology
Greenville, NC 27858 USA

Lionfishes, *(Pterois miles and Pterois volitans)* are marine reef fishes native to the Indo-Pacific oceans. Established populations now exist in the western Atlantic and Caribbean. It has been demonstrated that lionfish are capable of reducing prey fish abundance at significant levels; however, quantification of the cumulative biomass that lionfish may remove from native reef fish communities is not well understood. For this reason, we are developing a bioenergetics model for lionfish capable of assessing the impact of lionfish populations on lower trophic levels through predation. This model is also being used to identify regions of suitable and optimal habitats for these invasive species. Size dependent and temperature dependent functions of maximum consumption and respiration are the core of this modeling effort and are being derived from laboratory trials conducted with lionfish of varying in size from small juveniles to large adults and at temperatures encompassing most of their thermal tolerance from 14-34°C. By assessing energy input and expenditures, the model can predict growth at various feeding rates and temperature regimes, as well as quantify biomass removal by lionfish at the individual and population levels. These predictions are valuable tools for assessing the direct impacts of lionfish on the native reef fish community including both the reduction in forage fishes and the competitive interactions with higher level predators.

NOTES

Spread and Distribution of *Hydrilla verticillata* in North America: Where Will it Stop!

Alfred F. Cofrancesco
U.S. Army Engineer Research & Development Center
Environmental Laboratory, 3909 Halls Ferry Road, Vicksburg, MS 39180 USA

Presently, Hydrilla *verticillata* is found on every continent except Antarctica and South America. World wide it ranges from 55 degrees north latitude in the Northern Hemisphere (Lithuania) to 40 degrees south latitude in the Southern Hemisphere (New Zealand). The female dioecious form of *Hydrilla verticillata* was introduced into Florida in the early 1950s, and by 1980 it was found in Texas, Louisiana, Florida, Georgia and Panama. Monecious hydrilla was first noted in the United States in the late 1970s, and both biotypes continue to spread throughout North America. While natural mechanisms for dispersal of this plant do occur in North America, intentional or un-intentional dispersal of the plant by humans is the chief means of spread. As hydrilla continues to move northward in the United States it is apparent that it will eventually infest the Canadian provinces boarding the United States. The extent to which this plant will disperse in North America will be dependent on the plant's ability to withstand colder temperatures and the success/failure of human efforts to reduce its spread.

NOTES

Effects of Temperature, pH and Conductivity on Giant Salvinia (*Salvinia molesta*) Growth

Chetta Owens
U.S. Army Corps Engineers, Engineer Research and Development Center
201 E. Jones Street, Lewisville, TX 75057 USA

Giant salvinia (*Salvinia molesta*), an invasive, free-floating fern native to Brazil, is invading the U.S. In order to predict its ultimate distribution and to identify environmental factors that may affect the susceptibility of aquatic ecosystems to invasion, a series of studies were conducted to determine the effects of low temperatures, pH and conductivity on the growth of giant salvinia. Results from acute low temperature exposure in a controlled study demonstrated that formation of ice results in a decrease in percent survival of giant salvinia. All giant salvinia plants exposed to air temperatures of –16˚C (48hr) were killed while those exposed to –3˚C (48hr) survived due to incomplete ice formation in the surface water of the container. Additionally, growth of giant salvinia under different pH regimes was examined. Giant salvinia grew to completely cover a research pond over a 15-week period when pH was less than 7.5. Growth was reduced in a second pond maintained at higher pH (greater than eight units). Tank studies found that significantly greater giant salvinia biomass was produced at lower pH and that water chemistry of tanks changed when completely covered by the resultant mat.

Conductivity studies (two pH regimes) found that under low pH (seven units or less) except for the highest conductivity (4350 and 10000 µhmos) treatments averaged between 60-90 % surface coverage in all treatment containers. This study likewise found that giant salvinia produced significantly greater biomass (approximately 6-fold) when grown at low pH (less than seven units) than plants grown at higher pH but the plants were also impacted by increasing conductivity. Results suggest that the distribution of giant salvinia in the U.S. will be limited on the northern end by freezing surface waters and that the most susceptible sites are those having low pH (<7.5) and conductivity (<4000). However, once giant salvinia becomes established it is capable of spreading into less favorable conditions and even modifying those conditions to promote its growth.”

NOTES

Integrating Herbicides with *Mycoleptodiscus terrestris* to Control Hydrilla

Linda S. Nelson *and Judy F. Shearer*
U.S. Army Engineer Research & Development Center
3909 Halls Ferry Road, Vicksburg, MS 39180 USA

Integrated weed management practices have been largely overlooked as an approach for controlling submersed aquatic weeds. However, recent studies have shown that combining an indigenous fungal pathogen, *Mycoleptodiscus terrestris* (Mt), with low doses of herbicides has excellent potential as an integrated strategy for long-term management of hydrilla (*Hydrilla verticillata*) and Eurasian watermilfoil (*Myriophyllum spicatum*). We will present the results from two studies that were conducted to evaluate both diquat and fluridone applied alone and in combination with Mt against hydrilla. The data showed that compared to untreated plants, a 2-hr exposure to 0.37 mg L diquat combined with 0.42 g Mt L reduced hydrilla by 99.6%, six weeks after treatment. A 2-hr contact with diquat and Mt applied alone at these rates only controlled plants by 70 and 41%, respectively. Hydrilla exposed for eight hours to 0.185 mg diquat L^{-1} applied with Mt reduced plant biomass by 91%, whereas diquat alone at this rate and exposure controlled only 52% hydrilla. Similarly, combining fluridone with Mt provided better control of hydrilla (>90%) and reduced fluridone contact time requirements by more than 50%. The results of both studies demonstrated that combining either fluridone or diquat with Mt was superior against hydrilla than herbicide or pathogen applied singly. The data support the potential for integrating herbicides and pathogens as an effective, reduced-risk alternative for managing hydrilla.

NOTES

Addressing the Invasive Risks Associated with the Importation of Plants for Planting and Status of Aquatic Federal Noxious Weeds

Christa Speekmann
United States Department of Agriculture, Animal and Plant Health Inspection Agency
4700 River Road, Riverdale, MD 20737 USA

The United States Department of Agriculture (USDA) is proposing a comprehensive review and modernization of the regulations on the importation of plants for planting and propagation (nursery stock), including ornamental pond plants and aquatic plants in the aquarium trade. Appropriately mitigating the risks of quarantine pest introduction associated with the importation of plants for planting is important because quarantine pests, including noxious weeds, introduced via imported plants for planting are more likely to become established than pests introduced via other imported commodities such as fruits and vegetables for consumption. The Animal and Plant Health Inspection Service (APHIS) has begun the revision of the plants for planting regulations (7 CFR 319.37), familiarly known as Quarantine 37 (Q-37), by planning several measures that will reduce invasive risk while minimizing adverse economic impacts. Implementation will occur incrementally, starting with the creation of a new category of regulated plants, those Not Authorized for Importation Pending Pest Risk Analysis (NAPPRA). The NAPPRA category will consist of two components, pest plants and plant hosts of quarantine pests. The pest plant component of NAPPRA would dramatically increase the number of plants regulated as potentially invasive species. In the United States, the noxious weed regulations are separate from the plants for planting regulations and APHIS completes a comprehensive risk analysis to add a plant to the Federal Noxious Weed (FNW) list. There are 21 aquatic weeds out of the 106 species listed in the FNW regulations.

NOTES

Reproductive Ecology of Invasive Alien *Potamogeton pectinatus* L. in Freshwater Ecosystems of the Kashmir Himalaya, India

*Aijaz Hassan Ganie, **Zafar Reshi** and B.A. Wafai*
University of Kashmir, Department of Botany
Srinagar-190 006, Jammu and Kashmir, India

The introduction and spread of invasive alien species in aquatic ecosystems is one of the major contemporary ecological concerns. Control and management of such invasive species warrants detailed studies that aid in identification of key pathways, processes and factors that promote alien plant invasions. It is in this context, we studied reproductive ecology of *Potamogeton pectinatus* (Sago pondweed), a native of Europe, with emphasis on identifying the modes of reproductive strategies that it employs to achieve widespread occurrence and abundance in the Kashmir Himalayan freshwater ecosystems, such as lakes, ponds, rivers, streams, canals and water reservoirs. The species employs several asexual (through tubers, rhizomes, nodal plantlets, plant fragments) and sexual (through seeds) modes of reproduction. An individual ramet, on an average, produces 4-10 spikes and each spike bears 6-10 flowers that are bisexual, tetramerous and develop acropetally on a spike. Each spike produces 1-8 seeds. Besides, each plant produces 10-15 tubers and each tuber gives rise to a new plantlet. A meristematic branch, which in turn gives rise to nodal plantlets, also arises from each plantlet of germinating tuber. Each new rhizome bears 6-12 ramets. Sexual seeds, tubers, nodal plantlets are most common reproductive propagules in lentic water bodies, while in lotic waters it propagates through tubers and rhizomes. In addition to these reproductive propagules, plant fragments also aid in the spread of this species.

Thus, a highly flexible reproductive strategy is one of the key factors that contributes to spread and abundance of *P. pectinatus* in aquatic habitats.

NOTES

Presenter Biosketches

David Adams

David Adams is currently an ecologist with the New York State Department of Environmental Conservation's Office of Invasive species Coordination responsible for regulatory issues, and was formerly a biologist within the Division of Fish, Wildlife, and Marine Resources specializing in waterbird monitoring and management, with a focus on Great Lake populations. Recent projects include monitoring the impact of type E botulism on migrating waterbirds, Common Loon migration and movement patterns, and marsh bird use of coastal wetlands. He has been a member of the Wildlife Society, Waterbird Society, and New York State Association of Ornithologists.

Lad Akins

Lad Akins is Director of Special Projects for the Reef Environmental Education Foundation (REEF) a Florida based marine conservation organization. The organization's founding Executive Director until 2006, Lad has worked over the past 3 years on REEF's exotic species program, specifically focusing on invasive lionfish. Lad has led over 17 week-long lionfish research projects in the Caribbean, collecting more than 3,000 lionfish as part of collaborative research and control efforts. More recently, Lad has organized and led hands-on early detection/rapid response training workshops throughout the Caribbean and is focusing current efforts on control studies and capacity building in downstream countries.

David Aldridge

Dr. David Aldridge heads Cambridge University's Aquatic Ecology Group. His research interests focus on the ecology and conservation of unionid mussels and the biology and control of invasive mussels (notably zebra mussels and Asian clams). He has been Vice President of the Malacological Society, is member of the IUCN Mollusc Specialist Group and advisor to many British conservation steering groups. He provides a zebra mussel consultancy service to industry, managing projects for five major water companies and heading the UK Water Network project on zebra mussels.

Muriel Alix

Having completed a Master in Science degree in Aquatic Ecosystem Dynamics at UFR Sciences et Techniques de la Côte Basque (France),Muriel Alix is now in her third year of a PhD study within the Catchment Research Group of the School of Biosciences, at Cardiff University, UK. Supervised by Professor Steve Ormerod she works, alongside colleagues, on improving ecological and biological understanding of the consequences of impounding and creating an artificial lake in Cardiff Bay. Muriel's specific project is centred around the invasive zebra mussel species. By observing and manipulating the population in a series of studies, a better appreciation of the mechanism of aquatic biological invasions will be determined.

Ji Hyun An

Ji An completed a bachelors of science in Environmental Science program at the University of Western Ontario. She works as a research scientist at Trojan Technologies, a manufacturer of ultraviolet disinfection equipment, based in London, Ontario. Ji has been at Trojan for 4 years, working as part of the Validation and Research Services team and specializing in dose monitoring, testing of reactor performance, and regulatory compliance.

Kevin Anderson

Kevin Anderson is the aquatic invasive species coordinator at the Puget Sound Partnership, focused on improving the management of invasive species in the Puget Sound and Georgia Basin shared waters. Mr. Anderson has managed a number of aquatic invasive species projects related to data collection, monitoring, public education, ballast water management, and control and eradication of marine invasive species. He is also the past chair of the national Western Regional Panel on Aquatic Nuisance Species.

Garth Arsenault

Garth is employed by the Department of Health Management at the Faculty of Veterinary Medicine on the campus of the University of Prince Edward Island, where he has worked as a research technician for the Shellfish Research Group for the past 11 years. With his background as an Environmental Technologist he enjoys the challenges he faces while performing research on bivalve aquaculture species. For the last several years his primary research efforts have focused on the spread and control of invasive ascidians on Prince Edward Island mussel farms.

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.

Helge Bardal
Helge Bardal is a biologist graduated from the Norwegian University of Science and Technology. He is an employee at the National Veterinary Institute in Norway, Section for Environmental and Biosecurity Measures. His section's work on aquatic invasive species is predominantly on campaigns to eradicate the salmon parasite *Gyrodactylus salaris* from infested salmon rivers. He has participated in the eradication of Signal crayfish from Dammane as a part of the expertise group at the National Veterinary Institute.

Matthew Barnes
Matthew is a PhD student in his third year in the lab of Dr. David Lodge at the University of Notre Dame. Matthew's dissertation research focuses on the connections (or lack thereof) between freshwater habitats across a landscape. Studying desiccation tolerances of invasive plants provides a case study of one mechanism invasive aquatic organisms utilize to travel over land between aquatic patches.

Jean-Nicolas Beisel
Jean-Nicolas is an associate professor (LIEBE Laboratory, http://www.liebe.univ-metz.fr/) at the University of Metz (France), where he teaches population ecology, evolution and biostatistics. His research interests focus on the ecology of aquatic invasive species, specifically crustaceans and molluscs (zebra mussel and Asian clams), the role of parasitism in ecological functioning, and the developmental instability of species under stress. Currently he is developing a project concerning the impact of *Dreissena polymorpha* on European unionid mussels.

Dale Bergeron
Dale Bergeron is an Assistant Professor with Minnesota Sea Grant, serving as the program's Maritime Transportation Educator. Concerned with maritime issues of social, economic, and environmental importance, Bergeron supports the information needs of policy makers, industry representatives, academics, the media, and the public. In addition to participating on USCG and USACE committees, Bergeron is the Great Lakes Sea Grant Network liaison to the Great Lakes Maritime Task Force and the NOAA Great Lakes Planning Team. Bergeron has authored articles varying from ballast water regulation to land use around ports. He is currently working on a NOAA-funded effort regarding climate change.

Dan Bock
Dan Bock is interested in aquatic biological invasions. He received his BSc from the Babeş-Bolyai University, Cluj Napoca Romania (2008), where he studied the population genetics of marine invasive gastropods in the Black Sea. He is conducting M.Sc research at the Great Lakes Institute for Environmental Research (GLIER), University of Windsor, under the supervision of Dr. Melania Cristescu. His research focuses on the population genetics and phylogeography of invasive tunicates, with an emphasis on the species considered of particular concern for maritime Canada.

Chad J. Boeckman
Chad Boeckman is currently a PhD student at Oklahoma State University, under the direction of Dr. Joseph Bidwell. Chad is investigating zebra mussel dynamics in Oklahoma systems and the effects they may have within those systems. He began working with zebra mussels in 2003 as an MS student and has continued that work into his current degree track.

David Bolduc

David Bolduc completed a Bachelor of International Studies at York University in Toronto and a Master in International Relations at Laval University in Québec City. After several years as researcher and political advisor in Québec City and Ottawa, he joined the St. Lawrence Economic Development Council in 2005 where he held the position of environmental and economic coordinator. Since January 2008, he is also the coordinator of the Green Marine program.

William Bolen

Dr. Bill Bolen is a Senior Advisor with the U.S. Environmental Protection Agency in the Great Lakes National Program Office. In this capacity, he provides leadership, advice, and consultation on the development of policy that will be applied throughout the Great Lakes Basin. He is also engaged in the application of innovative methods and techniques related to unprecedented issues and problems particularly in the domain of invasive species. Bill has also served as the Emergency Response Program Manager and Superfund Enforcement Coordinator for the EPA in Chicago. In total, he brings over 30 years of public and private sector experience to bear.

Demetrio Boltovskoy

Demetrio Boltovskoy teaches Limnology (undergraduate) and Planktology (graduate) at the University of Buenos Aires. He has been active in research in biological oceanography and freshwater biology since the 1970s. During the last decade he has centered on the investigation of the effects of freshwater invasive bivalves in Argentina.

Jonathan M. Bossenbroek

Jon Bossenbroek is an assistant professor in the Dept. of Environmental Sciences and Lake Erie Center at the University of Toledo. The primary goal of his research is to apply the theories and concepts of landscape ecology to applied issues, such as invasive species biology and ecosystem management. His current research projects include modeling the potential risk of zebra mussels to the state of Colorado, predicting the economic benefits of slowing the spread of emerald ash borer in Ohio and Michigan, and understanding the community ecology darter species in Ohio rivers.

Johanna Bradie

Johanna Bradie completed her BSc at the University of Western Ontario with an Honours Double Major in Genetics and Medical Science. She is currently completing her MSc at GLIER, University of Windsor supervised by Drs. Hugh MacIsaac and Sarah Bailey. Her current project aims to prevent the influx of invasive species through ballast water management. Johanna is investigating the efficacy of NaCl brine as a new treatment option for ballast water.

Elizabeta Briski

Elizabeta Briski received her degree in Engineering of Agricultural Sciences in 2000, from the University of Zagreb, Croatia. She completed her Masters in Aquaculture at University of Gent, Belgium and is currently working towards her PhD in Environmental Science at The Great Lakes Institute for Environmental Research, part of the University of Windsor. She is being supervised by Dr. Hugh MacIsaac, focusing on the comparative assessment of invertebrates and resting stages in sediment of ballasted ships entering the Canadian Great Lakes and marine ports.

Beth Brownson

Beth Brownson is a Senior Invasive Species Biologist with the Ontario Ministry of Natural Resources (MNR) who is coordinating programs, partnerships and policy to prevent the introduction and spread of invasive species. She has enjoyed the challenge of working on this issue since 1992 when she accepted a position with the Ontario Federation of Anglers and Hunters to coordinate the Invading species Awareness Program; a partnership between the MNR and the OFAH. She represents Ontario on a number of national and international task groups including: the Great Lakes Panel on Aquatic Nuisance Species; acting as Co-Chair along with Fisheries and Oceans Canada on the Canadian Council of Fisheries and Aquaculture Ministers' National Aquatic Invasive Species Committee; and a member of the Management Board for the Canadian Aquatic Invasive Species Research Network.

Lyubov E. 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 PhD 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, Texas Parks and Wildlife Department, and Wisconsin DNR. She has published 45 peer-reviewed papers, and made over 40 presentations at scientific meetings.

Mark J. 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 AIS Rapid Response Policy 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 17 years and includes development of zebra mussel control protocols and installations, biofouling turnkey treatment systems, fire protection system control, client relations, and contract administration.

Joseph Caffrey

Dr. Caffrey is a Senior Research Officer with the Central Fisheries Board. The Board is a statutory body, which has primary responsibility for the co-ordination of protection, conservation, management and development of inland fisheries. He has conducted applied research with the Board for the past 30 years and specialises in the areas of Aquatic Plant Management and Recreational Fisheries Development.

Dr. Caffrey currently heads-up the Coarse Fish Unit within the Board and has been responsible for a number of multimillion euro EU sponsored projects. A significant proportion of this money was spent on angling development in inland waterways and the improvement of habitats and infrastructure to better promote angling. Aquatic invasive alien 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 has considerable experience in the area of aquatic plant 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. He also convened a major international conference on Aquatic Vegetation in Dublin in 1994. This event was attended by 270 delegates from 35 countries worldwide. Dr. Caffrey is a Committee Member of the Aquatic Research Unit of the European Weed Research Society (EWRS) and also of the European Inland Fisheries Advisory Commission (EIFAC).

Marnie Campbell

Associate Professor Marnie Campbell was educated at Murdoch University, Western Australia. She has a PhD in marine ecology with an emphasis on ecosystem restoration, and undertook a postdoc at the University of North Carolina, Wilmington studying the Florida Everglades restoration efforts. Marnie has worked in more than 12 countries as a biosecurity (introduced marine species) researcher with agencies such as CSIRO-CRIMP, the IMO GloBallast Programme, and Biosecurity New Zealand. She has 14 years experience in introduction marine species, being involved in more than 65% of the port surveys (either as second in charge or scientist in charge) for introduced marine species that have occurred globally and has trained more than 22 international agencies, universities and museums in introduced species sampling and monitoring. She is an active researcher in effects of fishing on the marine environment, risk analysis and ecosystem restoration.

Currently, she is an Associate Professor for the National Centre for Marine Conservation and Resource Sustainability at the Australian Maritime College, an institute of the University of Tasmania. Marnie's research interests have focused 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. Her publications include 3 co-authored books on marine biological invasions and taxonomy, seven book chapters, 1 monograph, 25 internationally peer reviewed publications, five internationally peer reviewed publications in review, co-author on four international guidelines, and 58 technical reports; and she has been an invited speaker (keynote, plenary and panel member) at 12 international fora.

Allegra Cangelosi

Allegra Cangelosi is Director of Environmental Projects for the Northeast-Midwest Institute in Washington DC (www.nemw.org), and the Principal Investigator for the Institute's Great Ships Initiative (www.greatshipsinitiative.org). Ms. Cangelosi helped pioneer the area of ballast treatment technology development and testing. She was co-principal investigator and biological team leader of the "Algonorth Experiment", which first demonstrated the potential role of filtration as a ballast treatment in the shipboard context, and subsequently led to three other shipboard treatment tests. She co-led the Great Lakes Ballast Technology Demonstration Project which established a barge based treatment testing platform, between 1996-2002. She is lead author on several technical publications related to ballast water treatment, including on methods for measuring performance of ballast treatment systems, and performance evaluations of various levels of filtration.

Ms. Cangelosi participated in the United States delegation to the Marine Environment Protection Committee of the International Maritime Organization Ballast Water Working Group between 1996 and 2002, and was a member of the Invasive Species Advisory Committee to the National Invasive Species Council until 2006. She also coordinated legislative activity leading to the National Invasive Species Acts of 1990 and 1996. Between 1989-1993, Ms. Cangelosi served as legislative director of the bipartisan Congressional Great Lakes Task Forces in the office of Senator John Glenn.

Previously, Ms. Cangelosi was Environmental Project Director with the Coalition of Northeastern Governors (CONEG). She managed regional environmental initiatives and conducted policy research on source reduction, groundwater protection, and integrating economic development and water quality protection. She established the State-industry-environmentalist Source Reduction Council of CONEG. Ms. Cangelosi holds a Masters of Science in Resource Development from Michigan State University, and a B.A. in Biology from Kalamazoo College.

Mária Čápová-Plachá

Currently Mária is a third year PhD student at Comenius University, in the Department of Ecology. Her PhD program is devoted to the study of phenotype plasticity and life-history traits of monkey goby, *Neogobius fluviatilis*, an invasive fish species. She has published one paper in an international peer-reviewed journal and further papers are under the process of peer-review. Mária participated at the XII European Congress of Ichthyology, Croatia (September 2007), as well as at several national conferences. She is scheduled to complete her PhD degree in Ecology in September 2010. Mária is a member of the Slovak Ichthyological Society.

Mary Carman

Mary Carman has been studying the ecological impact of invasive ascidians since 1996, when she found *Didemnum vexillum* in Massachusetts, near the east entrance to the Cape Cod Canal. *Didemnum vexillum* has been documented attached to anthropogenic surfaces and natural surfaces such as rocks, bivalves but in 2008, Carman found *D. vexillum* attached to eelgrass. Carman is involved in assessing the impact of invasive ascidians on eelgrass and aquaculture in New England and is currently documenting Panama ascidians, comparing Pacific and Atlantic faunas and utilized substrates. She organized the first and second International Invasive Sea Squirt Conferences.

Oscar Casas-Monroy

Oscar Casas-Monroy began his doctoral studies in 2007 at the Université du Québec à Rimouski. His principal research interests deal with invasion biology, particularly in marine aquatic ecosystems, and understanding the general spread patterns of species and their link with climatic change. Oscar's doctoral work focuses on examining marine phytoplankton invasive species in Canadian aquatic ecosystems; mostly ballast water-mediated introductions of dinoflagellate cysts and motile cells, their taxonomy and propagule pressure on marine ecosystems, and the application of molecular tools to detect harmful or toxic dinoflagellate species.

James Casey

Dr. Casey is an Associate Professor in the Department of Microbiology and Immunology at Cornell University and has been associated with the department since 1988. He received the BS degree from Wayne State University in 1966 and his PhD from the University of Chicago in 1973. Dr. Casey was a post-doctoral fellow at Cal Tech from 1974-1980 where he studied molecular virology in the laboratory of Norman Davidson. Research in the Casey lab focuses on the recent outbreak of viral hemorrhagic septicemia (VHSV) in the great lakes an agent that is having a major impact on numerous species that inhabit these waters.

Farrah Chan

Farrah Chan received her BSc (Joint Honours Biology-Environment and Resource Studies) in 2003, from the University of Waterloo. She is currently working towards her M.Sc. (Environmental Science) at Great Lakes Institute for Environmental Research (GLIER), University of Windsor, under the supervision of Dr. Hugh MacIsaac and Dr. Sarah Bailey. Her research focuses on the risk assessment of ship-mediated non-indigenous species introductions in the Canadian Arctic.

Samuel Chan

Samuel Chan, Assistant Professor at Oregon State University (OSU) is the statewide watershed health and aquatic invasive species specialist and Assistant Program Leader for the Oregon Sea Grant College Program and Extension Service. Sam serves on the legislatively established Oregon Invasive Species Council. Sam's current research and education focuses on understanding invasive species pathways. Sam is leading a national/international project on the role of classrooms, curricula and biological supply houses as potential pathways for aquatic invasive species. Prior to joining OSU, Sam served as a research plant physiologist with the USDA Forest Service.

Suchana Apple Chavanich

Dr. Suchana Apple Chavanich is now working as an Assistant Professor at the Department of Marine Science, Faculty of Science, Chulalongkorn University, Bangkok, Thailand. She received her PhD from University of New Hampshire. At present, her research focuses on biological invasion and pathways of introduction of marine invasive species in Thailand.

Chinnagounder Chinnusamy

Dr. Chinnagounder Chinnusamy is a Professor in the Department of Agronomy, Centre for Soil and Crop Management Studies, at Tamil Nadu Agricultural University in India.

Graduated in Agriculture (1980) with distinction and two proficiency awards. Post graduated in Agronomy with ICI Junior Research Fellowship and Doctoral degree with ICAR Senior Research Fellowship.

Specialized in Weed Management, developed integrated management technologies for problem and parasitic and aquatic weed management. Currently, operating fourteen Government and Private Agencies sponsored schemes on Weed Management, ten as PI and four as CO PI. Published four books, 50 research papers in national and international journals and 146 research abstracts in symposia and 23 chapters in books and manuals. Disseminating technologies on weed management for various crops and cropping systems through AIR, booklets and leaflets.

Awarded with Diwan Bahadur R. Ragunatha Rao Prize and Anstead Prize (1978 and 1979), Best Farm Management Award (1994), Best Paper Award in International Agronomy Congress (1996), Best Weed Science Agronomist Award, 2005, ISWS Fellow 2008 and Best AICRP Centre Award 2008. Underwent training on Educational Technology at UWSH, Australia, 14 trainings at national institutes on weed management and an one month International Training on Herbicide Use Efficiency at University of Florida, USA.

Renata Claudi

Renata Claudi is a biologist with over 25 years of diverse business and technical experience.

At this time she is the Chief Scientist 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. The company has an international clientele.

After received her BSc and MSc degrees in Marine Biology from McGill University, Montreal, Québec, Ms. Claudi worked for a major Canadian Electrical Utility until the year 2000. 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. She was also one of the chief organizers of numerous International Conferences on Aquatic Nuisance Species. Further, she has authored and edited several volumes on the topic of invasive species and their control.

Alfred F. Cofrancesco, Jr.

Dr. Alfred F. Cofrancesco, Jr. is the Technical Director, Civil Works Environmental Engineering and Sciences at the U.S. Army Engineer Research and Development Center, Vicksburg Mississippi. He is responsible for the integration of civil works environmental research and developmental activities across all functional programs. Over the last 28 years Dr. Cofrancesco has held positions as a Researcher, Team Leader, Branch Chief and Program Manager in the Environmental Laboratory. His research has focused on environmental issues. He has published over 30 technical papers, book chapters and a book dealing with environmental issues and invasive species management.

Currently, Dr. Cofrancesco represents the U.S. Army Corps of Engineers on the Aquatic Nuisance Species Task Force, Federal Interagency Committee on Management of Noxious and Exotic Weeds and has served since 1991 as Chairman of the USDA-APHIS, Technical Advisory Group for Biological Control Agents of Weeds. He holds a PhD in Biology from the University of Southern Mississippi.

D. Bruce Conn

Bruce Conn is Associate in Invertebrate Zoology at the Museum of Comparative Zoology at Harvard University, and Professor of Biology and Dean of the School of Mathematical and Natural Sciences at Berry College. His research centers on various invertebrate groups, and includes primarily work on parasites and reproduction. Bruce and his wife, Denise A. Conn, have conducted research for more than 25 years on invasive species in major lakes and rivers of North America and Europe. His collaborations with Thaddeus Graczyk at Johns Hopkins University have introduced and developed the use of invasive bivalve molluscs as biomonitors for zoonotic pathogens.

Gordon H. 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 was awarded a 'Habilitation à diriger la Recherche' 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 (Reader in Ichthyology) of the University of Hertfordshire (England). Gordon is currently a Principal Scientist in Fish Biology at Cefas (Lowestoft, UK) and Visiting Professor at Bournemouth University (Bournemouth, UK). Gordon's current work deals mainly with research on the risks and impacts of non-native freshwater fishes, including the development of risk analysis protocols, but also includes other areas of conservation biology (threatened native freshwater fishes, river rehabilitation, interactions between fish and Eurasian otters).

Richard (Dick) Corfe

Richard Corfe has served as President and CEO of The St. Lawrence Seaway Management Corporation since April 1, 2003. Previous to this appointment, he held various executive positions with the Seaway over a period of some 20 years, making a substantial contribution to the waterway's safety and reliability, and modernizing its infrastructure management process.

At the outset of his tenure as CEO, Mr. Corfe spearheaded the Hwy H_2O marketing campaign, seeking to improve the business and public sectors' perception of the Seaway. Over the course of the last four years, the campaign has brought about a coalition of 41 partners, spread across a diverse group of stakeholders, which include ports, carriers and other members of the logistics industry. Working together, the partners are raising awareness of the Seaway's untapped potential, in an age where energy efficiency and a low carbon footprint are critical aspects to cargo transport.

Technological innovation has also advanced markedly under his leadership. From efforts to optimize vessel draft, utilizing satellite navigation and 3D imaging of the channel floor, to the development of self-spotting and hands free mooring technologies, the Seaway is steadily advancing in its quest to further refine the system's dependability and productivity.

The recent conclusion of a five-year agreement with the Government of Canada provides an excellent platform for future growth. Various incentive programs, combined with a three year freeze on toll rates, speak volumes of Richard Corfe's vision for a Seaway that is ready to take on a broader role within the transportation sector, with sustainability as the defining characteristic of the system's future potential.

Timothy D. Counihan

Tim is a Research Fishery Biologist for the United States Geological Survey Western Fisheries Research Center, which conducts aquatic research in the western United States. Tim has been conducting research for the Western Fisheries Research Center since 1993. His research encompasses a variety of subject matter areas and has been focused in the Columbia River Basin.

Ashley D.M. Coutts

Ashley is a Senior Research Scientist at Aquenal Pty Ltd, a private environmental consultancy based in Tasmania, Australia. Ashley is responsible for managing Biofouling Solutions Pty Ltd., which is responsible for: risk assessments and development of management strategies; undertaking hull inspections for marine pests; and development of novel incursion response tools. Prior to this Ashley worked for the Australian Quarantine and Inspection Service as a Marine Pest Advisor and assisted with the development of Australia's proposed Biofouling Management Requirements and other invasive marine pest policies. Prior to this Ashley was a Marine Biosecurity Scientist at Cawthron Institute in New Zealand.

Annie Cox

Ms. Cox is a PhD candidate at the Graduate School of Oceanography at the University of Rhode Island. She has a Master's in Environmental Science from Western Washington University.

Becky Cudmore

Becky Cudmore is a Senior Science Advisor for Fisheries and Oceans Canada (DFO) on aquatic invasive species and is based out of Burlington, Ontario, Canada. She is also the manager of DFO's national Centre of Expertise for Aquatic Risk Assessment (CEARA). CEARA developed the national standard to assess the biological risk of aquatic invasive species for Canada. She has conducted risk assessments for Asian carps and northern snakehead in Canada, and is continuing work to assess the risk of live trade of aquatic organisms. In her role as manager of CEARA, she advises DFO researchers on risk assessment of all unauthorized introduced marine and freshwater organisms.

Katherine Dafforn

Ms. Dafforn is in the final stages of her PhD candidature at the University of New South Wales in Sydney, Australia. Her research focuses on shipping and boating structures and their effects on marine invasion. In particular she has considered effects of antifouling paints and recreational and commercial vessels as differing vectors of invasion. More recently Katherine has begun work in the rocky subtidal to answer questions about the invasibility of natural reef systems.

John Darling

John Darling is a postdoctoral research biologist in the Molecular Ecology Research Branch of the US Environmental Protection Agency. His research focus is the utilization of phylogeographic and population genetic approaches to reconstruct invasion histories and to make inferences regarding the sources of introduced populations and the mechanisms driving their post-establishment spread. He is also actively involved in the development of molecular methods for the identification, detection and monitoring of invasive propagules.

Gustavo Darrigran

Dr. Gustavo Darrigran is a biologist, Professor at the National University La Plata, and a scientific researcher of CONICET (National Council Scientific Research of Argentina). He is also the macrofouling service consultant and director of the Invading Mollusc Research group of the División Zoología Invertebrados. Fac. Ciencias Naturales y Museo. UNLP. La Plata, Buenos Aires, Argentina.

Matej David

Dr. Matej David is an assistant professor at the University of Ljubljana, Faculty of Maritime Studies and Transport where he teaches different subjects on maritime transport. He was involved in different national and international research, mainly in the field of ballast water issue (ballast water sampling, risk assessment and management, decision support systems) and oil pollution from ships (contingency planning, illicit spills monitoring) and port sustainable development (Port of Koper study). He is the Slovenian delegate to Marine Environment Protection Committee and Ballast Water Working Group of the International Maritime Organization (IMO), and National focal point for ballast water issue at European Maritime Safety Agency (EMSA) and GEF/IMO/UNDP GloBallast partnership program, and EU program EMPOLLEX (EMSA Marine Pollution Expert Exchange Programme). For bibliography please visit http://izumbib.izum.si/bibliografije/Y20090227111357-21832.html.

Gareth Davies

After obtaining an MSc at the University of Wales, Swansea in 2003, Mr. Davies began work for the Environment Agency, where his work has focused primarily on understanding non-native fish distribution, ecology and management in England and Wales. Much of Gareth's work has been on developing management and control techniques, and this has been reflected in his involvement in a series of eradication operations on the invasive topmouth gudgeon, Pseudorasbora parva, to prevent their wider dispersal. Integral to this has been the development of a decision-making toolkit, ensuring managers have the tools available to them to take more strategic decisions on the most appropriate method to deal with an invading fish population. Gareth has also just commenced his PhD through Bournemouth University, where his goal is to develop a framework for the better management of non-native fishes in England & Wales.

Martin Davis

Martin joined Central Electricity Research Laboratories in 1970 as a marine chemist studying the environmental effects of power generation. He developed an interest in fouling organisms that led to a degree in biology and a doctorate in ascidian larval physiology. In 1990, he became a director of Fawley Aquatic Research Laboratories Ltd. with responsibility for biofouling control research, and in 2000 he founded Fawley Biofouling Services, a biofouling consultancy. In addition, he teaches mathematics, chemistry and estuarine sciences to naval nuclear engineers. His current interest is the distribution of *Styela clava*; he recorded the first populations in Portugal, New Zealand and the Mediterranean.

Yves de Lafontaine

Yves is a Aquatic Ecosystems Analyst with Environment Canada, Aquatic Ecosystems Protection Research Division at the St. Lawrence Centre in Montreal, QC. He completed a MSc in oceanography and a PhD in marine biology at McGill University in Montreal. He worked as a fisheries biologist at the Bedford Institute of Oceanography in Dartmouth, NS and as a research scientist in fisheries oceanography at the Maurice-Lamontagne Institute, Mont-Joli, QC until 1992. He joined the St. Lawrence Centre of Environment Canada in 1992. His research interests include aquatic invasive species in fresh waters, river ecology and biodiversity, ecotoxicology and contaminants in aquatic organisms. His present research activities (related to aquatic invasive species) include ecology and distribution dynamics of aquatic exotic species in large river systems, and toxicological risk and environmental impact of ballast water treatment methods.

Simone de Almeida Delphim

Simone holds a Master degree in Computational Modeling from the National Laboratory for Scientific Computing (LNCC) with concentration in Numerical Modeling to Population Dynamic with Allee effect and a Baccalaureate degree in Mathematic from the Faculty of Humanity Pedro II (FAHUPE) in Rio de Janeiro. Currently, she is a Doctorate Student at LNCC where associated to Biodiversity Component in the Amazonia Environmental Modeling Network (GEOMA) develops numerical methods applied to Biological species which are the basis for extractive economy.

David Delaney

David Delaney is a PhD Candidate in McGill University's Department of Biology and has conducted research in Canada, U.S., and the Galapagos. His research is multidisciplinary but mainly falls into the fields of marine ecology, invasion biology, oceanography, community ecology, evolutionary biology, and limnology. Research questions of interest are both applied and theoretical. He conducts laboratory and manipulative field experiments complimented with broad-scale surveys to test theory and better understand drivers of large-scale patterns in nature. His research works toward identifying important biotic and abiotic factors controlling the diversity of an ecosystem in order to better inform managers and policy-makers.

Matthew G. Deneau

Mr. Deneau graduated with a biology degree from the University of Windsor in 2007. Soon after, he began his work with Fisheries and Oceans Canada as a Research Assistant under the supervision of Dr. Sarah Bailey. In his current role as an Aquatic Science Biologist, he supports Fisheries and Oceans Canada's ballast water monitoring program by conducting biological sampling of ballast tanks and studying vessel movement and activity.

Kristen DeVanna

Ms. Devanna is a PhD student in the Department of Environmental Sciences at the University of Toledo, and her research is conducted at the Lake Erie Center. For her dissertation Kristen is studying how invasive ecosystem engineers can alter habitat in a way that affects native ecosystem engineers and the consequent changes of energy flow through the food-web. Specifically, she is examining how the soft sediment colonization of invasive *Dreissena* sp. (zebra and quagga mussels) affect the habitat preference of burrowing mayflies and how this spatial association may interfere with the trophic transfer of benthic energy in western Lake Erie.

Marty Deveney

Marty received a PhD for work on taxonomy and biology of flatworm parasites of fish from the Department of Molecular and Microbial Sciences at The University of Queensland. He joined the Department of Primary Industries and Resources, South Australia (PIRSA) in 2001 where he had responsibility for managing aquatic animal health policy in South Australia. He contributed to the development of Australia's aquatic animal health policy, AQUAPLAN and its response plan for aquatic animal health emergencies AQUAVETPLAN. Marty is a co-opted member of the Australian National Aquatic Animal Health Technical Working Group. He has been Subprogram Leader, Marine Biosecurity at the South Australian Research and Development Institute (SARDI) since 2007. His current research focuses on the environmental effects of invasive species, including the alga Caulerpa taxifolia and on developing technologies for pest detection.

Jaimie T.A. Dick

Dr. Jaimie Dick is a Behavioural Ecologist at Queen's University Belfast with an interest in Invasive Species, utilising the methodologies of the former discipline to elucidate patterns and processes of the latter. Thus, Jaimie examines details of the behavioural interactions among native and invasive species, helping to understand the impacts of invasive species in recipient communities. For example, Jaimie show that the 'functional response' (FR) of invasive and native predators gives insights into understanding, and perhaps predicting, invasive species impacts. Further, this methodology has revealed that, counter to the 'enemy release hypothesis', parasites can enhance the impacts of invaders.

Marcia Divina de Oliveira

Marcia Divina de Oliveira has worked at the Brazilian Center of Agricultural Research, located in the Pantanal wetland, since 1995. Her interest is in wetland aquatic ecology. During the last 8 years she has dedicated 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. Marcia's presentation at the conference will be related to her experience with golden mussels in the Pantanal wetland and on projecting its expansion to some North American rivers.

Melinda Donnelly

Melinda Donnelly is a PhD candidate at the University of Central Florida in the conservation biology program. She is currently studying abiotic and biotic factors affecting mangrove and salt marsh restorations, including facilitative and competitive interactions between salt marsh flora and fiddler crabs, and invasion by non-native species. Brazilian pepper (*Schinus terebinthifolius*) is a highly invasive non-native plant species, which thrives in human-altered estuarine environments. Melinda's previous research focused on the ecology of Brazilian pepper in coastal wetlands, including the potential for water dispersal, its allelopathic effect on native Florida mangroves, and the effect of Brazilian pepper on biodiversity of habitats within Mosquito Lagoon, FL.

Martijn Dorenbosch

Martijn Dorenbosch conducted his PhD research for the Radboud University Nijmegen, The Netherlands, in the Caribbean and western Indian Ocean where he studied interlinkages of coral reef fish assemblages between seagrass beds, mangroves and coral reefs. Since 2006 he is working as an aquatic ecologist for the Radboud University, Department of Animal Ecology and Ecophysiology and an independent consultancy, where he studies population developments of both native and invasive freshwater fishes in Dutch rivers and lowland streams. At present, his research is focused on the influence of local climate effects and water quality improvement on changes in freshwater fish assemblages.

Andrew Drake

Andrew Drake is currently pursuing his PhD in the Department of Ecology and Evolutionary Biology at the University of Toronto under the supervision of Harold Harvey from the University of Toronto and Nick Mandrak from Fisheries and Oceans Canada. Andrew's graduate research involves using field data to develop risk models that describe the probability of introducing and spreading aquatic invasive species, genes and pathogens, using Ontario's baitfish pathway as a model system.

Lisa Drake

Lisa Drake is a marine scientist who has conducted research on organisms in ships' ballast water and in biofouling of ships' submerged surfaces for more than ten years. Her current position is located at the U.S. Navy'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 treatment systems. Specifically, the biology group is developing robust, automated analyses of phytoplankton and zooplankton viability.

Craig Duxbury

Craig Duxbury is an environmental scientist with Walt Disney Imagineering, Research and Development (WDI R&D). In his role, Mr. Duxbury provides science-based support for environmental activities and issues relevant to the Walt Disney Company. His work focuses water quality and treatment, biomonitoring, and management of invasive species. He has an undergraduate degree in biology from the University of Vermont, and a graduate degree in Watershed Science from Colorado State University. He is currently pursuing a doctorate in Conservation Biology from the University of Central Florida. In his research, he is exploring the metacommunity concept in macroinvertebrates.

Michael G. Dyer

Mr. Dyer has thirty years of diverse experience in the marine field. He formerly worked as an engineer and project manager for U.S. Navy ship conversions and modernizations. He has worked twenty years at the Volpe National Transportation Systems Center in marine safety and environmental protection, regulatory analysis, risk assessment, technology assessment, and transportation systems analysis. Mr. Dyer's work over the last eight years has included ballast water treatment systems assessment, in particular as the leader of the Shipboard Technology Evaluation Program (STEP) Review Panel leader on behalf of the U.S. Coast Guard.

Mr. Dyer is a member of the Society of Naval Architects and Marine Engineers (SNAME) and a Trustee of the Manchester-Essex Conservation Trust in Massachusetts.

Anna Dziubińska

Anna Dziubińska is a PhD student at the Institute of Oceanography, University of Gdańsk (Poland) in the Department of Experimental Ecology of Marine Organisms. She received her MSc in 2006 in oceanography. She completed her Master Thesis on the influence of temporal variability of disturbance on the structure and biodiversity of fouling communities in the Gulf of Gdańsk, Southern Baltic Sea. The main area of her current research is the succession process of marine fouling communities and relationship between organisms composing these assemblages.

Matt Edwards

Lieutenant Commander Matt Edwards is the Supervisor of U.S. Coast Guard Marine Safety Detachment Massena, NY. Most of his career has been spent in the marine safety and security field and includes assignments as the assistant Engineering Officer onboard the U.S. Coast Guard Cutter VIGOROUS, vessel salvage and staff engineer at the USCG Marine Safety Center and the small vessel inspection branch chief at USCG Sector Baltimore. He is a licensed Professional Engineer and holds a Master of Science in Naval Architecture and Masters of Engineering in Aerospace Engineering from the University of Michigan.

Paul Edwards

Mr. Paul Edwards is currently a graduate student at McGill University in Montreal. His research is on developing new, theoretical management strategies to combat invasive species. He aims to build new strategies by generalizing from case studies of tunicates in PEI. This work has focused on eradication, monitoring, and forecasting by combining ecology with numerical modeling and logic.

Gary Egrie

Dr. Gary Egrie is a Veterinarian for the United States Department of Agriculture, Animal and Plant Health Inspection Service (APHIS). Gary is involved with aquaculture related programs, policies and regulations with respect to domestic activities – including the VHS Federal Order and interim rule. Prior to joining APHIS he worked at Michigan State University doing fish health work for the Michigan Department of Natural Resources' hatchery program. Prior to that he was involved in shrimp farming in Ecuador in the mid 1990s. He likes the smell of thyme and watching meteor showers.

Richard A. 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 ballast water management to the U.S. Delegate to IMO. 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.

Carlos Fernández-Delgado

Carlos Fernández-Delgado is a biologist working at the University of Córdoba (Spain). His studies focus on biology, ecology, conservation and management of freshwater fish in Andalucía (South of Spain). Carlos has developed several conservation programs such as those with the European Eel and the Iberian Toothcarp (*Aphanius baeticus*) an endemic cyprinodontid. He has also participated in invasive species eradication programs and in the fisheries management of the Guadalquivir River estuary. Recently, Carlos has been involved in aquatic habitat restoration programs after the toxic mine tailing accident in Aznalcóllar (Seville, Spain).

Isla Fitridge

Isla Fitridge previously worked for seven years in New Zealand in the field of marine biodiversity and biosecurity. She was heavily involved in nationwide baseline surveys to locate invasive marine species in New Zealand's major ports, harbours and marinas. She has also been involved in surveys of vessel biofouling and the effectiveness of hull cleaning facilities, as well as sustainable aquaculture. Isla is currently enrolled in a PhD at the University of Melbourne, Australia, where she has been able to combine these areas of interest by studying the native and non-indigenous hydroid species fouling man-made structures in Port Phillip Bay.

Oliver Floerl

Oli is a marine ecologist at the National Institute of Water and Atmospheric Research (NIWA) in New Zealand, where he spends a lot of his time working on different aspects of invasion ecology and management. He is particularly interested in the development of predictive tools to prevent new species introductions and in the delivery of training for biological baseline surveys in nearshore environments.

Tiffany Sacra Garcia

Dr. Tiffany Sacra Garcia is a broadly trained ecologist with a strong interest in amphibian systems and freshwater habitats. She works mainly in ephemeral streams and ponds studying the impacts of environmental stressors on species interactions. Tiffany's current research at Oregon State University quantifies behavioral and physiological plasticity in larval amphibians in response to environmental stress and the indirect effects on aquatic communities. These stressors, which include water quality, invasive species, and hydroperiod, are strongly associated with neighboring agricultural systems. Successfully integrating ephemeral habitats into modern agricultural landscapes is contingent upon the management of these direct and indirect stressors.

Tiffany is currently an assistant professor in the Department of Fisheries and Wildlife at Oregon State University. She received a doctorate in 2002 under Dr. Andrew Sih at the University of Kentucky comparing trait interactions in closely related salamander species and completed an NSF postdoctoral fellowship in 2006 with Dr. Andrew Blaustein at Oregon State University.

Kyle Garver

Kyle Garver began investigating fish viruses as a postdoctoral research fellow at Western Fisheries Research Center, Seattle, WA after receiving his PhD in molecular virology from Purdue University`s School of Veterinary Medicine. In 2005, Kyle took a research position with Fisheries and Oceans Canada, at the Pacific Biological Station in Nanaimo, BC, where he heads the virology program. Designated as the Canadian reference laboratory for VHSV and IHNV, a primary aim of the PBS virology laboratory is to employ both traditional and molecular based techniques to develop improved detection methods and better characterize the epidemiology and disease ecology of these pathogens.

Andrée Gendron

Andrée Gendron is a research biologist with Environment Canada in Montreal, Québec. She has been active in the field of environmental parasitology for almost a decade, contributing to multidisciplinary studies on the combined effects of anthropogenic and natural stressors on aquatic wildlife. She recently undertook research on the parasite fauna of alien fish species, using the tench and the invasive round goby as models to address issues such as: 1) competitive advantage over indigenous species due to parasite release, 2) interplay between introduced hosts and native parasite community, and 3) conditions of establishment of exotic parasites in receiving ecosystems.

Erin Gertzen

Erin Gertzen is a graduate student in the Department of Biology at McGill University, Montreal, Canada, under the supervision of Dr. Brian Leung. Her research interests include the ecology and spread of aquatic non-indigenous species. For her Masters project, she is making use of manipulated field experiments and modeling techniques to predict the spread of spiny waterfleas (*Bythotrephes longimanus*) in Canadian Shield lakes, based on vectors of recreational boating and natural connections.

Sara Ghabooli

Sara Ghabooli received her BSc in Marine Biology from the University of Shahid Beheshti, Tehran, Iran. She finished her MSc 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.

Hélène Godmaire

With a research and teaching background in science and environmental education, Ms. Godmaire is the Director of the Great Lakes United Québec. Her degrees include a PhD (University of Toronto) in Freshwater Ecology, Master's degrees in Biology and Environmental Education, as well as a Bachelor's degree in Biology (University of Québec in Montréal) and a post-doctorate in Biotechnology (Armand Frappier Institute). She is particularly interested in community-based projects and engagement, having developed a number of environmental education and communication programs and strategies adapted for schools and communities. She has collaborated with museums, municipalities, environmental organizations, ministries and school boards. Ms. Godmaire has published in refereed journal as well as in popular media.

Robin Goettel

Robin Goettel is Associate Director for Education with Illinois-Indiana Sea Grant. She has coordinated four award-winning national and regional curriculum projects on aquatic invasive species. She is principal investigator for a Great Lakes NSF project and administers "Nab the Aquatic Invader," a nationally-focused Website featuring classroom activities and stewardship projects on marine/aquatic invaders. She organizes school-university-community partnerships that engage students in service-learning activities to reduce spread of AIS. Robin is a PI on a national project to reduce the risk of schools and biological supply houses as pathways for AIS spread. She holds an EdM in Curriculum & Instruction and a BA in Geography from the University of Illinois.

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.

Jonathan F. Grant

Jonathan F. Grant serves as Test Director for Naval Research Laboratory's Ballast Water Treatment Test Facility (BWTTF) located in Key West, FL. He has been involved with the facility since its inception in 2003, where initially he was responsible for design and implementation of the instrumentation, control and data acquisition facilities. He subsequently was responsible for the facility test plan and directed the Environmental Technology Verification Pilot Test at the BWTTF. Recently, Mr. Grant has been part of the team responsible for revising the ETV Draft Protocol, and is supporting development and validation of new methods suited for full scale testing at the BWTTF. 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 Federal Government and their contractors.

The Right Honourable Herb Gray

The Rt. Hon. Herb Gray represented the federal riding of Windsor West in the Canadian House of Commons from June 1962 to January 2002. He was elected a record thirteen consecutive times and also set a record for continuous days of service in the House of Commons 39 years, six months and 26 days.

Mr. Gray ceased to be Deputy Prime Minister and resigned from the House of Commons in January 2002 to become the full-time Chair of the Canadian Section of the International Joint Commission an autonomous international organization created by the Boundary Waters Treaty between Canada and the United States dealing with transboundary issues concerning water and air. He graduated from the School of Commerce of McGill University, Montreal, Canada and Osgoode Hall Law School, Toronto, Canada. He is a member of the Ontario Bar. Mr. Gray worked extensively as Deputy Prime Minister, as a Minister, and as a Member of Parliament in the fields of parliamentary affairs; economic and industrial development; foreign investment; finance; consumer protection; competition; international trade; federal law enforcement; the environment and climate change; and Canada-US border issues. In November 2001 he received the first John Fraser award for Environmental Excellence from the Sierra Club of Canada.

In January 2002 The Governor General of Canada bestowed on Mr. Gray the title Right Honourable making him one of only 16 Canadians to currently hold this title. Mr. Gray is also a Companion of the Order of Canada the highest designation of the Order of Canada. Mr. Gray was appointed to the position of Chancellor of Carleton University on November 28, 2008.

Stephanie Green

Stephanie Green is a PhD student with the Tropical Marine Conservation Laboratory at Simon Fraser University, Burnaby, BC. Her research focuses on the impact of invasive lionfish (*Pterois volitans)* predation on Caribbean coral reef fish community structure, lionfish habitat selection and foraging ecology. Stephanie has conducted extensive field work on invaded reef habitats in the Bahamas, and is currently expanding studies to include Puerto Rico and the U.S. Virgin Islands, to explore colonization processes at the edge of the invasion front.

Jill Hardiman

Jill Hardiman is a fishery biologist working at the Columbia River Research Laboratory (CRRL) for the USGS. She began working for the USGS in 1996 and took a small hiatus to complete a Master's degree in Fishery and Wildlife Biology from Colorado State University in 2003. She returned to CRRL where her research focuses on large scale telemetry and juvenile salmon survival studies, invasive species in the Columbia River Basin, and design and implementation of early detection programs for aquatic invasive species. Most recently Jill has implemented an early detection survey for New Zealand mudsnail on the Klickitat River, Washington.

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. He is co-author of the Columbia River Basin Interagency Invasive Species Response Plan: Zebra Mussels and Other Dreissenid Species. Prior to joining USFWS, Paul worked on invasive species programs as an assistant professor with Oregon State University's Sea Grant Extension program.

Michael Hoff

Michael Hoff is the Aquatic Invasive Species Program Coordinator for the Midwest Region of the U.S. Fish and Wildlife Service. Mike works with the 28 States in the Mississippi River Basin, and the 8 states in the Great Lakes Basin. He began working on aquatic invasive species issues in 1975.

Eric Hoffman

Eric A. Hoffman, PhD, is an Assistant Professor in the Department of Biology at the University of Central Florida. The main theme of Dr. Hoffman's research program is to investigate levels of genetic variation present in natural populations and to utilize this information to address hypotheses about the molecular ecology/population genetics of the organism. This theme has manifested into an array of research avenues that share this common goal. Within population genetics, Dr. Hoffman's research falls into two general categories: what genetic diversity tells us about the evolutionary history of an organism and what genetic diversity tells us about the conservation genetics of an organism. In particular, Dr. Hoffman's current research involves the investigation of population genetic structure of southeastern anurans (*Pseudacris ornata* and *Hyla squirella*) and conservation genetic studies of Striped Newts (*Notophthalmus perstriatus)*, Lower Keys Marsh Rabbits (*Sylvilagus palustris hefneri*), and the invasive charru mussel (*Mytella charruana*), green mussel (*Perna viridis*), and pink titan acorn barnacle (*Megabalanus coccopoma)*. He has obtained funding from a variety of sources to carry out this research including the US Department of Agriculture, the US Fish and Wildlife Service, The Nature Conservancy, the Indian River Lagoon National Estuary Program, and Disney's Animal Kingdom.

Iver Iversen

Mr. Iver Iversen, Business Development Director in Wilhelmsen Ships Equipment, who has for the last 10 years been involved in innovation i.e. identifying and implementing new technologies predominately related environmental systems and solutions for ships. Iver has been in charge of or involved in developing the Ballast Water Treatment Systems, Air Emissions Abatement Systems, Fuel Efficiency Improvement Systems and Waste Management Products and Services for the Wilhelmsen Group. Iver is a part of the Wihelmsen Ships Equipment management group. Iver is a naval architect and has been with WW group for 29 years. He has held various senior positions including Corporate Technical Manager (Unitor, a company aquired by Wilhelmsen Maritime Services), Business Manager – Nitrogen (Unitor Marine Systems) and Business Development Manager (Wilhelmsen Maritime Services). He has also extensive experience from engineering, project management, sales and marketing of ships equipment to the marine and industry.

Tor Gunnar Jantsch

Tor Gunnar Jantsch holds a BSc (Hons) in biotechnology, Imperial College of Science, Technology and Medicine, UK (1997) and a PhD in environmental biotechnology, Lund University (2003). His professional experience includes five years of research and teaching at Lund University and four years of basic and applied research at NIVA. Tor's assignments at NIVA have included drinking water, sludge, industrial process water treatment and impact assessment and design testing of a system for verification of ballast water treatment systems. For the last four years he has worked mainly with land based and shipboard testing of ballast water management systems at different stages of development.

Douglas A. Jensen

Doug Jensen is with the University of Minnesota Sea Grant Program in Duluth, MN, where he's been the aquatic invasive species program coordinator for over 15 years. Last October, Doug co-chaired the first ever Minnesota Invasive Species Conference 2008, which drew 440 people from terrestrial and aquatic invasive species arenas. He serves as a member of the Minnesota Invasive Species Advisory Council and as an at-large member of the Great Lakes Panel on Aquatic Nuisance Species. His teaching and research interests include human dimensions in natural resources management. Doug brings an outcomes-based approach to aquatic invasive species outreach programs through applications of social science and evaluation.

Christopher L. Jerde

Dr. Jerde uses an interdisciplinary approach to link ecological theory to conservation and natural resources management. This approach includes the development and application of statistical models, the formulation of novel ecological theory, and the communication of ideas between scientists, managers, educators, and the public. His current research includes modeling Asian carp dispersal through the Chicago Sanitary and Ship Canal, risk assessment of aquatic plants in trade, detection of invasive species using environmental DNA, and regional planning for aquatic invasive species surveillance using economic evaluation. Chris is a postdoctoral research associate at the University of Notre Dame's Center for Aquatic Conservation.

Kevin B. Johnson

Dr. Kevin B. Johnson is an Associate Professor of Oceanography at the Florida Institute of Technology. His research expertise is in the ecology of aquatic animals, including invasive planktonic organisms. Dr. Johnson held Postdoctoral Fellowships funded by the Smithsonian Institution and the National Science Foundation. Dr. Johnson has worked at seven marine field laboratories and aboard oceanographic vessels. He is a member of several scientific societies and has published more than a dozen peer-reviewed articles and book chapters. His book *A Guide to Marine Coastal Plankton and Marine Invertebrate Larvae* is used as a supplement in laboratories around the world.

Lisa Jones

Lisa is a PhD candidate in Dr. Anthony Ricciardi's lab at McGill University in Montreal. Her 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.

Thomas R. Jones

Tom Jones is the Amphibians and Reptiles Program Manager at the Arizona Game and Fish Department (AGFD), and has worked with amphibians and reptiles in Arizona and the American Southwest for over 25 years. Before coming to AGFD in 2005, Tom was Professor and Chair of Biology at Grand Canyon University, in Phoenix, AZ. In his current position, he oversees conservation and management efforts aimed at amphibians and reptiles in the state, including several efforts to limit or eliminate invasive species.

Lisa Ka'aihue

Lisa is the Director of Administration for the Prince William Sound Regional Citizens' Advisory Council (PWSRCAC). PWSRCAC is an independent non-profit corporation whose mission is to promote environmentally safe operation of the Valdez Marine Terminal and associated tankers.

Lisa is responsible for the work PWSRCAC has been engaged in on the research of potential impacts of aquatic nuisance species in Alaska via the ballast and hulls of tankers, and research into treatment options. She has been managing this work for several years now, working closely with other stakeholders.

Irena Kaczmarska

Dr. Irena Kaczmarska (or Dr. K) is a Professor of Biology at Mount Allison University where she teaches courses in botany and marine science. Her research interest embraces "All Things Diatomological – Past, Present and Future", and currently includes survival of non-indigenous diatoms during ship ballast transits (in water and sediment) and invasive potential of species arriving at Canadian ports. Her research group addresses these issues using both classical (microscopy, statistics) and novel (single cell-based molecular markers) approaches. Dr. K received her PhD from Jagiellonian University (Krakow, Poland), and was a Postdoctoral Fellow at Brigham Young University and Texas A&M University. Further details are available at: http://www.mta.ca/~iehrman

Tomasz Kakareko

Tomasz works at the Nicolaus Copernicus University (Torun, Poland) in the Department of Hydrobiology. His scientific interests focus on biology and ecology of Ponto-Caspian gobiids, with particular emphasis on their interactions with other organisms and factors affecting their distribution in novel environments. His current research areas include habitat preferences of monkey and racer goby in relation to water flow, bottom type and macrophytes coverage as well as interactions between these fish and zebra mussel.

Lisa Kanary

Lisa Kanary is in the process of completing a PhD at the University of New Brunswick. She is researching the impact of tunicates and green crab in the southern Gulf of Saint Lawrence area. Her PhD, funded by NSERC, MITACS and AMEC Earth and Environmental Ltd., focuses on modeling mathematically: the effectiveness and cost of several search methods search in response to a tunicate sighting, the estimated establishment period of the tunicate in a bay, the vector epidemiology of the tunicate movement from bay to bay, and the predator-prey cycle of the green crab.

Alexander Y. 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, PhD, 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 over 70 peer-reviewed papers, and made over 80 presentations at scientific meetings. His research has been funded by numerous federal and state agencies including US Fish and Wildlife Service, US Department of Agriculture, and US National Geographic Society.

Tarja Katajisto

Tarja Katajisto works as a post doc on the project The strategy and success of invasive species in the Baltic food web at the Marine Centre of the Finnish Environment Institute (until this year in the Finnish Institute of Marine Research) and at Tvärminne Zoological Station. Tarja studies recruitment of Cercopagis pengoi from benthic resting eggs after winter. She worked with similar questions for her PhD, which she completed in 2006. For her thesis she studied the occurrence and role of resting eggs in the life cycles of calanoid copepods, two native and one invader species, in the Baltic Sea. Lately, she has also participated in monitoring of invasive ctenophores in the Baltic Sea.

Reuben Keller

Reuben Keller is a Postdoctoral Research Associate in the Center for Aquatic Conservation at the University of Notre Dame. He has recently published Bioeconomics of Invasive Species: Integrating Ecology, Economics, Policy and Management (Oxford University Press; co-editors David Lodge, Mark Lewis and Jason Shogren). Reuben's current research is focused on assessing the economic and ecological risks posed by non-native species, with an emphasis on aquatic invaders. Projects underway include work on the invasion risks posed by different shipping routes to the Great Lakes, development of a screening tool so that aquatic plant species introduced to Indiana can be assessed for invasiveness, and the development of cost-effective strategies for controlling invasive aquatic plants. Reuben is also collaborating with the Aquatic Ecology group at the University of Cambridge (UK), where he is analyzing patterns in the vectors and timing of European freshwater invasions. Reuben has worked with the Canadian Department of Fisheries and Oceans, the City of Chicago, and the Indiana Department of Natural Resources, to design risk assessment strategies for invasive species.

John Kelly

John is a Research Ecologist for EnviroCentre (www.envirocentre.co.uk) and has been involved in the Invasive Species Ireland project (www.invasivespeciesireland.com) since its inception in 2006. This is a comprehensive project addressing invasive species issues in both jurisdictions on the island of Ireland. It is jointly funded by Northern Ireland Environment Agency and National Parks and Wildlife Service. The project has involved carrying out a risk assessment for potential and established invaders, development of management plans, exclusion strategies and contingency plans; legislation review and revision; stakeholder engagement; development of codes of practice and education and awareness programmes; and provision of advice to both Governments.

Kevin Kelly

Kevin Kelly is a Research Chemist with the Water and Environmental Resources Division at the Technical Service Center of the U.S. Bureau of Reclamation. He received his Bachelor of Science degree from Willamette University (1987) and his PhD from the University of Colorado (1992). He began his federal career working at the U.S. Department of Agriculture and is currently employed with Reclamation since 1995. His research focuses on developing tools and solutions to support Reclamation water management, including Dreissena monitoring and control, iron bacteria biofouling, and water recovery technologies. Reclamation is the largest wholesale provider of water and the second largest producer of hydroelectric power in the United States.

Åsa Kestrup

Åsa Kestrup is a PhD student in the Department of Biology at McGill University (Montreal, Canada) under the supervision of Dr Anthony Ricciardi. Åsa received her MSc degree at Lund University (Sweden) in 2003, in which her research tested the effects of multiple indigenous predators on the invasive golden apple snail in Laos. She has also done fieldwork throughout Scandinavia as well as in Poland, Greece, Uganda, and the Dominican Republic. Her doctoral research examines the effect of interspecific interactions and environmental heterogeneity on the dominance of an invasive crustacean.

Rebekah Kipp

Ms. Rebekah Kipp is a graduate student in Anthony Ricciardi's invasion ecology lab in the Biology Department at McGill University. She is broadly interested in patterns of native and exotic macroinvertebrate species diversity and abundance in the St. Lawrence River and Great Lakes.

Georgia Klein

Georgia Klein currently works as a Postdoctoral Fellow at Mount Allison University, New Brunswick, Canada. Her work concerns the introduction of non-indigenous microalgae into Canadian waters. She is a member of the Canadian Aquatic Invasive Species Network (CAISN), a research group that assesses the risk of invasive species arriving in ship's ballast water in various ports of the Great Lakes, and the East and West coasts Canada. Her research involves the identification and the evaluation of the viability of phytoplanktonic organisms from ballast water samples. She is also interested in the introduction of resting stages and toxic phytoplankton organisms.

Jaroslaw Kobak

Jaroslaw works at the Nicolaus Copernicus University (Torun, Poland) in the Department of Invertebrate Zoology. His scientific interests focus on zebra mussel biology, particularly the behaviour of larvae and metamorphosed individuals. His current research areas include interactions between these Ponto-Caspian bivalves and other organisms. He is studying the behavioural defensive responses of mussels to the presence of potential predators and the habitat-forming role of mussels for aquatic organisms, especially Ponto-Caspian amphipods.

Brenda Koenig

Brenda is currently the lead for the bait policy development and issues in Ontario. The risk of spreading invasive aquatic species, including pathogens, through the movement of bait raises a number of concerns for stakeholders and the public. This has given Brenda a crash course over the last year and a half to learn about the complexities of trying to mitigate the risks and satisfy those with vested interests in the resource. Brenda's PhD work in biology focussed on global transport of organochlorine contaminants, using zooplankton as a biomonitor. She is enjoying the change in scale associated with her foray into the world of fisheries management.

Marten Koops

Dr. Marten Koops is a research scientist with Fisheries and Oceans Canada at the Great Lakes Laboratory for Fisheries and Aquatic Sciences in Burlington, Ontario. His current research activities include a combination of life history research, risk assessment and ecological modelling to address questions related to the invasion and impact of non-native species, conservation of species at risk, and aquatic ecosystem recovery.

Gael Kurath

Gael Kurath is a federal virologist with the USGS Western Fisheries Research Center in Seattle, Washington. She directs a research program in molecular biology of fish viruses, and focuses on how RNA viruses move across landscapes, adapt to new environments, and evolve over time. She has many years of experience studying IHN virus in Pacific salmonid fishes, and has more recently applied similar approaches to research on the emergence of VHS virus in the Great Lakes. She currently directs a research project to compare biological properties of different genetic types of VHS virus from different geographic areas.

Olivia Lacasse

Ms. Olivia Lacasse completed a BSc in marine sciences at the University of Québec in Rimouski in 2007. At that time, she was already interested in the problem of invasive marine species and their introduction via ballast water and maritime traffic. She decided to pursue her interests during her MSc in oceanography by joining the Canadian Aquatic Invasive Species Network. Olivia is currently working on identifying dinoflagellate cysts found in some ports of Nova Scotia, Canada and she recently travelled to the University of Tasmania, Australia for a three-week internship on dinocysts with Prof. Hallegraeff.

Imke Lang

Dr Imke Lang is a Postdoctoral Fellow of biology at the Mount Allison University in Sackville, NB, Canada. Her areas of expertise include lipid biochemistry and molecular taxonomy of microalgae. Her current project is part of the CAISN research program and includes the investigation of the change in the genetic structure of diatom populations taking place during the transoceanic voyages in ballast waters of ships arriving at Canadian ports. This includes the development of a method for DNA extraction and PCR amplification of single cells, as well as the identification and improvement of molecular markers.

Ivan Lantz

Capt. Ivan Lantz is Director of Marine Operations for the Shipping Federation of Canada, which represents and promotes the interests of shipowners, operators and agents involved in Canada's world trade. He is responsible for a wide range of subjects related to the safety and efficiency of commercial navigation. Key among such subjects are marine pilotage, water levels, Coast Guard services, St. Lawrence Seaway operations, ballast water management, and winter navigation. He also works closely with the Federation's membership to develop consensual positions on specific issues, provide technical and operational advice, and ensure a steady flow of information from the Federation to member companies.

Capt. Lantz serves on a number of government councils and advisory committees, including the Coast Guard's Marine Advisory Boards in Newfoundland / Labrador and the Great Lakes; the Stakeholder Advisory Council of the

Eastern Scotian Shelf Integrated Management Plan; the Canadian Aquatic Invasive Species Network; the Regional Advisory Council on Oil Spill Response for Québec; Environment Canada's Weather and Environmental Services Advisory Board; the Comité sectorielle de la main d'oeuvre de l'industrie maritime; and the Great Lakes Waterways Forum. He is also the principle lecturer in the Certificate in Marine Transportation, which is a marine industry familiarization program that the Federation offers in conjunction with Concordia University.

Mayi Lecuona
Destruction and fragmentation of habitats, construction of artificial structures, chemical pollution, eutrophication and the over-harvesting of high commercial value species deeply alter marine biodiversity and may increase the vulnerability of natural communities to biological invasions. By increasing nutrient concentrations, and thus phytoplankton abundance, coastal eutrophication may facilitate the establishment of aquatic invasive species. Moreover, artificial surfaces (*i.e.* mussel culture structures) could facilitate their establishment as they provide available hard surfaces for larval recruitment. My PhD project called impact of anthropogenic disturbances on the establishment of aquatic invasive species in Prince Edward Island will test the general hypothesis that human activities (land-use patterns and bivalve culture) increase food and space availability and thus facilitate biological invasions.

Edward J. 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 directs research in marine corrosion and coatings, cathodic protection, fouling control, condition based maintenance and material science in general. Additionally, 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 member of the GESAMP Ballast Water Working Group for the review of Active Substances.

Rob S.E.W. Leuven
Dr. Rob Leuven studied aquatic ecology and aquaculture. He is an associate professor at the Department of Environmental Science, Institute for Water and Wetland Research, Radboud University Nijmegen and member of the Dutch Commission for Environmental Impact Assessment. His PhD thesis (1988) concerns the impacts of acidification on aquatic ecosystems. His recent research has been focused on ecology and sustainable management of rivers. Current projects deal with aquatic invasions, ecological risk assessment of exotic species and biodiversity conservation. Special attention is paid to physiological tolerances and biological traits of invasive species and effects of climate change on displacement of native species by invaders. Rob Leuven was project leader of several large research projects commissioned by the World Bank, European Commission, and several Dutch governmental and non-governmental organizations.

David Lodge
Dr. David Lodge's research is rooted in freshwater ecology and limnology, but has gradually expanded to encompass many aspects of ecology including land-water links, invasive species biology, and environmental policy. In his current research, he examines the many ways that human activities change the habitats that provide people with drinking water, recreation, fisheries, and valuable biodiversity. Ecological changes are being caused by increasing human use of the landscape, increasing human use of limited water supplies, or by humans moving plant and animal species from one place to another. Dr. Lodge is increasingly committed not only to studying these anthropogenic changes, but to relating ongoing research explicitly to environmental ethics and the need for solutions to environmental problems. He received a B.S. in 1979 from the University of the South, Sewanee, Tennessee. Supported by a Rhodes Scholarship, he earned a D.Phil. in 1982 from the University of Oxford. Following postdoctoral research and teaching at the University of Wisconsin-Madison, he joined the faculty at the University of Notre Dame in 1985, where he is now Professor. He also directs the Center for Aquatic Conservation.

Frances E. Lucy
Dr. Frances 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.

Michael MacGillivary
Michael MacGillivary is a Masters student at Mount Allison University, New Brunswick, Canada. His research from his undergraduate degree, also at Mount Allison, included the frustule morphology of the nanoplanktonic diatom *Minidiscus trioculatus* and epigenetic and morphological inheritance in the araphid pennate diatom *Tabularia fasciculata*. Since the fall of 2008, he has worked in the Canadian Aquatic Invasive Species Network (CAISN) where he aims to determine the genetic composition of diatom populations in ballast tanks from two trans-Atlantic voyages. In addition to CAISN funding, he also holds an NSERC PGS-M Scholarship.

Hugh J. 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 PhD 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.

Caitriona Maguire
Cathy Maguire is principal researcher at EnviroCentre and visiting research fellow at Queens University Belfast. She has a BSc (Hons) in Environmental Biology, MSc in Applied Environmental Sciences and a PhD in Freshwater Ecology. She is the project manager for the Invasive Species in Ireland project run by EnviroCentre and Quercus and jointly funded by Environment and Heritage Service and National Parks and Wildlife Service. The project consists of risk assessments for potential and established invaders, development of management plans, exclusion strategies and contingency plans; legislation review and revision; stakeholder engagement and development of codes of practice and education and awareness programmes.

Andrew R. Mahon
Dr. Andrew Mahon's research interests are best summarized in the fields of aquatic ecology, invasive species biology, phylogeography, systematics, population genetics, and larval dispersal. These areas allow him to address broad conceptual questions while still undertaking investigations at all levels of ecological and evolutionary biology. Andrew is currently a Postdoctoral Research Associate in the Center for Aquatic Conservation at the University of Notre Dame developing and applying a portable real-time microfluidic genetic probe for detection of aquatic invasive species in ships' ballast.

Nicholas Mandrak
Dr. Nicholas Mandrak is the Executive Directive of Fisheries and Oceans Canada's National Centre of Expertise for Aquatic Risk Assessment. This Centre is responsible for coordinating risk assessments on aquatic invasive species (AIS) that may be accidentally released into the wild in Canada. Dr. Mandrak is also a member of the NSERC Canadian Aquatic Invasive Species Network. He is an Adjunct Professor at four universities in Ontario and currently supervises six graduate students. Dr. Mandrak has over 100 published papers and reports on the biodiversity and conservation of Canadian freshwater fishes.

Lucie Maranda
Lucie Maranda has a PhD in Oceanography and works as a Marine Research Scientist at the Graduate School of Oceanography of the University of Rhode Island. She came to evaluate the efficacy of ballast water treatments after spending more than 15 years studying the ecology of harmful algal blooms, their associated toxins and bio-active compounds. In addition to the treatment of ballast water, her current funding covers the response of underwater sensor surfaces to fouling deterrence approaches.

Pam Marrone
Dr. Marrone is currently CEO/Founder of Marrone Organic Innovations, a company she started in 2006 to discover and develop natural products for pest management. The company launched two products, with six more in development (including a microbial for controlling zebra/quagga mussels). Dr. Marrone founded AgraQuest in 1995 and

served as its CEO, Chairman and President until 2006. Before AgraQuest, she was founding president for Entotech, Inc., a biopesticide subsidiary of Novo Nordisk. At Monsanto, she led the Insect Biology group. She is a Fellow of AAAS and has a BS from Cornell and a PhD in from NCSU.

Jennifer Martin

Jennifer Martin is a researcher for Fisheries and Oceans Canada whose work focuses primarily in two fields: 1) phytoplankton ecology, with particular emphasis on harmful algal blooms, and 2) aquatic invasive species including vectors and pathways of invasion, and invasive tunicates in Atlantic Canada.

Sergey E. Mastitsky

Sergey received his PhD degree in aquatic ecology in 2004. After that he taught for four years at the General Ecology Department of the Belarusian State University. In September 2008, he began work as a research scientist in the Great Lakes Center, Buffalo State College. His research interests include ecology and parasitology of zebra mussels and other aquatic invasive species and the role they play in aquatic ecosystems. Sergey is a chief editor of the on-line database "Aquatic invaders of Belarus".

Dmitriy V. Matafonov

Dmitriy V. Matafonov is a research scientist at the Laboratory of Parasitology and Ecology of Aquatic Species, Institute of General and Experimental Biology SD RAS, Russia. He has been interested in biological invasions since 1995. His postgraduate studies were concentrated on population ecology of invasive Baikalian amphipod *Gmelinoides fasciatus* Stebb., penetrated in the Transbaikalian lakes, and its interaction with native species *G. lacustris* Sars. Dmitriy's present research deals with the impact of invasive macrophyte *Elodea canadensis* Michx. on Baikalian and Palearctic species in Lake Baikal, risk assessment of invasions in the Lake Baikal basin (Siberia).

Andrée McCracken

Ms. McCracken is currently a graduate student completing a Master's degree in Integrative Biology at the University of Guelph in Ontario. Andrée received a BScH in Biology from Queen's University where she did genetic work on orange-crowned warblers for her undergraduate thesis and developed an interest in conservation issues. For the past year and a half she has been working as a part of Dr. Brian Husband's lab on her current project concerning the invasive aquatic plant *Cabomba caroliniana*, the goal of which is to use genetic markers to determine the pathways of introduction of this species across North America.

Cynthia McKenzie

Dr. Cynthia McKenzie is a Research Scientist with the Science Branch of Fisheries and Oceans Canada. She is the Federal scientific lead for Aquatic Invasive Issues in the Newfoundland and Labrador region. She is the Federal Co-chair for the Newfoundland and Labrador AIS Advisory Committee and the National Scientific lead for the Green crab research network. Her projects includes monitoring, surveys and research for all invasive species that may impact the region. These projects are conducted in collaboration with Memorial University of Newfoundland, where she holds an adjunct position at the Ocean Sciences Centre. She co-supervises several graduate students conducting research on AIS in NL.

Sarah McLean

Sarah McLean is a second year Doctorate student at Queens University Belfast on placement at the Fisheries and Aquatic Ecosystems Branch of the Agri-Food and Biosciences Institute Northern Ireland, funded by Department of Agriculture and Rural Development. She is studying the recent zebra mussel invasion in Lough Neagh, focussing on potential impacts for the fishing industry and lake ecology .

She holds a BSc in Zoology from Queens University Belfast, and completed her honours thesis on the First Observation and reproduction) of the Zebra Mussel *Dreissena polymorpha* (Pallas, 1771) in Lough Neagh, Northern Ireland. Sarah's first records of the introduction of Zebra mussels to Lough Neagh are in press (McLean *et al* 2009. *Biology and Environment: proceeding of the Royal Irish Academy, in press).* She has presented on her studies at Neobiota 2008, Prague, and the Malacological Society Molluscan Forum 2008, London.

Robert F. McMahon

Dr. Robert McMahon holds a B.A. from Cornell University (1966) and a PhD from Syracuse University (1972) and is a Professor of Biology at The University of Texas at Arlington. His research involves the biology and control of invasive aquatic species, particularly Asian clams, dressenid mussels and apple snails. He has published over 130 research papers and treatise chapters. His invasive species research has been funded by the USFWS, USACE, State of Texas, and power and chemical industries. He serves on the Western Regional Panel on Aquatic Nuisance Species, the 100th Meridian Initiative and the Invasive Species Advisory Committee.

Vincent Médoc

Vincent Médoc defended his PhD Thesis in Ecology in October 2008 at the Paul Verlaine-Metz University (Metz, France). He is currently working as an Assistant Lecturer at the University of Burgundy (Dijon, France), and joined the "Biogéosciences" laboratory to investigate the outcome of biotic interactions between lotic predators and invertebrate prey whose behaviour is manipulated by bird and fish acanthocephalan parasites. He currently attempts both to underline the flexibility of certain complex life cycles, and to identify new anti-predatory adaptations among amphipods.

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. As researcher at the UANL he has collaborated extensively 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 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 aquatic invasive species in Mexico. Together with members of the US Fish & Wildlife Service he organized the first workshop on the use of use 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.

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 PhD from The School of Natural Resources and Environment at the University of Michigan in 2002.

Laëtitia Minguez

Laëtitia Minguez is a second-year PhD student in environmental parasitology, an emergent field of research in the interface of ecotoxicology and parasitology. She integrated the laboratory of Interactions Ecotoxicology, Biodiversity and Ecosystems (University of Metz, France, CNRS UMR 7146) to investigate the interactions between the environmental quality and parasitism on a well-known freshwater bivalve, the zebra mussel *Dreissena polymorpha*. Her researches aim at determining if parasites can modify biological responses of exposed zebra mussels and if some parasite species can be a sign of an environmental contamination.

Daniel P. Molloy

Dan is an aquatic biologist with the New York State Museum and Director of its Field Research Laboratory in Cambridge, New York. He will speak today on a green technology that his lab developed for the biological control of zebra and quagga mussels – a control method now on the brink of full commercialization.

Brian Moore
Lieutenant Commander Brian Moore is the program manager for the US Coast Guard's innovative Shipboard Technology Evaluation Program (STEP). He has been a CG Marine Inspector and Investigator since 1999, working in the Gulf of Mexico region. Prior to joining the Coast Guard LCDR Moore was a chemistry teacher and environmental response hazardous material technician. He has masters degrees in Environmental Science from Johns Hopkins University and Quality Systems from the National Graduate School.

James A. Morris, Jr.
James A. Morris, Jr. is an Ecologist with NOAA's National Ocean Service, Center for Coastal Fisheries and Habitat Research, Beaufort, North Carolina. James's research background includes various aspects of marine ecology with a focus on invasive species and aquaculture. James has extensive experience in shellfish and finfish aquaculture and has cultivated various marine fish including *Pagrus pagrus*, red porgy, *Centropristis striata*, black sea bass, *Leiostomus xanthurus*, spot, and *Orthopristis chrysoptera*, pigfish. Recently, James's work has involved assessments of invasive lionfish biology and ecology, the propagation and impacts of invasive tunicates in New England, and development of early detection and rapid response programs South Florida and the Caribbean.

John C. Morris
Mr. John Morris is an environmental protection specialist at U.S. Coast Guard headquarters. His previous positions include a director at the American Chemistry Council trade association and an environmental protection specialist at the U.S. Department of Energy. Mr. Morris has a master's degree in environmental policy and management from the University of Denver.

Katie Mosher Patterson
North Carolina Sea Grant's communications director since 1998, Katie Mosher Patterson previously was a newspaper and online reporter/editor, and TV news assignment manager. She coordinates the *Aquatic Invaders* project with the Association of Zoos and Aquariums and other partners. A mentor for Indonesia's Sea Partnership Program based on the Sea Grant model, Mosher is managing editor for North Carolina Sea Grant's *Coastwatch* magazine. She has a bachelor's degree in journalism from Kent State University in Ohio and a master's in liberal studies from NC State University. Her honors include multiple national APEX awards.

Philip B. Moy
Dr. Moy is the Fisheries and Non-indigenous Species Specialist for the University of Wisconsin Sea Grant Institute. In that role, 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. He holds a doctorate in zoology from Southern Illinois University at Carbondale. 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.

Thomas Nalepa
Thomas Nalepa is a research biologist with the Great Lakes Environmental Research Laboratory, NOAA in Ann Arbor and has been with NOAA for over 30 years. He was a biologist with EPA for 3 years prior to working for NOAA. He has over 100 publications dealing with Great Lakes issues, and has co-edited a book and special journal issue on the biology and ecological impacts of zebra mussels. His research interests include long term trends in benthic communities, role of benthic invertebrates in the cycling of contaminants and nutrients, trophic interactions between benthic communities and the upper food web, and impacts of invasive species.

Bruce N. Nelson
Mr. Nelson is responsible for directing the Naval Research Laboratory's efforts for the development and evaluation of systems for performing automated enumeration and classification of zooplankton and phytoplankton in support of the Ballast Water Treatment Test Facility operations. This involves the design of complete systems for performing these functions as well as conducting extensive laboratory evaluations on these and other systems potentially applicable systems. Mr. Nelson has extensive experience in camera, sensor and optical system design

and a strong track record of implementing advanced computational algorithms in these systems so that they can perform functions normally performed by human operators or analysts. Mr. Nelson is President of Battenkill Technologies, Inc., a small business that provides scientific, engineering and software R&D services to the US Federal Government and their contractors.

Harry Nelson

Harry Nelson is Director of Sales & Marketing for Fluid Imaging's Aquatic Markets. In addition to his role promoting FIT's FlowCAM at international scientific conferences, he is involved in product and application development, as well as user training. Harry has extensive experience with technology companies, and holds an BA in Environmental Science from Colby College and an MBA from the University of New Hampshire.

Linda S. Nelson

Linda Nelson is a Research Biologist with the U.S. Army Engineer Research and Development Center, Vicksburg, MS. As a member of the Chemical Control Team, Nelson conducts research to identify effective chemical techniques for managing invasive aquatic, wetland, and terrestrial vegetation. Current research projects include: evaluating the use of new herbicides and plant growth regulators for aquatic plant management; identifying impacts of herbicide use on non-target plant species; and evaluating integrated control strategies (chemical + biological) for nuisance plant control. Nelson received a B.S. degree in Biology from the University of South Dakota, a M.S. in Crop Production and Physiology from Iowa State University, and a PhD in Botany/Weed Science from Purdue University.

Fred Nibling, Jr.

Fred L. Nibling, Jr. is Research Botanist at the Bureau of Reclamation Technical Service Center (TSC) in Denver, Colorado. He is Team Leader of the Invasive Species Research Team at the TSC. Mr. Nibling has been involved in studying the management of aquatic plants since 1973. During this period, his research interests have focused on the biology and control of aquatic invasive species. Following military service and staff employment at the University of Texas, he began his federal career with Reclamation in 1977. Mr. Nibling has a B.A. Degree in Zoology and M.A. Degree in Botany (Plant Ecology) both from University of Texas at Austin. He is Past President of the Western Aquatic Plant Management Society and a past officer of the Aquatic Plant Management Society. He has participated as a presenter in many pest management related seminars related to aquatic pest management in western irrigation systems for the past 31 years.

In the mid-1990s, Mr. Nibling participated in the formation of the interagency Western Zebra Mussel Task Force which later became known as the Western Regional Panel. Internationally, he has worked on many aquatic invasive species management topics in Spain, Mexico, Brazil, and Africa. He also serves on a number of technical review and advisory committees pertaining to invasive aquatic invasive species management issues with various international, federal and state agencies.

Andrew Nikiforuk

For the last two decades Andrew Nikiforuk has written about energy, economics and the west for a variety of Canadian publications including Walrus, Maclean's, Canadian Business, Report on Business, Chatelaine, Georgia Straight, Equinox and Harrowsmith.

In the late 1990s he investigated the social and ecological impacts of intensive livestock industries for the Calgary Herald. In recent years he has written two critical policy papers about the abuse of water in Canada for the University of Toronto's Munk Centre (2004/2006).

Nikiforuk's journalism has won seven National Magazine Awards since 1989 and top honors for investigative writing from the Association of Canadian Journalists. His dramatic Alberta-based book, Saboteurs: Wiebo Ludwig's War Against Big Oil, won the Governor General's Award for Non-Fiction in 2002. Pandemonium, a look at how globalization has impoverished biology and accelerated disease exchanges, has received widespread national acclaim. His latest book, Tar Sands: Dirty Oil and the Future of a Continent, is already a national best seller.

Whether speaking or writing about melting glaciers, educational shams, peak oil, or the destruction of the boreal forest, Nikiforuk has earned a reputation as an honest and provocative voice in Canadian journalism.

Monika Normant

Dr. Monika Normant is an assistant professor at the Department of Experimental Ecology of Marine Organisms at Gdańsk University, Poland. She received her PhD in Earth Sciences from Gdańsk University in 1998. In the years of 2002/2003 Dr. Normant was employed by the Zoological Institute of the Free University of Berlin, Germany. Her research has been supported by several national and international grants and fellowships and covered ecology and ecophysiology of native and non-native species. One of the latter is the Chinese mitten crab, *Eriocheir sinensis*, which occurrence has been increasing in the southern Baltic Sea and its adjacent areas.

Mordecai Ogada

Dr. Mordecai Ogada is a carnivore ecologist who has been involved in conservation in Kenya through the private sector for the last 10 years. His most recent research focus has been the ecological integrity of aquatic ecosystems competition between fishermen and otters in Lake Victoria. His research on aquatic ecosystems in Kenya has found that species introductions are a key component of the unsustainable management of fisheries and other natural resources in Kenya. Dr. Ogada maintains a keen interest in the human dimensions of wildlife conservation and is a research associate at the National Museums of Kenya Zoology Department.

Stan A. Orchard

Stan A. Orchard is a conservation biologist/herpetologist. From 1981-1999 he ran a herpetology program in the Natural History Section of the Royal British Columbia Museum. From 1994-1999 he was the National Co-ordinator for Canada for the IUCN/SSC Task Force on Declining Amphibian Populations in Canada (DAPCAN). In 1994 he co-founded the Canadian Amphibian and Reptile Conservation Network (CARCNet) and served as its Chairman from 1994 to 1999. He is a member of the IUCN's Species Survival Commission. In 1998 he was invited to Australia by WWF to - over four years - design, co-ordinate and manage the world's largest privately-funded amphibian conservation program. It is now an independent organization known as 'Frogs Australia'. In 2003, he resurrected plans to develop the strategies and tools to effectively control and eradicate populations of alien invasive amphibians. Currently, as President of BullfrogControl.com Inc., he works on southern Vancouver Island creating innovative, cost-effective, eco-friendly strategies, tactics and techniques for eradicating populations of the American bullfrog (*Rana catesbeiana* = *Lithobates catesbeianus*) - listed as one of the 100 Worst Alien Invasive Species in the World.

Matthew Oreska

Matthew Oreska currently pursues a Masters in Philosophy degree at the University of Cambridge, as part of the Aquatic Ecology Group under David Aldridge. Matthew's current research project combines aquatic invasive species ecology with economic considerations in the United Kingdom. Prior to studying in the Cambridge Department of Zoology, Matthew received a B.S. in geology and economics at the College of William and Mary and undertook research in invasive species biogeography at the Smithsonian Environmental Research Center. While at William and Mary, Matthew's research endeavors investigated Cretaceous paleoecology and recent molluscan communities in the Chesapeake Bay.

Chetta Owens

Chetta Owens works as a plant ecologist under the Aquatic Plant Control Research Program and conducts research at the USACE Environmental Research and Development Center-Lewisville Aquatic Ecosystem Research Facility, Lewisville, TX. For the past 15 years, Ms. Owens research has focused on phenology, ecology and dispersal of invasive aquatic plants in the United States, especially giant salvinia and hydrilla. Ms. Owens has a BS and MS in biology from Texas Woman's University.

Christine Paetzold

Christine Paetzold completed a BSc Honours from UPEI in 2004. Her honours thesis focused on the effect of acetic acid as tunicate mitigation treatment on potential micropredators of tunicates. After completing an MSc in Ecotoxicology at Dalhousie University in 2008, she began working as research associate on a four-year Atlantic Innovation Fund project with the Shellfish Health Group at the Atlantic Veterinary College (UPEI). Her duties involve the development of new mitigation strategies against *Ciona intestinalis* and other invasive tunicates on PEI, as well as studying the histopathology of *C. intestinalis* and *Styela clava*.

Bivan Patnaik

Mr. Patnaik serves as the Regulatory Coordinator for the division and has held this position since 2002. His primary responsibility is to manage regulatory teams consisting of attorneys, environmental analysts, economists and technical writers that develop environmental protection regulations for ballast water and aquatic nuisance species. He also reviews and analyzes proposed legislation and regulations, leads interagency working groups, and coordinates with International government organizations, Federal agencies, State agencies, and other stakeholders. He served as the Secretariat for the International Standards Organization's Subcommittee for Ship's Technologies-Marine Environmental Protection from 2003-2008. Prior to his employment with the Coast Guard, he was a consultant to both the U.S. Coast Guard and the U.S. Environmental Protection Agency. He has a B.S. in Biology from Virginia Commonwealth University, and an M.S. in Environmental Policy from Johns Hopkins University.

Stephen A. Phillips

Stephen Phillips has worked for the PSMFC since 1992 and has managed the commissions' AIS program for the past 10 Years. He received his undergraduate degree in biology from Baldwin Wallace College (a long time ago) and masters in fisheries science from the Oregon State University.

Cintia Pinheiro dos Santos

Cintia Pinheiro dos Santos is a PhD student at the Federal University of Rio Grande do Sul (UFRGS), Brazil. Cintia has an undergraduate degree in Biological Sciences from the Catholic University of Rio Grande do Sul and a Master's degree in Ecology from the Federal University of Rio Grande do Sul as well. She is currently researching the control of the golden mussel larvae by exposure of ultraviolet radiation advised by Dr. Maria Teresa Raya Rodriguez. Cintia has wide experience in Ecology, working mainly in the following areas: aquatic ecology, bivalves-mussels-invasive. She is an engaged researcher in areas related to prevention, monitoring, and control of invasive species.

Dirk Platvoet

Dirk Platvoet's main interest is the functional morphology of invaders compared of that of natives. Also the importance of substrate structure as a limiting factor is subject of an intensive ongoing study. The species *Dikerogammarus villosus* has been chosen for a three-year 'Amphipod Pilot Species» project (AMPIS). This is a collaboration of the University of Amsterdam, the Chinese Academy of Science and the Radboud University Nijmegen. During this project a large amount of morphological, ecological and behavioural data will be collected of this aggressive Ponto-Caspian invader. The project is now in its third year and the results will be published in 2010.

John Polglaze

John is a Senior Principal Evironmental Scientist specialising in ports and shipping, particularly biosecurity risks. Before this he served in the Royal Australian Navy, gaining first-hand experience of ship operational and maintenance procedures.

His marine biosecurity experience encompasses around 100 dive and drydock biofouling inspections of a diverse array of ships and specialist vessels, as well as participation in the development of national and international ballast water and biofouling risk evaluation and management measures for the IMO, GISP, Australian national authorities, ports and the shipping industry. These have included national biofouling quarantine protocols, biofouling management guidelines, and response to marine pest incursions.

Oana Paula Popa

Dr. Popa is a Research Scientist at the Molecular Biology Department of the "Grigore Antipa" National Museum of Natural History Bucharest, Romania. I study different aspects of genetic diversity, molecular identification of juvenile forms and actual distribution of invasive freshwater bivalves species in the Romanian Fauna. Until now, four species of invasive freshwater mussels have been reported in Romania: *Dreissena polymorpha, Dreissena bugensis, Corbicula fluminea, Sinanodonta woodiana.*

Dandu Pughiuc

Dandu Pughiuc spent eight years at sea serving on different types of vessels. In 1985 he joined the Romanian Maritime Administration within the Ministry of Transport. During his 12 years in the public service he dealt with maritime training, maritime fleet operations and between 1994 and 1997 served as Chief Inspector, Head of the Maritime Safety Administration. He joined the International Maritime Organization in March 2000 as Chief Technical Adviser for the Global Ballast Water Management Project (GloBallast) and in March 2004 was appointed Head, Marine Biosafety Section in the Marine Environment Division of IMO.

Capt. Pughiuc is a graduate from Constanta Maritime Institute, Romania, holds a Master of Science degree from the WMU of Malmo, Sweden and a Master Mariner licence for sea-going vessels.

Samir Qureshi

Samir Qureshi completed his undergraduate BSc degree in biology from the University of Windsor this year. He has worked in Hugh MacIsaac's invasive species laboratory at the Great Lakes Institute for Environmental Research for almost two years, learning to identify aquatic invertebrates and zooplankton species and conducting field work. Since working in the MacIsaac lab, he has developed an interest in the movement of species from one geographic region to another and their establishment within their new habitats. The research he completed for his honors thesis resulted in the publication that accompanies the poster he is presenting at ICAIS.

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). In March 1994, he was selected for Group Study Exchange Programme (best Young Scientist) by the Rotary International (District 3000), Illinois, USA and visited Argentina, Paraguay and Brazil as a Rotary International Ambassador of goodwill and understanding. 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 Groupo 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.

Aaron Ramsay

Aaron Ramsay received his BSc in Environmental Science from Mount Allison in 2003. After, he worked on a project investigating new mitigation agents for a green algae that was challenging the mussel seed collection industry before starting a MSc on "*Ciona intestinalis* ecology and mitigation strategies" at the Atlantic Veterinary College (AVC-UPEI). As of 2007 Aaron has been managing a project researching new mitigation strategies to reduce the impact of invasive tunicates on mussel production at AVC-UPEI. As well, Aaron is involved in an international collaborative project between Canada and Spain to determine why *C. intestinalis* is invasive in Canada, but not in Spain.

Euan D. Reavie

Euan Reavie is Research Associate and Director of the Natural Resources Research Institute Field Station in Ely, University of Minnesota Duluth. His research focuses on algal indicators of human impacts, with particular applications to cultural eutrophication, hydrologic manipulation, invasive species, climate change and paleoecological concerns. A recent focus has been the development and application of methods to assess the effectiveness of ballast water treatment technologies on the control of algae and other microscopic, freshwater organisms. Euan received his PhD from Queen's University, Ontario, Canada and was a Post-doc, in the Department of Geology at the University of Toronto, Ontario, Canada.

Zafar Reshi

Dr. Zafar Reshi is currently working as Associate Professor in the Department of Botany, University of Kashmir, Srinagar, Jammu & Kashmir, India. He has about 20 years of teaching and research experience in the fields of ecology and invasion biology. He has 56 research publications to his credit and has successfully completed 6 research and consultancy projects. He has been instrumental in establishing one the best research teams in India that works on various facets of plant invasions, such as stage-based characterization of alien flora, species invasiveness and community invasibility and development of a robust early prediction and risk assessment protocol for effective management of alien plant invasions.

Yorick Reyjol

Dr. Yorick Reyjol is a fish ecologist at the Ministère des Ressources Naturelles et de la Faune du Québec. His research topics include community ecology, macroecology and biogeography, biostatistics and modelling, and effects of global change (river fragmentation, climate warming, spread of exotics) on natural communities.

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 on animal diversity, global environmental change, and biological invasions. His research examines the causes and consequences of aquatic invasions, focusing on the ecological impacts of non-native freshwater invertebrates and fishes. He is an associate editor for the journal *Diversity and Distributions*, and a member of the scientific committee of the Canadian Aquatic Invasive Species Network – a research group that assesses the risks and mechanisms of invasion in Canada's lakes, rivers and coastal waters. He received his PhD from McGill in 1997, and was an NSERC Postdoctoral Fellow at Laval University and a Killam Fellow at Dalhousie University. For more information about Dr. Ricciardi's research, visit: http://redpath-staff.mcgill.ca/ricciardi/index.html

Scott Riley

Scott Riley is a marine scientist who works for the Naval Research Laboratory in Key West, Florida. Under the sponsorship of the United States Coast Guard, Scott and his colleagues have developed and built the Ballast Water Treatment Test facility, which conducted a pilot test of a treatment technology under the guidelines of the Environmental Protection Agency's Environmental Technology Verification protocol. Scott continues to work on developing methods and procedures for rigorous testing of treatment technologies, as well as robust protocols for the enumeration and viability of phytoplankton and zooplankton with applied automation.

Peggy Roefer

Peggy Roefer is the Regional Water Quality Program Manager for the Southern Nevada Water Authority. She has worked for SNWA for 23 years and her positions have included Microbiology Supervisor and Regional Water Quality Supervisor. She has a degree in Microbiology from the University of Texas at Austin.

Quagga mussels were discovered in Lake Mead, Arizona-Nevada in 2007. In the past two years Ms. Roefer has served as SNWA's lead in coordinating and cooperating with local, state and federal agencies on the quagga mussel issue.

Sonya Santavy

Ms. Santavy graduated with biology degrees from the University of Western Ontario and the University of Guelph, and began working in genetic ecology in 1988. Her focus quickly changed to aquatic invasive species when a benthic grab in Lake St. Clair resulted in the discovery of the first zebra mussel infestation in the Great Lakes. In her current role, she manages the Canadian National Ballast Water Database and coordinates and participates in the biological sampling of ballast tanks to ensure the efficacy of ballast water exchange for ships entering the Great Lakes.

Mariusz R. Sapota

Dr. Mariusz Sapota is an associate professor with the University of Gdańsk Institute of Oceanography. He is an expert of the North European and Baltic Network on Invasive Alien Species (NOBANIS). His research interests focus on the biology and ecology of fish from shallow marine waters and the biology and control of invasive species (notably fish, especially round goby). Currently, he is leading the research project concerning the mechanisms of a sex differentiation and their influence on population dynamics of round goby.

Paula Sardiña

Paula is a junior research at the National Council of Scientific and Technical Research of Argentina. She did her PhD on estuarine fish and when she finished in 2005 started working with the aquatic invasive mussel *Limnoperna fortunei*. Her research interests include biological and ecological aspects of the invader as well as its impacts on the local communities and effects on ecosystem processes.

Linda Sealey

Linda Sealey completed a bachelors of science in the Biology Department of Carleton University in Ottawa. She works as a research scientist at Trojan Technologies, a manufacturer of ultraviolet disinfection equipment, based in London, Ontario. Linda has been at Trojan for 10 years, working as part of reactor design teams and specializing in dose monitoring, testing of reactor performance, and regulatory compliance. Currently Linda leads the research program on UV for ballast water at Trojan.

Isabelle Simard

Isabelle Simard is a biologist for Québec's ministère du Développement durable, de l'Environnement et des Parcs. She is the coordinator of Québec's interdepartmental committee on invasive species. She is completing a PhD degree at the Université du Québec à Chicoutimi on spruce budworm outbreak history.

Jennica Seiden

Jennica received her BSc in Environmental Science from Carleton University in June 2004. After which, she worked for three years at the National Research Council in scientific publishing. In September 2007, she returned to pursue her studies, a Master's in Environmental Science, which is when she joined Dr. Richard Rivkin's research lab at the Ocean Science Centre, Memorial University of Newfoundland. Her research is a component of the Canadian Aquatic Invasive Species Network and studies bacterial dynamics in the ballast water of trans-oceanic bulk carriers during transit. Research has been conducted on four voyages, two trans-Pacific and two trans-Atlantic. Miss Seiden will complete her graduate degree in December 2009.

Juliet Simpson

Juliet Simpson is a post-doctoral research associate at Brown University in Providence, Rhode Island, USA, where she is currently studying how the combined impacts of urbanization and climate change may interact to influence both public health and the spread of invasive aquatic species. She received her PhD at University of California, Santa Barbara in 2006. She subsequently worked as a consultant with Larry Walker Associates, working with public, private, and non-profit agencies to improve water quality management throughout the state of California. Before graduate school she worked as a zookeeper, wildlife rehabilitator, arts administrator, and professional cellist.

Marius Skolka

Marius Skolka is an Associate professor of Invertebrate Zoology and Entomology at Ovidius University of Constantza, Romania. Since 1997 develop studies of biology and ecology of some marine, freshwater and terrestrial invasive species in Romanian Black Sea area (*Mnemiopsis leidyi, Beroe ovata, Doridella obscura, Calinectes sapidus, Eriocheir sinensis, Corbicula fluminea, Cameraria ohridella*). Since 2000 coordinate a center for biodiversity studies in the Ovidius University, with research studies on terrestrial and marine biodiversity. Author of scientific works on invasive species impact in aquatic ecosystems, marine and terrestrial biodiversity of Dobroudja, ecology of plankton communities.

Hilary Smith
Hilary Smith directs the Adirondack Park Invasive Plant Program, a partnership program hosted by the Adirondack Chapter of The Nature Conservancy. For seven years, Hilary has specialized in regional invasive species planning, monitoring, management, and education. She received her undergraduate degree in Biology from Hamilton College and has participated in research and environmental education projects across the U.S, including monitoring forest health in the Great Smoky Mountains National Park, teaching coastal ecology in Long Island Sound, and teaching wetland ecology in Seattle. Hilary is also pursuing her Master's in Biodiversity, Conservation and Policy from the State University of New York.

Christa Speekmann
Christa Speekmann joined United States Department of Agriculture – Animal and Plant Health Inspection Services (USDA-APHIS) as an American Association for the Advancement of Science (AAAS) Science and Technology Policy fellow in 2007. Prior to starting her AAAS fellowship at the USDA, Christa was a post-doctoral research fellow in the Department of Biology at Temple University examining the effect of ultraviolet radiation (UVR) on food web dynamics in freshwater and marine ecosystems. Christa received her PhD in Marine Science from The University of Texas at Austin, Marine Science Institute, where she developed a molecular indicator to be used as a proxy for ecosystem health under different environmental conditions (temperature, salinity, harmful algae and heavy metals). These research interests stem from her Master's work at San Francisco State University and the Romberg Tiburon Center for Environmental Studies, investigating the effect of UVR on the vertical distribution and mortality of several marine organisms. She completed her undergraduate degree in Biology at Occidental College in Los Angeles.

Sophie Sroda
Sophie Sroda is a third-year PhD student in Ecotoxicology at the Paul Verlaine-Metz University (Metz, France), where she has obtained her Master's degree in Ecotoxicology in 2006. She joined the "Laboratoire des Interactions Ecotoxicologie, biodiversité, Ecosystèmes" to develop practical biological tools using a population-based approach for monitoring water resource quality in lotic ecosystems. In this respect, she focuses on various biomarkers serving as antitoxic defence systems such as antioxidant enzymes, or providing information about the energy status at the organism level such as lipid, glycogen and protein contents. She uses as biological model several species of the amphipod genus *Gammarus*.

Mia Steinberg
Mia Steinberg is a postdoctoral fellow with the U.S. Navy's Naval Research Laboratory in Key West 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 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 Director of the Lake Erie Research Center and a tenured Professor of Ecology at the University of Toledo. This coming May 18-22 she chairs the International Association for Great Lakes Research annual conference, on the main UT campus. Her Great Lakes Genetics Laboratory studies the invasion genetics of the round and tubenose gobies, dreissenid mussels, and ruffe; funded by National Science Foundation, USEPA, and NOAA Sea Grant. This summer she collected in Poland and Russia, and has sampled throughout the Black and Caspian Seas. Recent goby publications are in Molecular Ecology, Molecular Phylogenetics and Evolution, Fish Biology, Journal of Great Lakes Research, and Journal of Applied Ichthyology.

Rochelle Sturtevant
Dr. Rochelle Sturtevant is the Outreach Coordinator for the NOAA National Center for Research on Aquatic Invasive Species (NCRAIS). Dr. Sturtevant is a Regional Sea Grant Specialist of the Great Lakes Sea Grant Network. Both Dr. Sturtevant and NCRAIS are based at the NOAA Great Lakes Environmental Research Laboratory in Ann Arbor, Michigan. The close juxtaposition of research and outreach engendered by this hybrid position fosters a unique capacity to extend the results of federal research to stakeholders and decision makers. Dr. Sturtevant

received her PhD in systems ecology from Kent State University in 1998 and spent 5 years in Washington DC working for the Great Lakes Congressional Task Force on Great Lakes policy before returning to the Great Lakes in her current position.

Bei Sun

Ms. Bei Sun received her BSc in Environmental Ecology from Ocean University of China in July 2005. In September 2005, she continued her studies and research with Dr. Richard Rivkin in Ocean Sciences Centre, Memorial University of Newfoundland. Ms Sun was among the first team of graduate students recruited for research within Canadian Aquatic Invasive Species Network (CAISN). Her research studies the abundance and community structure of heterotrophic bacterial in several Canadian harbours and in ballast water collected from more than 140 ships which arrived into Great Lakes, East and West Coasts ports during 2007 and 2008. Ms. Sun will complete her graduate degree in spring 2009.

Lesly Swanson

Lesly holds a Biological Sciences degree from California Polytechnic State University. After graduation she began working at Salt River Project (SRP). SRP is the third largest public power utility in the United States 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. She has been coordinating the company's response to quagga mussels. These mussels have the potential to impact SRP's power generation as well as their water delivery. SRP is taking a proactive role in attempting to stop the spread of the mussels in Arizona.

Holly Sweat

Holly Sweat is a graduate student in Biological Oceanography at the Florida Institute of Technology in Melbourne, Florida. She received her Bachelor of Science in Marine Biology in 2002 from Eckerd College in St. Petersburg, Florida, where she became interested in the ecology of invasive marine organisms. Holly served as Marine Ecosystems Technician at the Smithsonian Marine Ecosystems Exhibit (Fort Pierce, Florida) for five years before leaving to pursue her Master's degree. Ms. Sweat's current research focuses on the settlement preferences and biotoxin tolerances of native and invasive barnacles along Florida's east coast.

Carol Swinehart

Ms. Swinehart has contributed Michigan's ANS Management Plan updates; helped develop Michigan's Hydrilla rapid response plan and has lead its Hydrilla Hunt; helped develop and write the Recreational Activities Team report for the Great Lakes Regional Collaboration's AIS Strategy; helped develop and coordinated Michigan's pilot Clean Boats, Clean Waters program; organized stakeholder involvement in developing Michigan's process for recommending additions or deletions from the state's list of invasive species; and served as Great Lakes Sea Grant Extension's alternate representative on the Great Lakes Panel on ANS. She holds a master's degree from Michigan State University in Environmental Policy and Law.

Francisco Sylvester

In 1998 Francisco Sylvester graduated from the Universidad Autónoma de Madrid (Spain). Between 1999 and 2002 he worked at the Argentine National Environmental Agency on the control and management of natural protected areas and national parks nominated for the UNESCO World Heritage List. Francisco completed his PhD in Biology at the University of Buenos Aires (Argentina) in 2006, on "Feeding biology and ecology of the invasive mussel *Limnoperna fortunei* (Mytilidae) in the lower Paraná river and Río de la Plata". Since March 2007 he holds a postdoctoral fellowship at the Great Lakes Institute for Environmental Research, University of Windsor (Canada), where he focuses on hull-fouling as a vector for the introduction of aquatic invasive species.

Anna Szaniawska

Since 2005, Professor Anna Szaniawska has been the head of the Department of Experimental Ecology of Marine Organisms in the Institute of Oceanography at Gdańsk University.

The main scientific interest of the Department concerns biology, ecology and ecophysiology of marine invertebrates (both native and non-native), and biocalorimetry/bioenergetics, aquaculture and socio-economic importance of marine ecosystems. The current professional foci of professor Szaniawska include invasive and engineering species in the Baltic Sea (the role they play in the ecosystem, vectors of their introduction, their adaptational mechanisms), as well as ecophysiology of marine crustaceans and aquaculture.

Alice Michiyo Takeda

Alice Michiyo Takeda is a doctor of Biological Oceanography (Universidade de São Paulo) and, since 1985, a Zoology Professor at the Univesidade Estadual de Maringá – Paraná State. In that year, she began researching about zoobenthos of aquatic continental and, in 2001 she developed a project about *Limnoperna fortunei* in the Itaipu Reservoir (2001-2002) and, she participated the project "Program of research to control of golden mussel (*Limnoperna fortunei*) in Brazilian water jurisdiction", financed by CNPq (Brazilian National Council for Sciences and Technology). She is now analyzing *L. fortunei* in the alluvial plain of Paraná River in LTER (Project Long Term Ecological Research: 2000-2009) financed by CNPq.

Rahel Tedla

Rahel Tedla is a fourth year undergraduate student at the University of Windsor where she is studying Biological Sciences and completing an undergraduate thesis project on 'Trends of publications on 100 worst invasive species'. She currently works as a research assistant in an invasion ecology lab. Her conference presentation is based on studies of 100 worst invasive species from 1965-2007. It focuses on the trends of invasional literatures that have been accumulated within these years and the growth of the number of publications since 1965.

Charles G. Trick

Charles Gordon Trick is the Beryl Ivey Chair for Ecosystem Health at the University of Western Ontario. He holds a PhD in oceanography and is an authority on harmful algal blooms, environmental aspects of ecosystem health and community adaptation to environmental changes. He is a Professor in the department of Microbiology and Immunology, Department of Pathology and the Department of Biology.

Current projects include an marine ecosystem studies off Dubai, an ecosystem health/sustainability analysis of Lake Naivasha (Kenya), photobleaching of the corals of the Great Barrier Reef, and Safe Seafood/Aquaculture potential for countries in the Pan-Pacific region.

Sylvie Trudel

Sylvie Trudel is an ecologist since more than 20 years involved in forest, energy, invasive species and water issues. She is specialist in international development and environment. She worked for several projects and NGOs but since 1999 she is the International Coordinator for Great Lakes United for the "River to River Initiative" in Niger and Mali. The goals of this Initiative are to improve agriculture and biodiversity through soil restoration by using aquatic invasive species (mainly water hyacinth, *Salvinia molesta*, water lettuce, others) to improve environmental, social, health, and economic conditions of the people living in these communities.

Henry A. Vanderploeg

Hank Vanderploeg is a Research Ecologist at GLERL/NOAA specializing in food web research and non-indigenous species. He has done research on pelagic invaders' (Bythotrephes, Cercopagis) impacts on the planktonic food web and ecosystem impacts of dreissenid mussels. Particular interests are feeding ecology of zooplankton and mussels, spatial distribution of plankton and fishes, and regional impacts non-indigenous species.

Gerard van der Velde

Gerard van der Velde studied biology 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 National Museum of Natural History 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 300 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 and new in the board of Aquatic invasions. Main topics of his group are biological invasions and biofouling, riverine, estuarine and tropical coastal ecosystems, macroinvertebrates and fish.

Bénédikte Vercaemer

Bénédikte Vercaemer is a marine biologist with Fisheries and Oceans Canada. She was educated both in France, as an engineer, and in Canada, where she obtained her Master's degree. She has been working on shellfish aquaculture R&D projects and is currently focussing on marine invasive species. She and her colleagues initiated a monitoring program for invasive tunicates in Nova Scotia in 2006 and she is collaborating on a number of projects related to Aquatic Invasive Species in Eastern Canada. Bénédikte would like to collaborate with Arctic projects where links between climate change, changes in navigation routes and biological invasions are being studied.

Hugo Verreycken

Hugo Verreycken studied Biology at the University of Louvain. He graduated in 1986 and started research on the ecology of freshwater fish in the Laboratory of Ecology and Aquaculture at the same University. In 1992 he became fisheries biologist at the Research Institute for Nature and Forest. Here Hugo was responsible for the Aquaculture Division from 1992 to 2000. Research was carried out on the optimisation of the culture of indigenous fish for reintroduction and stocking purposes. Currently Hugo is monitoring the non-indigenous fish species in Flanders (Belgium) and is responsible for the management of a fish database. This database, which includes data on all indigenous and non-indigenous freshwater fish species in Flanders, is available (in Dutch) through the internet since 2007.

Matthias Voigt

Dr. Matthias Voigt has been working as a self-employed environmental consultant in Germany and in Australia. Matthias has been involved in the Ballast Water issue since 1997. He became a partner in the EU Concerted Action on 'Testing Monitoring Systems for Risk Assessment of Harmful Introductions by Ships to European Waters,' where he concentrated on treatment options for ballast water. With his company, he developed test protocols especially for the evaluation of the biological efficacy of ballast water treatment options. He is an advisor to the CEFIC delegation at IMO's MEPC. Since Jan. 2004 he is working with Hamann AG, where he is responsible for R&D projects.

John L. Wachsmuth

John received a BS degree in Natural Resource Management from the School of Forestry at the University of Montana, Missoula, Montana. He is currently completing his M.S. in Natural Resource Management through the School of Environmental Policy and Management at Denver University, Denver, Colorado. John has spent 25 years working for Montana Fish, Wildlife & Parks on fisheries related research projects in Northwestern Montana.

John was involved in writing and coordination of the first Montana Aquatic Invasive Species Management Plan in 2002. He feels that public involvement through partnerships with State and Federal agencies is critically important when it comes to the topic of Aquatic Invasive Species (AIS).

Christopher Walker

Chris Walker received a MS in Environmental Sciences and Resources from Portland State University conducting research in urban areas evaluating land use effects on stream water quality and biota. Currently, he is a biologist with the U.S. Geological Survey conducting research examining the survival and behavior of anadromous juvenile salmonids as they migrate downriver. He also works on projects developing methods for monitoring and early detection of aquatic invasive species in the Columbia River basin.

Linda Walters

Dr. Linda Walters is an Associate Professor at the University of Central Florida. Her research focuses on human impacts in marine systems, including understanding how the aquarium industry uses and disperses invasive (*Caulerpa* spp.) and potentially invasive (*Chaetomorpha* spp.) macroalgae. She and Susan Zaleski, Coastal Resource Specialist for USC Sea Grant, have developed a scientifically-based outreach/educational campaign for the hobbyist industry to reduce the number of "aquarium dumping" events. They attend hobbyist meetings, work with customs agents, and have produced an animated movie, *Caulerpa* identification key, alternatives to release brochure and are currently completing two children's books on this topic.

Tony Wang

Tony Wang received his BSc (Honours Marine and Freshwater Biology) in 2004, from the University of Guelph. He is currently working towards his M.Sc. (Environmental Science) at Great Lakes Institute for Environmental Research (GLIER), University of Windsor, under the supervisions of Dr. Hugh MacIsaac and Dr. Sarah Bailey. His research focuses on the use of brine as a ballast tank treatment technology for transoceanic vessels entering the Great Lakes.

Jessica MacKay Ward

Jessica MacKay Ward is a PhD student in the Department of Biology at McGill University (Montreal, Canada) under the supervision of Dr Anthony Ricciardi. Her doctoral research investigates patterns in the effects of non-indigenous animals on aquatic communities. She is conducting field experiments in the Saint-Lawrence River and using meta-analytical techniques to examine patterns of variation in the ecological effects of exotic species. Her research further extends the application of meta-analysis toward developing and testing hypotheses in invasion biology, and includes a published meta-analysis on the suppression of introduced plants by native herbivores.

Wendy Watson-Wright

Dr. Wendy Watson-Wright is the Assistant Deputy Minister (ADM), Science Sector, in Fisheries and Oceans Canada (DFO). In this role, she is responsible for providing the leadership, and policy and scientific direction for all science activities in the department, including oceanography, hydrography, and fisheries, aquaculture, habitat, climate and aquatic ecosystem science.

Wendy began her career in the Canadian federal public service in 1989 as a research scientist with the Inspection Services branch of DFO in Halifax, Nova Scotia. Since then she has held various other positions, including Director of the DFO St. Andrews (Marine) Biological Station in New Brunswick, Director General of DFO Audit and Evaluation (Ottawa, Ontario), and Director General of Strategic Policy and later Associate ADM of Population and Public Health in Health Canada.

Dr. Watson-Wright holds a PhD in Physiology from Dalhousie University in Halifax, Nova Scotia. She is a member of several boards including the Canadian Foundation for Climate and Atmospheric Science, is one of the Canadian commissioners on the Great Lakes Fishery Commission and is head of the Canadian delegation for the UNESCO Intergovernmental Oceanographic Commission.

Mathew Wells

Dr. Mathew Wells is an assistant professor at the University of Toronto in the Department of Physical and Environmental Sciences, where he teaches courses on physical limnology, oceanography and contaminant transport in aquatic systems. His research expertise is on environmental fluid dynamics; in particular how physical mixing processes transport chemicals and biota in inland and coastal waters. As a member of the Canadian Aquatic Invasive Species Network he studies the transport and fate of ballast water discharges into waters of the Great Lakes.

Laurie Wesson

Laurie Wesson, Biologist, Fisheries and Oceans Canada, manages the Aquatic Invasive Species file for the Prairie Provinces and North Western Ontario. She implemented the Aquatic Invasive Species Watercraft Inspection Program at international borders in North Western Ontario.

Laurie is a member of the Invasive Species Councils of Manitoba and Saskatchewan; the Manitoba, Alberta, and National Introductions and Transfers Committees; and Canadian member of the Western Regional Panel on Aquatic Nuisance Species. She is dedicated to preventing the spread of Aquatic Invasive Species in Canadian waters.

Christopher J. Wiley

Chris straddles two Canadian Federal Government departments. He is the Aquatic Invasive Species Coordinator for Fisheries and Oceans Canada, Central and Arctic Region as well as the Environmental Issues Manager for Transport Canada, Ontario Region.

Chris spent 15 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), Regional Director of Technical Services for the Canadian Coast Guard, Manager of a number of multinational Arctic Science Programs, (SHEBA, TUNDRA, NORTHWATER) and Executive Assistant to the Regional Director General of Fisheries and Oceans Canada. He has had regional involvement in the Ballast Water file since 1994. His is Chair of the Ballast Water Working Group at the International Maritime Organization. And Co Chair of the Ballast Water Working Group and Tug / Barge Working Group for the Canadian Marine Advisory Council.

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 U.S. 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.

Chris Woods

Chris is a marine ecologist specializing in marine invasion science and aquaculture. Graduating from Victoria University of Wellington with a PhD on seahorse aquaculture, he has worked for NIWA for the past 14 years on various aquaculture and biosecurity projects. He has had a long-term involvement in NIWA's national marine port baseline surveys and national target marine pest surveillance commissioned by MAF-BNZ. Recently, Chris has led a MAF-BNZ project that examined the viability of biofouling assemblages before and after the application of different hull cleaning methods; the results of which are to be presented at the conference.

David Wright

Dr. Wright is Professor of Environmental Toxicology at the University of Maryland Center for Environmental Science. He holds PhD and DSc degrees in Physiology and Environmental Toxicology from the University of Newcastle-upon-Tyne and is a Fellow of the Institute for Marine Engineering Science and Technology. He has published over 100 peer-reviewed papers and books, and has focussed on the biology and control of invasive species for more than 20 years. Dr. Wright has performed more than 15 shipboard trials of ballast water treatment systems designed to eliminate nuisance species introduced via this vector.

Darren C. J. Yeo

Darren C.J. Yeo is currently a visiting scholar at the Department of Biological Sciences, University of Notre Dame. His interests are in freshwater invasion biology and invasive species risk assessments. His home institution is the National University of Singapore, where he is an instructor in the Department of Biological Sciences and a research associate in the Raffles Museum of Biodiversity Research. Other areas of interest include taxonomy, systematics, and biogeography of freshwater decapod crustaceans.

Eva Záhorská

In 2005, Eva became a PhD student at Comenius University, in the Department of Ecology. Since that time, she has been working on phenotype plasticity and life-history traits of topmouth gudgeon (*Pseudorasbora parva*) – an invasive fish species in Europe. Eva published three papers in international peer-reviewed journals and participated at several international conferences, such as Neobiota, the 4th European Conference on Biological Invasions, Austria (2006); FSBI Annual International Symposium, UK (2007); XII European Congress of Ichthyology, Croatia (2007). She is scheduled to complete her PhD degree in Ecology in September 2009. Eva is a member of the Slovak Ichthyological Society.

Philine zu Ermgassen

Philine zu Ermgassen is a final year PhD student in the Department of Zoology, University of Cambridge. Her research interests include non-native species interactions, patterns of freshwater invasions, predicting invasive species arrival and climate change impacts.

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