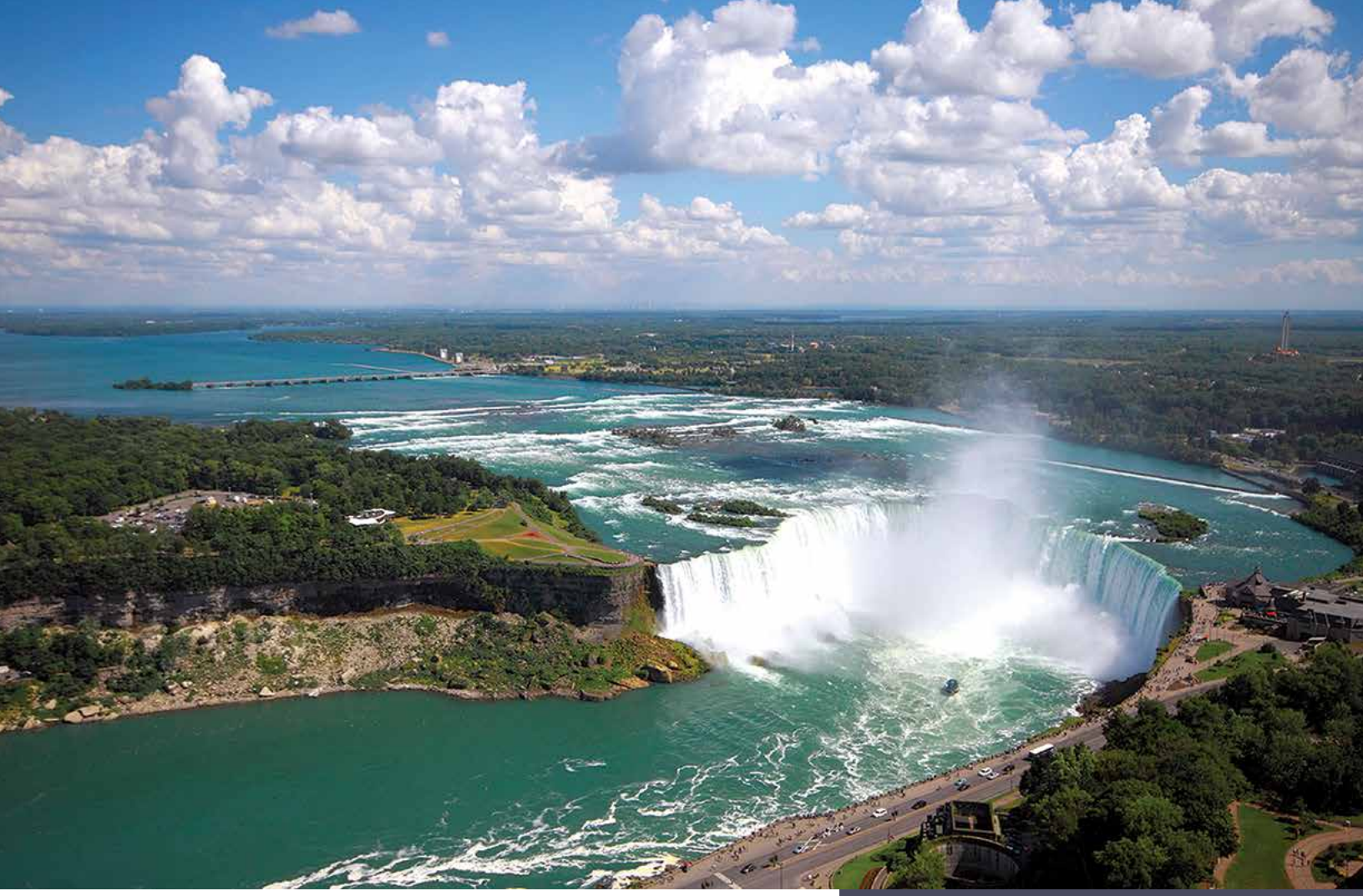

18th International Conference on Aquatic Invasive Species

2013

ICAIS

Hosted by

Invasive Species Centre

April 21 to 25, 2013

Sheraton-on-the-Falls Hotel

Niagara Falls, Ontario, Canada

2013

ICAIS

Post-Conference Version of the Final Program

April 26, 2013

Some presentations were cancelled due to sequestration and austerity measures.

Fisheries and Oceans Canada | Pêches et Océans Canada

Photo: Jean-Marc Carisse

Welcome to Niagara Falls for the 18th International Conference on Aquatic Invasive Species.

This annual conference provides a valuable forum for the kind of collaboration that is essential in understanding and responding to the threat posed to Canada's waterways by invasive species.

The agenda in front of you is impressive, both in terms of the subject matter and the experts who have come here from every corner of the world to review the work that has been done, while helping map out the best course for the future.

Our Government is well aware of the threats posed by invasive species. The danger has increased over the years and the best way to counter it is through continued scientific research, development of new technology and public education.

Conferences such as this provide an opportunity to continue the important work that has been done and address new and emerging issues.

One of the immediate threats to our inland waters – particularly the Great Lakes – continues to be Asian carp. It is estimated that the contribution of the fisheries and tourism generated by the Great Lakes is close to $9 billion to the Canadian economy.

That is why our Government last year dedicated $17.5 million to combat the threat posed by Asian carp through a program of prevention, early warning, rapid response, and management and control. In addition, the recent federal budget provides $4 million over three years to continue the protection and preservation of all our waterways from the threat of aquatic invasive species.

I wish you well in your discussions on this important topic over the next three days and trust you will find the conference both informative and helpful as you continue your work to combat this problem.

The Honourable Keith Ashfield, P.C., M.P.
Minister of Fisheries and Oceans

Canada

Ontario

MESSAGE FROM NATURAL RESOURCES MINISTER DAVID ORAZIETTI

I'm pleased to extend greetings to everyone attending the 18th International Conference on Aquatic Invasive Species. Welcome to Ontario and to Niagara Falls.

Ontario is proud to be hosting this important international event, widely considered to be the most comprehensive international forum on aquatic invasive species.

My congratulations to the conference organizers for providing a first-rate agenda of speakers and workshops to address our common challenge of protecting the world's aquatic resources.

As in the rest of the world, invasive species pose a growing threat to the health and productivity of Ontario's waterways. With more than 250,000 lakes, and countless rivers and streams, our province has a lot at stake.

Ontario also shares four of the five Great Lakes, which are vital to the quality of life for tens of millions of people in Canada and the United States who depend on them for trade and transportation, food, recreation, renewable energy and drinking water.

To date, there have been 186 non-native species recorded in the Great Lakes and we know that number is increasing. We're also living with the threat of Asian carp on our doorstep. These realities add some urgency to our ongoing efforts to prevent, detect, respond to and manage invasive species in our waters.

Ontario has made good progress over the years, but we know there is still work to be done.

The Ontario Invasive Species Strategic Plan, released in 2012, is our guide for working with our partners to prevent the arrival and establishment of new invasive species, to slow down and where possible reverse the spread, and to reduce the harmful impacts of those already here.

In July 2012, I was pleased to attend the official opening of the new Invasive Species Centre in my riding of Sault Ste. Marie. This Centre is funded in part by a $15 million contribution by our government and is dedicated to combating alien invasive species that threaten Canada's natural resources and ecosystems. By co-ordinating scientific research, technology, knowledge sharing and public outreach efforts, the Centre will be an invaluable asset in helping us mitigate these threats.

Ontario is also working on a number of bi-national initiatives in the Great Lakes basin to protect this shared resource. As an active member of the Asian Carp Regional Coordinating Committee, a cross-border partnership created by the White House Council on Environmental Quality, we're collaborating with our neighbours on prevention, detection and monitoring of Asian carp.

While there is still much to accomplish in the battle against aquatic invasive species in Ontario, we're confident we have the right approach, strategies and partnerships in place.

Every jurisdiction has a responsibility to ensure the world's water resources remain a healthy, abundant and bountiful legacy for future generations. This conference is taking on that global challenge by providing a forum for delegates from around the world to share research and experience, explore new and emerging issues, and promote greater international cooperation.

Thank you for your participation. My best wishes for a productive and enjoyable conference.

Hon. David Orazietti
Ontario Minister of Natural Resources

Invasive Species Centre

Catalyst for research and response

1219 Queen Street East
Sault Ste. Marie, Ontario P6A 2E5
www.invasivespeciescentre.ca

On behalf of the Board of Directors of the Canada-Ontario Invasive Species Centre (ISC), I am honored to host the 18th International Conference on Aquatic Invasive Species (ICAIS) in Niagara Falls, Ontario, Canada. ICAIS is renowned as a forum at which the most current international research is shared and participants are given opportunities to engage in exchanges which shape public policy and best management practices around the world.

Thanks to outstanding efforts by our partners in this conference, we have a remarkable line-up of speakers whose presentations will stimulate rich discussion among scientists, managers and policy makers engaged in addressing one of the most significant ecological and socio-economic threats of our time – alien invasive species.

The ISC was established in 2011 to enhance coordination of natural and socio-economic scientific research, technology and knowledge transfer, and public outreach and communications to mitigate the ecological and economic threats of aquatic and terrestrial invasive species. To fulfill its mandate, the ISC must establish and nurture partnerships with all levels of government, academia, First Nations, industry and non-government organizations.

ICAIS is an excellent example of this partnership in action locally, nationally and internationally. I look forward to your participation and contribution towards what I know will be a wonderful conference.

I am especially encouraged to have seen such keen interest from student participants. As people travel more both domestically and internationally, and as economies become more intertwined globally, so too will the threats of invasive species remain a growing concern. It is comforting to know that we have an emerging generation of new leaders engaged in academic studies and embracing knowledge transfer from highly-regarded experts. You are one of the reasons why we have such optimism for the future despite the challenges that lie ahead.

Finally, I thank our growing list of partners for their contributions in making the 18th ICAIS a reality. They are to be commended for their support of this important conference. I also thank members of the Technical Program Committee for their leadership and tireless efforts in reviewing over 220 abstracts and for organizing them into a cohesive conference program.

I look forward to meeting you at the conference next April.

Sincerely,

Bob Lambe

Robert G. Lambe
Executive Director

Conference Chair

Robert G. Lambe
Executive Director, Canada-Ontario Invasive Species Centre

Technical Program Committee

Sarah Bailey, Fisheries and Oceans Canada

Margaret (Peg) Brady, National Oceanic and Atmospheric Administration

Jeff Brinsmead, Ontario Ministry of Natural Resources

Renata Claudi, RNT Consulting Inc.

Becky Cudmore, Fisheries and Oceans Canada

Alfred F. Cofrancesco, Jr., U.S. Army Engineer Research & Development Center

Richard Everett, U.S. Coast Guard

Cherie-Lee Fietsch, Bruce Power

Marc Gaden, Great Lakes Fishery Commission

Lyn Gettys, University of Florida, Fort Lauderdale Research and Education Center

Nick Heisler, International Joint Commission, Canada Section

Alexander Karatayev, Buffalo State College

Cynthia Kolar, U.S. Geological Survey

Rob Leuven, Radboud University Nijmegen

Frances Lucy, Institute of Technology, Sligo, School of Science

Sophie Monfette, Ontario Federation of Anglers and Hunters

Don MacLean, U.S. Fish & Wildlife Service

Linda Nelson, U.S. Army Engineer Research & Development Center

Stephen Phillips, Pacific States Marine Fisheries Commission

Scott Poulton, Ontario Power Generation

Sanjeevi (Raju) Rajagopal, Radboud University Nijmegen

David F. Reid, Consultant

Tony Van Oostrom, Ontario Power Generation

Christopher J. Wiley, Transport Canada Marine Safety

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Conference at a Glance

Sunday, April 21, 2013

12:00 PM to 6:00 PM
Conference Registration and A/V Check-in

Monday, April 22, 2013

7:00 AM to 6:00 PM
Conference Registration and A/V Check-in

7:30 am
Continental Breakfast (provided)

8:30 AM
Opening Plenary Session

9:30 AM
Networking Break

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

3:10 PM to 3:40 PM
Networking Break

3:40 PM to 6:00 PM
Concurrent Sessions

6:00 PM to 7:30 PM
Poster Session and Exhibitor Reception

Tuesday, April 23, 2013

7:00 AM to 6:00 PM
Conference Registration and A/V Check-in

7:30 am
Continental Breakfast (provided)

8:45 AM
Plenary Session

9:30 AM
Networking Break

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

3:10 PM to 3:40 PM
Networking Break

3:40 PM to 5:40 PM
Concurrent Sessions

Evening Free

Wednesday, April 24, 2013

7:00 AM to 6:00 PM
Conference Registration and A/V Check-in

7:30 am
Continental Breakfast (provided)

8:45 AM
Plenary Session

9:30 AM
Networking Break

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

3:10 PM to 3:40 PM
Networking Break

3:40 PM to 5:40 PM
Concurrent Sessions

Evening Free

Thursday, April 25, 2013

7:00 AM to 12:00 PM
Conference Registration and A/V Check-in

7:30 am
Continental Breakfast (provided)

8:30 AM
Plenary Session

9:30 AM
Networking Break

9:50 AM to 12:10 PM
Concurrent Sessions

12:10 PM
Conference Adjourns

1:30 PM to 3:10 PM
NAISN Workshop

How to Create and Operate a Successful Cooperative Invasive Species Management Area (CISMA)

3:10 PM to 3:30 PM
Networking Break

3:30 PM to 5:00 PM
NAISN Workshop continued

5:00 PM
Workshop Adjourns

Table of Contents

Conference Program xviii

Monday, April 22

Opening Plenary Session

Invited Keynote Presentation

Why Invasions Matter: A Response to Recent Criticisms of Invasion Biology 1
Anthony Ricciardi, *Associate Professor, Redpath Museum and McGill School of Environment, McGill University*

A-1 – Early Detection and Monitoring I

Invited Keynote Presentation

Surveys, Surveillance and Monitoring – Strategies for Early Detection and Long-term Management of Aquatic Invasive Species 2
Chad L. Hewitt*, Pro Vice-Chancellor (Research) and Marnie L. Campbell, Chair in Ecological Security, Central Queensland University, School of Medical and Applied Sciences*

Strategy for Designing a Regional Network for AIS Monitoring, Detection, and Response 3
Bill Bolen*, U.S. Environmental Protection Agency*

A Multi-Jurisdictional Approach to Asian Carp in the Upper Illinois River and Chicago Area Waterway System 4
Kevin Irons*, Illinois Department of Natural Resources*

AIS Integration into Existing Monitoring Programs: Lessons Learned in Michigan 5
Sarah LeSage *and Sue Tangora, Michigan Department of Environmental Quality*

Early Detection and Monitoring of Exotic Invasive Plants in Quebec: Building Networks with Citizen Scientists in the Context of Climate Change 6
Isabelle Simard*, ministère du Développement durable, de l'Environnement, de la Faune et des Parcs, Québec*

B-1 – Crustaceans I

Invited Keynote Presentation

Crustacean Invaders: Past, Present and Future 7
Jaimie T.A. Dick*, Professor of Invasion Ecology, Queen's University Belfast*

Bloody-red Shrimp (***Hemimysis anomala***) Populations in Montreal Harbour Waters, St. Lawrence River: Potential Risk of Species Transfer. 8
Yves de Lafontaine*, Environment Canada; Jérôme Marty, St. Lawrence River Institute*

Spatial and Temporal Variation in the Predatory Impact of an Invasive Mysid Shrimp (***Hemimysis anomala***) 9
Mhairi Alexander[1], Anthony Ricciardi[2], Jaimie T.A. Dick[1], ***Josephine Iacarella****[2,3], [1]Queen's University Belfast; [2]Redpath Museum, McGill University; [3]Groupe de recherche interuniversitaire en limnologie et en environnement aquatique (GRIL)*

Understanding the Invasion Success and Ecological Impacts of Invasive Species: A Comparative Functional Response Methodology 10
Daniel Barrios-O'Neill*[1], Jaimie T.A. Dick[1], Mhairi Alexander[1], Helene C. Bovy[1], Anthony Ricciardi[2], Mark Emmerson[1], [1]Queen's University Belfast; [2]Redpath Museum, McGill University*

Novel and Emerging Tools to Assess the Impacts of Aquatic Invasive Species 11
Tim Johnson*[1], Shelley Arnott[2], Linda Campbell[3], Lucia Carreon[4], Meagan King[1], Kent McDonald[1], Brent Metcalfe[1], Mike Yuille[1], Chris Wilson[1], [1]Ontario Ministry of Natural Resources; [2]Queen's University; [3]Saint Mary's University; [4]University of Windsor*

C-1 – Biology and Ecology of Asian Carps I

Invited Keynote Presentation

Update on the Asian Carp Control Strategy Framework 12
John Goss*, Asian Carp Director, White House Council on Environmental Quality* ***Note:*** *Presented by Becky Cudmore on behalf of John Goss*

Invited Keynote Presentation

Asian Carps – Science and Management Interplay in Canada 13
Becky Cudmore*, Acting Manager, Canadian Asian Carp Program; Manager, National Centre of Expertise for Aquatic Risk Assessment; Senior Science Advisor, Aquatic Invasive Species, Fisheries and Oceans Canada*

Preliminary Assessment of the Suitability of Canadian Great Lakes Tributaries for Asian Carp Spawning 14
Nicholas Mandrak*, Fisheries and Oceans Canada, Centre of Expertise for Aquatic Risk Assessment*

A Stage-Structured Population Model for Bighead and Silver Carps in the Great Lakes 15
Warren Currie and Marten Koops, Fisheries and Oceans Canada; ***Kim Cuddington****, University of Waterloo*

Movements and Habitat Use of Silver Carp in the Wabash River, Indiana (USA) 16
Alison Coulter*[1], Doug Keller[2], Tom Stefanavag[2], Jon Amberg[3], Elizabeth Bailey[1], Reuben Goforth[1], [1]Purdue University; [2]Indiana Department of Natural Resources; [3]U.S. Geological Survey*

Assessment of Non-Planktonic Food Sources for Bigheaded Carps in the Laurentian Great Lakes 17
Michael Lucey, ***Duane Chapman****, Elizabeth Brothers, Karl Anderson and Karthik Massagounder, U.S. Geological Survey*

D-1 – Shipping Pathways I

Invited Keynote Presentation

The Role that the Zebra Mussel and ICAIS Conferences Have Played in Reducing the Risk of AIS Being Discharged from Ships' Ballast Water 18
Christopher J. Wiley, *Fisheries and Oceans Canada/Transport Canada Marine Safety*

Examining the Role of Domestic Shipping in the Spread of Nonindigenous Species 19
Sarah Bailey *and Elizabeta Briski, Fisheries and Oceans Canada; Christopher J. Wiley, Transport Canada Marine Safety*

Hull Fouling on Domestic Vessels as a Vector for Secondary Spread of Marine Nonindigenous Species 20
Marco Meloni[1], Nancy Correa[2], Fábio Pitombo[3], Demetrio Boltovskoy[1], ***Francisco Sylvester****[1], [1]Universidad de Buenos Aires; [2]Servicio de Hidrografía Naval; [3]Universidade Federal Fluminense*

Estimating the Risk of Ship-mediated NIS Introductions into Marine and Freshwater Ecosystems of Canada 21
Oscar Casas-Monroy*[1], Farrah Chan[2], Jennifer Adams[1], Robert Linley[1], Sarah Bailey[1], [1]Fisheries and Oceans Canada; [2]University of Windsor, Great Lakes Institute for Environmental Research*

Risk Assessment for Ballast Water Exchange in the Canadian Eastern Arctic 22
Kimberly Howland*[1], Shannon Nudds[1], Charles Hannah[1], Bruce Stewart[2], Jeff Higdon[1], Tim Siferd[1], Robert Stewart[1], Margaret Treble[1], Christopher J. Wiley[3], [1]Fisheries and Oceans Canada; [2]Arctic Biological Consultants; [3]Transport Canada Marine Safety*

A-2 – Early Detection and Monitoring II

How to Build an Effective Rapid Response Task Force in the Lake Champlain Basin 23
Margaret Modley, *Lake Champlain Basin Program*

The U.S. Fish and Wildlife Service's Provisional, Early Detection Program for the Great Lakes 24
Michael H. Hoff, *U.S. Fish & Wildlife Service, Fisheries Program*

Search Strategies and Network Design Issues for Early Detection of Aquatic Invasive Species 25
John R. (Jack) Kelly, *Joel Hoffman, Anett Trebitz, Gregory Peterson and Erik Pilgrim, U.S. Environmental Protection Agency*

Estimating Sampling Effort for Early Detection of Non-Indigenous Benthic Species in the Toledo Harbor Region of Lake Erie 26
Jeffrey L. Ram, *Fady Banno, Richard Gala, Jason P. Gizicki and Donna Kashian, Wayne State University*

Capturing Dispersal Patterns and Tolerance of Early Invaders with Enhanced SDMs: Applications for Design of Detection Programs 27
Paul Edwards *and Brian Leung, McGill University; Ladd E. Johnson and Sam Collin, Université Laval*

B-2 – Crustaceans II

'The Pump Don't Work, 'Cause the Vandals Took the Handles': Why 'Killer Shrimps' and Other Invasive Amphipods Threaten Freshwater Biological Water Quality Monitoring in the British Isles 28
Calum MacNeil, *Isle of Man Government*

Dispersal of Invasive Species by Drifting 29
Mariëlle van Riel, *Alterra, WUR; Abraham bij de Vaate, Waterfauna Hydrobiologisch Adviesbureau; Gerard Van der Velde, Radboud University Nijmegen*

Predicting Aquatic Invader Impacts and Testing Major Hypotheses in Invasion Biology with Comparative Functional Responses 30
Jaimie T.A. Dick*[1], Mhairi Alexander[1], Anthony Ricciardi[2], Jennifer Dodd[1], Calum MacNeil[1], Kevin Gallagher[1], Suncica Avlijas[2], David Aldridge[3], [1]Queen's University Belfast; [2]Redpath Museum, McGill University; [3]Cambridge University*

Integrated Ecological Modelling as a Tool for Detection of Potential Hot Spots for Invasive Macroinvertebrates 31
Pieter Boets, *Koen Lock and Peter Goethals, Ghent University*

Temporal and Spatial Community Dynamics of Invasive and Native Amphipods in the River Rhine and its Tributaries, Germany 32
Wei Chen, *Martin Plath, Bruno Streit and Sebastian Klaus, Frankfurt University; Johann Wolfgang, Goethe-Universität*

C-2 – Biology and Ecology of Asian Carps II

Changes in Zooplankton Community of the Illinois River Since Establishment of Bighead and Silver Carp 33
Collin Hinz, *Illinois Natural History Survey*

Preliminary Assessment of the Trophic Consequences of Asian Carp Establishment in Offshore Lake Ontario 34
Tom Stewart, *Ontario Ministry of Natural Resources; Hongyan Zhang, University of Michigan; Warren Currie, Fisheries and Oceans Canada*

Assessing Risk of Asian Carp Invasion and Bioeconomic Impacts on the Food Web and Fisheries of Lake Erie 35
Edward Rutherford *and D. Mason, NOAA, Great Lakes Environmental Research Laboratory; Hongyan Zhang and J. Breck, University of Michigan; Marion Wittmann and David Lodge, University of Notre Dame; J. Rothlisberger, U.S. Forest Service; R. Cooke, Resources for the Future; Tim Johnson, Ontario Ministry of Natural Resources; Xinhua Zu, Fisheries and Oceans Canada; D. Finnoff, University of Wyoming*

Phenotypic Plasticity in Life History Traits of Bigheaded Carps in Novel Environments 36
Reuben Goforth *and Alison Coulter, Purdue University; Jon Amberg, U.S. Geological Survey; Elizabeth Bailey, Purdue University; Doug Keller, Indiana Department of Natural Resources*

Invasion History, Population Dynamics and Trophic Structure of Asian Carps on the Northwestern Front of the Invasion in the United States 37
Cari-Ann Hayer, *Katie Bertrand and Brian Graeb, South Dakota State University*

D-2 – Shipping Pathways II

Canadian Implementation of the Ballast Water Convention 38
Colin Henein, *Transport Canada Marine Policy*

A Multi-dimensional Approach to Invasive Species Prevention 39
Elizabeta Briski*[1], Lisa Allinger[2], Mary Balcer[3], Allegra Cangelosi[4], Lana Fanberg[3], Tom Markee[3], Nicole Mays[4], Christine Polkinghorne[3], Kelsey Prihoda[3], Euan Reavie[3], Deanna Regan[3], Donald Reid[5], Heidi Saillard[3], Tyler Schwerdt[6], Heidi Schaefer[3], Matthew TenEyck[3], Christopher J. Wiley[7], Sarah Bailey[1], [1]Fisheries and Oceans Canada; [2]University of Minnesota; [3]Universitiy of Wisconsin-Superior; [4]Northeast-Midwest Institute; [5]Consultant; [6]AMI Engineering; [7]Transport Canada Marine Safety*

Evaluating Efficacy of a Ballast Water Filtration System for Reducing Risk of Spread of Aquatic Species in the Great Lakes 40
Robert Linley, *Jennifer Adams, Sarah Bailey and Elizabeta Briski, Fisheries and Oceans Canada*

Adenosine TriPhosphate: A Promising Tool for Ballast Water Compliance Monitoring 41
Cees van Slooten, *Tom Wijers and Louis Peperzak, Royal Netherlands Institute for Sea Research, NIOZ*

Assessing the Utility of Vital Fluorescent Stains for Viability Analysis of Organisms Transported by Ballast Water 42
Jennifer Adams, *Elizabeta Briski and Sarah Bailey, Fisheries and Oceans Canada*

A-3 – Early Detection and Monitoring III

Early Detection of Non-native Fishes Using Fish Larvae 43
Joel Hoffman, *Erik Pilgrim, Anett Trebitz, John Kelly and Gregory Peterson, U.S. Environmental Protection Agency*

Metagenomic Approaches to Detecting Invasive Species in Lake Superior 44
Erik Pilgrim, *Joel Hoffman, John Kelly, Gregory Peterson, Anett Trebitz and John Martinson, U.S. Environmental Protection Agency*

Assessing the Role of Genomic Surveillance Methods in Mitigating the Erie Canal Corridor Invasion Risk 45
Andrew Mahon, *Central Michigan University; W. Lindsay Chadderton and Andrew Tucker, The Nature Conservancy*

Environmental DNA Monitoring for Detecting Aquatic Invasive Species in Ontario 46
Caleigh Smith, Kristyne Wozney, ***Chris Wilson*** *and Jennifer Bronnenhuber, Ontario Ministry of Natural Resources; Christopher Kyle, Trent University*

Evaluating Canadian Zooplankton Biodiversity through DNA Barcodes: Assessing Non-indigenous Species Presence to Provide a Framework for Future Monitoring 47
Robert Young*[1], Cathryn Abbott[2], Tom Therriault[2], Sarah Adamowicz[1], [1]University of Guelph; [2]Fisheries and Oceans Canada*

Eurasian Ruffe – Implications of Recent eDNA Surveillance Efforts in the Laurentian Great Lakes 48
W. Lindsay Chadderton*[1], Andrew Mahon[2], John Bossenbroek[3], Jennifer Sieracki[3], Andrew Tucker[1], Christopher Jerde[4], David Lodge[4], Marion Wittmann[4], Dmitry Beletsky[5], [1]The Nature Conservancy; [2]Central Michigan University; [3]University of Toledo; [4]University of Notre Dame; [5]University of Michigan*

B-3 – Crustaceans III

Use of Functional Response Experiments and Modelling to Assess Intra-guild Interaction between a Native and Invasive Amphipod in Northern Ireland 49
Mandy Bunke*[1], Mhairi Alexander[2], Jaimie T.A. Dick[2], Alison Dunn[1], Melanie Hatcher[1], [1]University of Leeds; [2]Queen's University Belfast*

Predatory Functional Responses of Native vs. Exotic Amphipods: Effects of Predation Risk and Parasitism 50
Rachel Paterson*[1], Marilyn Ennis[1], Melanie Hatcher[2], Alison Dunn[2], Jaimie T.A. Dick[1], [1]Queen's University Belfast; [2]University of Leeds*

Trophic Impacts of Two Invasive Decapods on Freshwater Communities 51
Paula Rosewarne, Chris Wing, Christopher Grocock, Robert Mortimer and ***Alison Dunn****, University of Leeds*

Combined Effects of Food Abundance and Temperature on Large Bodied vs. Small Bodied Cladoceran Species Replacement 52
Irina Feniova *and Yury Dgebuadze, Institute of Ecology and Evolution, Russian Academy of Sciences; Vladimir Razlutski, Anna Palash and Elena Sysova, the Scientific and Practical Center for Bioresources, National Academy of Sciences of Belarus; Jacek Tunowski , Institute of Inland Fishery; Andrew Dzialowski, Oklahoma State University*

Invasion of Asian Tiger Shrimp (*Penaeus monodon* Fabricius, 1798) in the Western Atlantic and Gulf of Mexico 53
Leslie Hartman, Texas Parks & Wildlife Department; ***Pamela Fuller,*** *U.S. Geological Survey; David Knott, Poseidon Taxonomic Services, LLC; James Morris, NOAA Fisheries; Peter Kingsley-Smith, South Carolina Department of Natural Resources*

Early Life Stage Biology of a New Population of Green Crab (*Carcinus maenas*) in Placentia Bay & Implications for Mussel Culture in Newfoundland 54
Kiley Best*[1], Cynthia McKenzie[2], Cyr Couturier[1], [1]Marine Institute of Memorial University of Newfoundland; [2]Fisheries and Oceans Canada*

Disruption of Essential Habitat by a Non-Indigenous Predator in Shoreline Habitats of the Southern Gulf of St. Lawrence 55
Pedro Quijon, *Paula Tummon Flynn, Cassandra Mellish, Tyler Pickering and Andrey Malyshev, University of Prince Edward Island*

C-3 – Management and Control of Asian Carps I

Managing Asian Carp at the Detectable Population Front in the Illinois Waterway through Standardized Monitoring and Removal by Contracted Commercial Fishers 56
Victor Santucci, *Kevin Irons and James Mick, Illinois Department of Natural Resources; David C. Glover, Southern Illinois University Carbondale, Center for Fisheries, Aquaculture and Aquatic Sciences*

The Use of Chemical Stimuli in the Control of Asian Carp 57
***Edward E. Little**, Robin D. Calfee, H. Puglis and E. Beahan, U.S. Geological Survey, Columbia Environmental Research Center; Peter Sorensen, University of Minnesota*

Asian Carp (*Hypophthalmichthys spp.*) and the Viability of a Vulnerable Native Fish: An Ecological Risk Analysis for Paddlefish (*Polyodon spathula*) in the Lower Mississippi River 58
***Nicholas A. Friedenberg**, Adam Laybourn and Jonathan Borelli, Applied Biomathematics; Jan J. Hoover, U.S. Army Corps of Engineers*

Development of a Microparticle Delivery System for the Delivery of Control Agents to Bighead Carp and Silver Carp 59
*Jon J. Amberg, James A. Luoma, Terrance D. Hubert and **Mark P. Gaikowski**, U.S. Geological Survey, Upper Midwest Environmental Sciences Center*

Swimming Performance of Asian Carp 60
***Jan Jeffrey Hoover**, Alan Katzenmeyer, Larry Southern and Nicky Hahn, U.S. Army Corps of Engineers, Engineer Research and Development Center*

D-3 – Shipping Pathways III

Organism Patchiness in Ballast Water Tanks – Implications for Ballast Water Management Compliance Control Sampling 61
***Stephan Gollasch**, GoConsult; Matej David, David Consult*

'Fouling Begets Fouling': Can Species-Based Biofouling Biosecurity Management Work for Ships? 62
***John Polglaze**, PGM Environment*

Does Transport Pathway Influence the Relationship between Colonization Pressure and Propagule Pressure of Zooplankton in Ballast Water of Ships? 63
***Farrah Chan** and Hugh MacIsaac, University of Windsor, Great Lakes Institute for Environmental Research; Elizabeta Briski and Sarah Bailey, Fisheries and Oceans Canada*

Hybrid Treatment to Control Plankton Densities in Ballast Water Tanks 64
***Esteban M. Paolucci**[1], Marco C. Hernandez[1], Alexei Potapov[2], Hugh J. MacIsaac[1], [1]University of Windsor, Great Lakes Institute for Environmental Research; [2]University of Alberta, Center for Mathematical Biology, Department of Mathematical and Statistical Sciences*

Poster Sesssion

Taxonomic relatedness and functional traits as predictors of establishment success after a massive freshwater fish invasion in Neotropics 65
*Felipe Skóra and Jean Ricardo Simões Vitule, Universidade Federal do Paraná; **Vinícius Abilhoa**, Museu de História Natural Capão da Imbuia*

Assessing Compliance with Ballast Water International Regulations in Argentina 66
*María Fernanda Ávila Velandia[1], Pablo Almada[2], **Francisco Sylvester**[1], Demetrio Boltovskoy[1], [1]Universidad de Buenos Aires; [2]Prefectura Naval Argentina*

Ballast Tank Biofilms are Protected Reservoirs of Microspecies that Challenge Native Biodiversity 67
***Robert Baier**, Robert Forsberg, Anne Meyer and Joseph Zambon, SUNY at Buffalo*

Mechanisms of Aquatic Species Invasions Across the South Atlantic States, USA 68
***Amy Benson**, Robert Dorazio, Fred Johnson, Michael Turtora and Pamela Fuller, U.S. Geological Survey*

Determinants of Rapid Response Success for Alien Invasive Species in Aquatic Ecosystems 69
***Boris Beric** and Hugh J. MacIsaac, University of Windsor, Great Lakes Institute for Environmental Research*

Ponto-Caspian Predatory Cladocerans *Cercopagis pengoi* (Ostroumov 1891) and *Evadne anonyx* G.O. Sars 1897 in the Gulf of Gdańsk (Baltic Sea) 70
***Luiza Bielecka**, Stella Mudrak-Cegiołka and Marcin Kalarus, University of Gdańsk, Institute of Oceanography, Department of Marine Plankton Research*

Functional Responses as Predictors of Invasive Species Impacts: An Examination of Inter-population Variation in an Invasive Predator's Functional Response 71
***Helene C. Bovy**, Jaimie T.A. Dick and Mark Emmerson, Queen's University Belfast*

A Cellular Automata Model for the Spread of the Golden Mussel (*Limnoperna fortunei*) 72
*Vinícius Carvalho Resende[1], **Mônica de Cássia Souza Campos**[1,2], Fabiano Alcísio e Silva[1], Hellen Regina Mota[3], Marcela David de Carvalho[3], Antônio Valadão Cardoso[1,2], [1]Centro de Bioengenharia de Espécies Invasoras de Hidrelétricas (CBEIH); [2]Fundação Centro Tecnológico de Minas Gerais (CETEC); [3]Companhia Energética de Minas Gerais (CEMIG)*

Effects of the Presence of Saxitoxin and Microcystin in the Grazing Rate of *Limnoperna fortunei* 73
*Vinicius Sergio Rodrigues Diniz[1], Antônio Valadão Cardoso[1,2], **Mônica de Cássia Souza Campos**[1,2], Hellen Regina Mota[3], Marcela David de Carvalho[3], Patrícia Pimentel[2], [1]Centro de Bioengenharia de Espécies Invasoras de Hidrelétricas (CBEIH); [2]Fundação Centro Tecnológico de Minas Gerais (CETEC); [3]Companhia Energética de Minas Gerais (CEMIG)*

The Non-indigenous Aquatic Species Program: Past, Present, and Future 74
***Matt Cannister**, Pamela Fuller, Amy Benson and Matthew Neilson, U.S. Geological Survey*

Watchlist Species: Assessing Risk for Future Invaders of the Great Lakes 75
***Alisha A. Dahlstrom**, Abigail J. Fusaro and Donna R. Kashian, Wayne State University*

Is a Recirculating Aquaculture System an Option for Non-native Species Management in the Polish Coastal Zone of the Baltic Sea? 76
***Barbara Dmochowska** and Anna Szaniawska, University of Gdańsk, Institute of Oceanography*

Developing a Risk Assessment Model for Identifying Potential Invasive Aquatic Weeds in Texas 77
***Elizabeth Edgerton**[1], Michael Masser[2], Lucas Gregory[1], [1]Texas Water Resources Institute; [2]Texas A&M University*

Parasite Effects on the Feeding Behaviour and Functional Response of the Invasive Amphipod *Gammarus pulex*. (Crustacea; Amphipoda) 78
***Marilyn Ennis**, Mhairi Alexander, Jaimie T.A. Dick, Rachel Paterson and Sheena Cotter, Queen's University Belfast*

Program to Control Exotic Species in the Area of Usina Hidrelétrica Serra do Facão 79
***Daniel Simões**, Maria Beatriz Ferreira, Norma Dulce de Campos Barbosa and Maria Edith Rolla, Usina Hidrelétrica Serra do Facão (SEFAC)*

Zebra Mussel (*Dreissena polymorpha*) Habitat Preference and Population Dynamics within and among Lakes in Northeast Wisconsin and Upper Michigan 80
***Maureen Ferry** and Tim Ginnett, University of Wisconsin-Stevens Point; Gregory Sass and K. Gauthier, Wisconsin Department of Natural Resources*

Phylogeography of the Invasive Ctenophore *Mnemiopsis leidyi* in Eurasia 81
Sara Ghabooli[1], Tamara Shiganova[2], Aibin Zhan[1], Elizabeta Briski[3], Melania Cristescu[1], Hugh MacIsaac[1], [1]University of Windsor,Great Lakes Institute for Environmental Research; [2]P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences; [3]Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences

Are there Benthic Non-indigenous Species in the Canadian Arctic? 82
***Jesica Goldsmit** and Philippe Archambault, Université du Québec à Rimouski; Kimberly Howland, Fisheries and Oceans Canada*

Moving Faster than a Snail's Pace: Trends and Consequences of Invasive Freshwater Snails 83
Danielle M. Haak[1], Bruce J. Stephen[2], Noelle M. Chaine[1], Karie Decker[3], Daniel R. Uden[1], Craig R. Allen[4], Valery E. Forbes[5], Kevin L. Pope[4], [1]Nebraska Cooperative Fish and Wildlife Research Unit, School of Natural Resources, University of Nebraska-Lincoln; [2]School of Natural Resources, University of Nebraska-Lincoln; [3]Nebraska Game and Parks Commission; [4]U.S. Geological Survey – Nebraska Cooperative Fish and Wildlife Research Unit, University of Nebraska-Lincoln; [5]School of Biological Sciences, University of Nebraska-Lincoln

Effects of Thermal Effluent on Exotic Benthic Invertebrates in the St. Lawrence River 84
*Anthony Ricciardi, Redpath Museum, McGill University; **Kayla Hamelin**, Groupe de recherche interuniversitaire en limnologie et en environnement aquatique (GRIL), Biology Department and Redpath Museum, McGill University*

Are Non-native species More Likely to Become Pests? 85
*Anthony Ricciardi, Redpath Museum, McGill University and **Ahdia Hassan**, Groupe de recherche interuniversitaire en limnologie et en environnement aquatique (GRIL) and Redpath Museum, McGill University*

Protecting the Great Lakes from Internet Trade of Aquatic Invasive Species 86
***Erika Jensen**, Great Lakes Commission*

The Experimental Evaluation of Habitat Preferences of the Ponto-Caspian Gammarid *Pontogammarus robustoides* 87
***Łukasz Jermacz** and Jarosław Kobak, Nicolaus Copernicus University*

Underwater Evaluation of Habitat Partitioning between Non-native Invader (Racer Goby) and a Threatened Native Fish (European Bullhead) in a European River 88
*Tomasz Kakareko[1], **Jarosław Kobak**[2], Małgorzata Poznańska[2], Łukasz Jermacz[2], Gordon H. Copp[3], [1]Nicolaus Copernicus University, Faculty of Biology and Environmental Protection, Department of Hydrobiology; [2]Nicolaus Copernicus University, Faculty of Biology and Environmental Protection, Department of Invertebrate Zoology; [3]Centre for Environment, Fisheries and Aquaculture Sciences and Centre for Conservation Ecology and Environmental Science, Bournemouth University and Environmental and Life Sciences Graduate Program, Trent University*

The Regional Euro-Asian Biological Invasions Centre (REABIC) Information System 89
*Vadim Panov[1], **Frances Lucy**[2], Vladimir Shestakov[1], [1]REABIC; [2]Institute of Technology Sligo*

Out with the Old, in with the New: Dealing with Aquatic Weed Succession in South Africa 90
*Julie Coetzee, Martin Hill and **Grant Martin**, Rhodes University*

The Successful Biological Control of Parrot's Feather, *Myriophyllum aquaticum* (Vell.) Verdc. (Haloragaceae) in South Africa by the Flea Beetle, *Lysathia* sp. (Chrysomelidae) 91
*Julie Coetzee, Martin Hill and **Grant Martin**, Rhodes University*

Exploring Management Alternatives for an Invasive Species in Atlantic Canada: Chemical Analysis and the Basis for a Fishery of the European Green Crab 92
***Cassandra Mellish**, Paula Tummon Flynn, Mary McNiven, Sophie St. Hilaire and Pedro Quijon, University of Prince Edward Island*

Third Prototype Shipboard Filter Skid (p3SFS): An Automated, Flow-Through Ballast Water Sampling Device 93
***Cameron Moser** and Lisa Drake, U.S. Naval Research Laboratory; Jonathan Grant, Battenkill Technologies, Inc.; Timothy Wier, U.S. Naval Research Laboratory-Excet Incorporated*

Containment of Knifefish (*Chitala ornata*) Infestation in Laguna De Bay, Philippines 94
***Adelaida Palma**, Bureau of Fisheries and Aquatic Resources*

Evaluating Incentive Programs as an Effective Tool to Control Invasive Species 95
***Susan Pasko**, National Oceanic and Atmospheric Administration – ERT; Jason Goldberg, U.S. Fish and Wildlife Service*

Ecological Determinants of Parasite Acquisition by Exotic Fish Species 96
***Rachel Paterson**, Queen's University Belfast; Colin Townsend and Robert Poulin, University of Otago; Daniel Tompkins, Landcare Research*

Developing and Refining a Rapid DNA Test for Invasive Fish Species 97
***Carson Prichard**, Carol Stepien and Von Sigler, University of Toledo*

An Unexpected Role for an Invasive Seaweed: Uprooted Rockweeds Act as Key Subsidies of Food and Habitat for Sandy Beach Invertebrates 98
***Pedro Quijon**, Mitchell MacMillan, Tyler Wheeler and Terrie Hardwick, University of Prince Edward Island*

RAMP: A Tool for Quickly Determining a Species Current and Potential Climate Envelope 99
***Scott Sanders** and Michael H. Hoff, U.S. Fish & Wildlife Service*

Modeling the Population Dynamics of the Species *Limnoperna fortunei* in Reservoirs Influenced by the Presence of Predatory Fish 100
Fabiano Alcísioe Silva[1], Roberto Lopes[1], Newton Gontijo[1], Mônica de Cássia Souza Campos[1,2], Hellen Regina Mota[3], Marcela David de Carvalho[3], Antônio Valadão Cardoso[1,2], [1]Centro de Bioengenharia de Espécies Invasoras de Hidrelétricas (CBEIH); [2]Fundação Centro Tecnológico de Minas Gerais (CETEC); [3]Companhia Energética de Minas Gerais (CEMIG)

Development of the Computational Tool TerraME for Modeling the Process of Invasion by the Species *Limnoperna fortunei* 101
Fabiano Alcísioe Silva[1], Thalisson Correia[1], Newton Gontijo[1], Roberto Lopes[1], Mônica de Cássia Souza Campos[1,2], Hellen Regina Mota[3], Marcela David de Carvalho[3], Antônio Valadão Cardoso[1,2], [1]Centro de Bioengenharia de Espécies Invasoras de Hidrelétricas (CBEIH); [2]Fundação Centro Tecnológico de Minas Gerais(CETEC); [3]Companhia Energética de Minas Gerais (CEMIG)

Autonomy Mediates the Impact of an Invasive Predator: Injury Patterns and Feeding Rates in Prince Edward Island Green Crab (*Carcinus maenas*) Populations 102
Paula Tummon Flynn, Cassandra Mellish, Tyler Pickering and Pedro Quijon, University of Prince Edward Island

Utilizing Different Eradication Methods to Manage Alien Fish Populations in the Cape Floristic Region Biodiversity Hotspot: South Africa 103
Megan van der Bank and Johannes Adriaan van der Walt, CapeNature

Tuesday, April 23, 2013

Plenary Session

Invited Keynote Presentation

Practical Management of Aquatic Invasive Species in Ireland 104
Joseph M. Caffrey, Senior Research Officer, Inland Fisheries Ireland

A-4 – Other Fishes I

Invited Keynote Presentation

Invasive Fishes: What's Next? 105
Nicholas Mandrak, Executive Director, Centre of Expertise for Aquatic Risk Assessment, Fisheries and Oceans Canada

Influence of Phylogenetic Community Structure on Fish Introductions in the Southeast United States 106
Matthew Neilson and Pamela Fuller, U.S. Geological Survey

Biological and Ecological Features, Enough to Predict Invasion – The Round Goby Case 107
Mariusz Sapota, University of Gdańsk

In the Driver's Seat? Disentangling the Influence of Habitat Degradation and Round Goby Invasion on the Structure and Function of Benthic Communities in the St. Lawrence River 108
Anthony Ricciardi, Redpath Museum, McGill University and ***Katherine Pagnucco***, Groupe de recherche interuniversitaire en limnologie et en environnement aquatique (GRIL) and Redpath Museum, McGill University

Rapid Recent Expansion of the Round Goby (*Neogobius melanostomus*) and the Western Tubenose Goby (*Proterorhinus semilunaris*) in Flanders (Belgium) 109
Hugo Verreycken[1], Jan Ostermeyer[2], Merlijn Mombaerts[3], Tine Huyse[3,4], Luc De Bruyn[1,2], [1]Research Institute for Nature and Forest (INBO), Department of Biodiversity and Natural Environment; [2]Universiteit Antwerpen, Department of Biology; [3]Katholieke Universiteit Leuven, Laboratory of Animal Diversity and Systematics; [4]Institute of Tropical Medicine

B-4 – Dreissenid Research I

Invited Keynote Presentation

Spread, Population Dynamics, and Ecosystem Impacts of Zebra Mussels versus Quagga Mussels: What Do We Know and What Do We Not? 110
Alexander Y. Karatayev, Director and Lyubov E. Burlakova, Research Scientist, Great Lakes Center, Buffalo State College; Diana K. Padilla, Stony Brook University, Department of Ecology and Evolution

Behavioural Responses of the Zebra Mussel (*Dreissena polymorpha*) to the Presence of Various Gammarid Species Inhabiting its Colonies 111
Jarosław Kobak[1], Małgorzata Poznańska[1] and Tomasz Kakareko[2], [1]Nicolaus Copernicus University, Faculty of Biology and Environmental Protection, Department of Invertebrate Zoology; [2]Nicolaus Copernicus University, Faculty of Biology and Environmental Protection, Department of Hydrobiology

***Dreissena* Impacts on Unionidae: General Trends in North America and Europe and Recent Findings from the Lower Great Lakes** 112
Lyubov Burlakova, Alexander Karatayev, Brianne Tulumello, Buffalo State College; David Zanatta, Central Michigan University; Frances Lucy, Institute of Technology Sligo; Sergey Mastitsky, RNT Consulting Inc.

Could Zebra Mussels Help Unravel the Mysterious Life Cycle of an Introduced and Virulent Parasite of Oysters? 113
Daniel Molloy[1], Laure Giamberini[2], Nancy Stokes[3], Bénédicte Sohm-Rederstorff[2], [1]SUNY at Albany; [2]University of Lorraine; [3]Virginia Institute of Marine Science

Evolutionary and Biogeographic Relationships of Dreissenid Mussels, with Revision of Component Taxa 114
Carol Stepien, University of Toledo

C-4 – Risk Assessment I

Invited Keynote Presentation

Emerging Integration of Risk Assessments in an Aquatic Invasive Species Program 115
Becky Cudmore, Acting Manager, Canadian Asian Carp Program; Manager, National Centre of Expertise for Aquatic Risk Assessment; Senior Science Advisor, Aquatic Invasive Species, Fisheries and Oceans Canada

Managing an Establishment Pathway Using Import Records and Biological Data 116
Johanna Bradie and Brian Leung, McGill University

Anticipating Bioinvasion Risks in a Coastal Context 117
Daniel Kluza, New Zealand Ministry for Primary Industries

Global Changes and Biological Invasion of Aquatic Alien Species: The Case in Russia 118
Yury Yu. Dgebuadze, A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences ***Note:*** presented by Lyubov Burlakova on behalf of Yury Dgebuadze

A Risk Analysis of Australia's Marine Ornamental Value Chain Focusing on Biosecurity (Diseases and Pathogens) Concerns 119
Kevin Erickson, Marnie Campbell, Chad Hewitt and Nicole Flint, Central Queensland University

D-4 – Outreach and Policy I

Invited Keynote Presentation

Is AIS Spread Inevitable: Fact or Fiction? 120
Douglas A. Jensen, Aquatic Invasive Species Program Coordinator, University of Minnesota Sea Grant Program

Curbing Invasion Pathways: A Sea Grant-U.S. Coast Guard Auxiliary Pilot Partnership to Assess and Enhance Aquatic Invasive Species Awareness among Coastal Anglers and Boaters 121
William Nelson, U.S. Coast Guard Auxiliary; ***Nancy Balcom***, Connecticut Sea Grant/University of Connecticut; Eric C. Dyson, Community College of Rhode Island

Education and Outreach: Changing Angler and Boater Behavior Over Time 122
Matt Smith, Ontario Federation of Anglers and Hunters

Understanding Motivations Behind the Live Release of Organisms 123
Debrupa Pathak, Ontario Ministry of Natural Resources

Lake Simcoe Aquatic Invasive Species Community-Based Social Marketing Project 124
Sophie Monfette, Ontario Federation of Anglers and Hunters; Erika Weisz, Ontario Ministry of Natural Resources; David Dilks and Jeff Garkowski, LURA Consulting

A-5 – Other Fishes II

Does the Racer Goby, a Ponto-Caspian Invader of Continental European Waters, Pose a Threat to the Endangered Native European Bullhead? – An Experimental Approach 125
Gordon Copp[1], Joanna Grabowska[2], Tomasz Kakareko[3], ***Jarosław Kobak***[3], Łukasz Jermacz[3], Malgorzata Poznanska[3], Dagmara Blonska[2] and Miroslaw Przybylski[2], [1]Centre for Environment Fisheries and Aquaculture Science; [2]University of Lodz; [3]Nicolaus Copernicus University

Identifying Drivers of Pumpkinseed Sunfish Invasiveness Using Population Models 126
Eelke Jongejans, Radboud University Nijmegen; ***Hein van Kleef***, Bargerveen Foundation

Community Dynamics of an Invaded Ecosystem: Investigation of a *Pterygoplichthys disjunctivus* Invasion in the Nseleni River System, KwaZulu Natal, South Africa 127
Ray Jones[1], ***Jaclyn M. Hill***[2], Olaf Weyl[3], Martin P. Hill[4]; [1]Ezemvelo KZN Wildlife; [2] Rhodes University, Department of Zoology & Entomology; [3]Centre for Invasion Biology, South African Institute for Aquatic Biodiversity; [4]Rhodes University, Department of Zoology & Entomology

Reconciling Large-scale Model Predictions with Small-scale – Impacts and Interactions of the Invasive Smallmouth Bass (*Micropterus dolomieu*) with Native Species in British Columbian Lakes 128
Martina Beck and John Volpe, University of Victoria; Leif-Matthias Herborg, BC Ministry of Environment

Evolutionary and Biogeographic Patterns of an Emerging Quasispecies: The Fish Viral Hemorrhagic Septicemia Virus (VHSv) 129
Carol Stepien, Lindsey Pierce and Jacob Blandford, University of Toledo

B-5 – Dreissenid Research II

Predicting the Zebra Mussel Spread: What Can We Learn From 200 Years of Continuous Invasion? 130
Alexander Karatayev and Lyubov Burlakova, Buffalo State College; Sergey Mastitsky, RNT Consulting Inc.; Dianna Padilla, Stony Brook University

Invasion of Western Europe by *Dreissena rostriformis bugensis* 131
Jonathan Marescaux and Karine Van Doninck, University of Namur

Rapid Range Expansion of the Invasive Quagga Mussel in Relation to Zebra Mussel Presence in Western Europe 132
Rob Leuven, Jon Matthews, Frank P.L. Collas, Remon (K.R.) Koopman and Gerard Van der Velde, Radboud University Nijmegen; Abraham bij de Vaate, Waterfauna Hydrobiologisch Adviesbureau

Exotic Species Replacement in Relation to Small-scale Environmental Heterogeneity 133
Lisa Jones and Anthony Ricciardi, Redpath Museum, McGill University

Comparative Variation in Growth of Two Invasive Mussels in the St. Lawrence River: Do Differences in Filtering Apparatus Matter? 134
Jordan Ouellette-Plante, Groupe de recherche interuniversitaire en limnologie et en environnement aquatique (GRIL) and Redpath Museum, McGill University; Anthony Ricciardi, Redpath Museum, McGill University; Ladd E. Johnson, Université Laval

C-5 – Risk Assessment II

The Utility of Hub and Spoke Network Models to Analyse Pre-border and Post-border Dispersal of Introduced Marine Species 135
Marnie L. Campbell and Chad L. Hewitt, Central Queensland University, School of Medical and Applied Sciences; Fauziah Azmi, University of Tasmania, National Centre for Marine Conservation and Resource Sustainability

Incorporating Biotic Interactions in Species Distributions: Community Distribution Modeling of the Invasive Species *Bythotrephes longimanus* ... 136
Kristina Enciso and Brian Leung, McGill University

Improving Model Transferability and Generality for Predictive Modeling on Invasive Species: A Case Study on *Bythotrephes longimanus* 137
Lifei Wang *and Donald A. Jackson, University of Toronto*

Implications of Uncertainty: Bayesian Modelling of Aquatic Invasive Species Spread 138
Corey Chivers *and Brian Leung, McGill University*

Response to Biofouled Marine Debris Generated by the 2011 Japan Tsunami 139
Margaret M. (Peg) Brady *and Susan Pasko, U.S. National Oceanic & Atmospheric Administration*

D-5 – Outreach and Policy II

Go Giddy Over Guidelines for Recreational Activities 140
Douglas A. Jensen*, University of Minnesota Sea Grant Program; Laura Norcutt, U.S. Fish & Wildlife Service*

An Ounce of Prevention: AIS Education, Evaluation, and Communication in Illinois and Indiana 141
Sarah Zack*, Patrice Charlebois and Lainey Pasternak, Illinois-Indiana Sea Grant & Illinois Natural History Survey; Erin Seekamp, North Carolina State University*

Working With Fishing Tournaments to Prevent the Spread of Aquatic Invasive Species 142
Philip B. Moy*, Wisconsin Sea Grant*

Mitigating the Threats Posed by Freshwater Invasive Species in Ireland 143
Joseph M. Caffrey*, Inland Fisheries Ireland*

Nab the Aquatic Invader! – Young Stewards Prevent the Spread of AIS 144
Marte Thabes Kitson[1]*, Robin Goettel*[2]*, Douglas A. Jensen*[1]*, [1]University of Minnesota Sea Grant Program; [2]Illinois-Indiana Sea Grant*

A-6 – Other Fishes III

Dispersion, Impact and Abundance Mitigation Study of Round Goby (*Neogobius melanostomus*) and Chinese Sleeper (*Perccottus glenii*) in Lithuania 145
Saulius Stakėnas*, Tomas Virbickas, Vytautas Rakauskas and Andrius Steponėnas, Nature Research Centre, Institute of Ecology, Department of Freshwater Biology*

Detecting the Invasive Snakehead: DNA Barcoding as a First Step in Developing Species Specific Primers and Probes for Environmental DNA Detection 146
Natasha Serrao[1,2]*, Dirk Steinke*[2]*, Robert Hanner*[2]*, [1]Trent University, Department of Environmental and Life Sciences; [2]University of Guelph, Biodiversity Institute of Ontario*

Morphological Responses to Competition in Native and Non-Native Fish 147
Stan Yavno *and A. Rooke, Trent University, Environmental and Life Sciences Graduate Program; M.G. Fox, Trent University, Environmental and Resource Studies Program and Department of Biology*

Thermal and Biotic Influences on Life-History Traits of Pumpkinseed Introduced in Europe 148
Michael G. Fox[1]*, E. Valente*[2]*, G. Masson*[2]*, Gordon H. Copp*[3]*, [1]Trent University, Department of Biology and Environmental and Resource Studies Program; [2]Université de Lorraine, Laboratoire Interactions Ecotoxicologie Biodiversité Écosystèmes ; [3]Cefas, Salmon & Freshwater Team and Environmental and Trent University, Life Sciences Graduate Program*

B-6 – Dreissenid Research III

Modelling the Occurrence of Zebra Mussel Parasites According to Contamination in France and the USA 149
Laure Giamberini *and Laëtitia Minguez, University of Lorraine; Simon Devin, Pascal Poupin and Francois Guerold, University of Metz; Daniel Molloy, SUNY at Albany*

A Non-Destructive Method for Monitoring Dreissenid Settlement and Evaluating Treatment Efficacy 150
Carolyn Link*, Marrone Bio Innovations*

Potential Use of the Calcite Saturation Index as an Indicator of Environmental Suitability for Dreissenid Mussel Survival 151
Katherine Prescott *and Renata Claudi, RNT Consulting Inc.; Jeffrey Janik and Tanya Veldhuizen, California Department of Water Resources*

Objective Method for Determining Mortality in Larval and Juvenile Lifestages of Dreissenid Mussels 152
Carolyn Link*, Marrone Bio Innovations; Renata Claudi and Carolina Taraborelli, RNT Consulting Inc.*

Dreissenid Veliger Detection and Enumeration Technology Enhanced to Improve Reliability and Sample Processing Using a Continuous Imaging Particle Analyzer (FlowCAM®) 153
Victoria Kurtz[1]*, **Denise Hosler***[2]*, Harry Nelson*[1]*, Kevin Bloom*[2]*, Ben Spaulding*[1]*, [1]Fluid Imaging Technologies; [2]Bureau of Reclamation*

C-6 – Risk Assessment III

Evaluating the Risk of Non-native Aquatic Species Range Expansions in a Changing Climate in Pennsylvania 154
Sara Grisé*, Pennsylvania Sea Grant; Theo Light, Shippensburg University*

An Empirical Analysis of the Causes, Consequences and Predictors of Aquatic Invasive Species in Inland, Freshwater Lakes in Southern Ontario 155
Tim Haxton*, Sarah Nienhuis and Tal Dunkley, Ontario Ministry of Natural Resources*

Invasive Species, Climate Change, and Emerging Infectious Disease Threats 156
David Bruce Conn*, Berry College*

Predicting the Spatial Heterogeneity of Invasional Vulnerability in Lake St. Clair Using Observed Zooplankton Spectra 157
Yajun Sun *and Mathew Wells, University of Toronto*

Modelling the Likelihood of Introduction and Establishment of Marine Non-native Species in the UK and Ireland 158
Fiona Pearce, Edmund Peeler and ***Paul Stebbing****, Centre for Environment, Fisheries and Aquaculture Science*

D-6 – Outreach and Policy III

A National Status Report on Aquatic Invasive Species in Canada 159
Åsa Kestrup *and David Browne, Canadian Wildlife Federation*

Assessing Needs and Developing Regulatory and Outreach Strategies for Preventing the Spread of Aquatic Invasive Species through Boating 160
Samuel Chan*, Oregon State University*

Aquatic Invasive Species Outreach Targeted at the Organisms in Trade Audiences 161
Greg Hitzroth*, Illinois-Indiana Sea Grant; Patrice Charlebois, Illinois-Indiana Sea Grant & Illinois Natural History Survey; Erin Seekamp, North Carolina State University*

GLANSIS Enhancements 162
Rochelle Sturtevant*, Abigail Fusaro and Edward Rutherford, NOAA, Great Lakes Environmental Research Laboratory*

Outreach on Great Lakes OIT Risk Assessments 163
Greg Hitzroth, Illinois-Indiana Sea Grant; Danielle Hilibrich, University of Illinois; ***Patrice Charlebois****, Illinois-Indiana Sea Grant & Illinois Natural History Survey; Mark Farley, Oregon Sea Grant; Bob Kirschner, Chicago Botanic Garden; Reuben Keller, University of Notre Dame*

Self-management: The Bane or Saviour of Non-Indigenous Marine Species Management? 164
Marnie L. Campbell *and Chad L. Hewitt, Central Queensland University, School of Medical and Applied Sciences; Dominic E.P. Bryant, University of Tasmania, National Centre for Marine Conservation and Resource Sustainability*

Wednesday, April 24, 2013

Plenary Session

Invited Keynote Presentation

Aquatic Invasive Species in Inland Lakes: Distribution, Abundance, Impact 165
M. Jake Vander Zanden*, Post-Doctoral Teaching Fellow, Biology Department, Villanova University and Susan Park, Assistant Director for Research, Virginia Sea Grant*

A-7 – Live Bait Pathway I

Invited Keynote Presentation

Preventing Aquatic Invasive Species through Management of the Live Bait Pathway: An Introduction 166
Amy Fowler*, Post-Doctoral Teaching Fellow, Biology Department, Villanova University and Susan Park, Assistant Director for Research, Virginia Sea Grant*

Estimating Bycatch Risk: The Role of Selective Fishing in Species Invasions 167
Andrew Drake *and Nicholas Mandrak, Fisheries and Oceans Canada*

Bycatch, Bait, Anglers, and Roads: Quantifying Vector Activity and Species Introduction Risk across Lake Ecosystems 168
Andrew Drake *and Nicholas Mandrak, Fisheries and Oceans Canada*

One of These Things is not Like the Others – Prevalence of Non-target Species in Commercial Baitfish in Ontario 169
Jeff Brinsmead[1]*, Brenda Koenig*[1]*, Andrew Drake*[2]*, Nicholas Mandrak*[2]*, David Copplestone*[1]*, Darryl Mitchell*[1]*, [1]Ontario Ministry of Natural Resources; [2]Fisheries and Oceans Canada*

Bait Fish in Quebec: New Regulatory Guidelines 170
Catherine Brisson-Bonenfant, Ministère des Ressources naturelles et de la Faune and ***Isabelle Desjardins****, Ministère du Développement Durable, de l'Environnement, de la Faune et des Parc du Québec*

B-7 – Dreissenid Control I

Invited Keynote Presentation

A Perspective on the Use of Biological Control Methods for *Dreissena* Management: The Past, the Present, the Future 171
Daniel P. Molloy*, Research Scientist and Adjunct Professor, SUNY at Albany*

Quagga Mussels and Lake Mead: Recent Trends and Mitigation 172
Todd Tietjen*, Eric Wert, Julia Lew and Peggy Roefer, Southern Nevada Water Authority*

UV Irradiation as a Means of Minimizing Downstream Settlement of Quagga Mussel Veligers 173
Renata Claudi *and Thomas Prescott, RNT Consulting Inc.; Ytzhak Rosenberg, Benzi Shoval and Yariv Abramovich, Atlantium Technologies Inc.*

Water Level Manipulation During Harsh Environmental Conditions as a Tool for Mitigating Effects of Invasive Dreissenid Mussels in Impounded River Sections 174
Rob Leuven*, Remon (K.R.) Koopman, Frank P.L. Collas, Gerard Van der Velde and Jon Matthews, Radboud University Nijmegen*

Watercraft Interception Programs for Dreissenid Mussels in the Western United States 175
Stephen Phillips*, Pacific States Marine Fisheries Commission*

C-7 – Aquatic Plants I

Invited Keynote Presentation

Critical Keys to Success Learned from Florida's Aquatic and Wetland Invasive Plant Management Program in Public Natural Areas and Why Invasive Plant Research and Outreach are Essential for Advancement 176
***Don Schmitz**, Research and Outreach Program Manager, Invasive Plant Management Section, Florida Fish and Wildlife Conservation Commission*

Registration of Minor Use Pesticides for Control of Aquatic Nuisance Species 177
*Lyn Gettys and **William Haller**, University of Florida, Institute of Food and Agricultural Sciences (IFAS), Center for Aquatic and Invasive Plants (CAIP)*

Application of the Aquatic Weed Risk Assessment Model to Manage Aquatic Weeds 178
***Paul Champion** and John Clayton, National Institute for Water and Atmospheric Research (NIWA)*

Pet Stores, Aquarists and the Internet Trade as Modes of Introduction and Spread of Invasive Macrophytes in South Africa 179
*Julie Coetzee and **Grant Martin**, Rhodes University*

Do Codes-of-Conduct Increase Public Awareness and Engagement in Problems with Aquatic Invasive Plants? 180
***Laura Verbrugge**, Rob Leuven and Riyan van den Born, Radboud University Nijmegen*

D-7 – Other Bivalves I

Invited Keynote Presentation

How Other Freshwater Exotic Bivalves Differ from Invasive Ones, or Why they are Not Invasive 181
***Gerald L. Mackie**, Professor Emeritus, University of Guelph and Owner, Water Systems Analysts*

Forecasting the Invasion of *Limnoperna fortunei* in Brazil: Experimental Knowledge Versus Environmental Niche Modeling 182
*André Alves Andrade[1], **Mônica de Cássia Souza Campos**[1,2], Fabiano Alcísioe Silva[1], Hellen Regina Mota[3], Marcela David de Carvalho[3], Antônio Valadão Cardoso[1,2], [1]Centro de Bioengenharia de Espécies Invasoras de Hidrelétricas (CBEIH); [2]Fundação Centro Tecnológico de Minas Gerais (CETEC); [3]Companhia Energética de Minas Gerais (CEMIG)*

Forecasting the Invasion of *Limnoperna fortunei* at a Global Scale 183
*Bárbara Gomes Kunzmann[1], Danielle Diniz Galvão[1], **Mônica de Cássia Souza Campos** [1,2], Fabiano Silva[1], André Felipe Alves de Andrade[1], Hellen Regina Mota[3], Marcela David de Carvalho[1], Antonio Cardoso[1], [1]Centro de Bioengenharia de Espécies Invasoras de Hidrelétricas (CBEIH); [2]Fundação Centro Tecnológico de Minas Gerais (CETEC); [3]Companhia Energética de Minas Gerais (CEMIG)*

Comparing Spatial Distribution Models to Predict the Potential Invasion Area of the *Limnoperna fortunei* (Dunker 1857) 184
*Danielle Diniz Galvão[1], Bárbara Gomes Kunzmann[1], **Mônica de Cássia Souza Campos**[1,2], Fabiano Alcisio e Silva[1], André Felipe Alves de Andrade[1], Hellen Regina Mota[3], Marcela David de Carvalho[3], Antônio Valadão Cardoso[1,2], [1]Centro de Bioengenharia de Espécies Invasoras de Hidrelétricas (CBEIH); [2]Fundação Centro Tecnológico de Minas Gerais(CETEC); [3]Companhia Energética de Minas Gerais (CEMIG)*

Characterization of the Foot of Invasive Species *Limnoperma fortunei* (Dunker, 1857) by Electron Microscopy 185
*Mônica de Cássia Souza Campos[1,2], **Arnaldo Filho Nakamura**, João Locke Ferreira de Araújo[1], Hellen Regina Mota[3], Marcela David de Carvalho[3], Antônio Valadão Cardoso[1,2], [1]Centro de Bioengenharia de Espécies Invasoras de Hidrelétricas (CBEIH); [2]Fundação Centro Tecnológico de Minas Gerais (CETEC); [3]Companhia Energética de Minas Gerais (CEMIG)*

A-8 – Live Bait Pathway II

The HACCP Approach to Prevent the Spread of Aquatic Invasive Species by Aquaculture and Baitfish Operations 186
***Ronald Kinnunen**, Michigan State University; Jeffrey Gunderson, University of Minnesota*

Arkansas Certified Commercial Bait and Ornamental Fish Program: A Method to Prevent Aquatic Invasive Species Introductions 187
***Anita Kelly** and Nathan Stone, University of Arkansas at Pine Bluff*

Live Bait as a Potential Vector for Crayfish Introductions in Pennsylvania: Problem and Potential Solutions 188
***David A. Lieb**, Pennsylvania Fish & Boat Commission and Western Pennsylvania Conservancy; John R. Wallace, Millersville University, Department of Biology*

Live Bait in Maryland: What We Know, Don't Know, but Need to Know to Effectively Manage this Invasive Species Vector 189
***Jay Kilian** and Ronald Klauda, Maryland Department of Natural Resources, Resource Assessment Service*

Bait Shop "Toolkit" and Outreach: Engaging Bait Shops as Opinion Leaders in the Prevention of Aquatic Invasive Species 190
*Bret Shaw and **Allison Howell**, University of Wisconsin*

B-8 – Dreissenid Control II

Integrated Approach to Managing Mussels – Resources and Benefits 191
***Stanley B. Pickles**, Bruce Power*

Evaluating Aquatic Herbicides for Potential Control of Quagga and Zebra Mussels 192
***Carolina Taraborelli** and Renata Claudi, RNT Consulting Inc.; Scott O'Meara, Bureau of Reclamation; Jeffrey Janik and Tanya Veldhuizen, California Department of Water Resources*

Release Coatings Combat Fouling in Power Generation and Water Treatment Facilities – Four Case Histories 193
***Steve Escaravage**, FUJIFILM Hunt Smart Surfaces, LLC*

Control of Dreissenid Mussels through pH Adjustment 194
***Renata Claudi** and Thomas Prescott, RNT Consulting Inc.*

Protecting Irrigation Systems from Dreissenid Mussel Infestation – Case Study 195
***Andrew Jamieson**, Agriculture and Agri-Food Canada*

C-8 – Aquatic Plants II

Invasion Pathways for Invasive Aquatic Species: Case Studies from Florida (USA) 196
***Lyn Gettys**, William Haller and Kathryn Wilson, University of Florida, Institute of Food and Agricultural Sciences (IFAS), Center for Aquatic and Invasive Plants (CAIP)*

Patterns of Impact of Three Invasive Plant Species on Freshwater Ecosystems 197
***Iris Stiers** and Ludwig Triest, Vrije Universiteit Brussel*

Decrease of Macrophyte Species Diversity of Pond Ecosystems by an Invasive Wetland Plant: *Alternanthera philoxeroides* 198
***Anindita Chatterjee** and Anjana Dewanji, Indian Statistical Institute*

Monitoring the Spread of *Alternanthera philoxeroides* in the Indian Context 199
***Anjana Dewanji**, Anindita Chatterjee and Achyut K Banerjee, Indian Statistical Institute*

D-8 – Other Bivalves II

The Invasive Bivalve Genus *Corbicula* as a Key Model to Androgenesis 200
***Karine Van Doninck**, Emilie Etoundi and Lise-Marie Pigneur, University of Namur*

The Key to Being a Successful Invader? Be Asexual?! The Case of *Corbicula* Clams 201
*Jonathan Marescaux[1], **Emilie Etoundi**[1], David Aldridge[2], Lise-Marie Pigneur[1], Nina Yasuda[3], Karine Van Doninck[1], [1]University of Namu; [2]Cambridge University; [3]University of Miyazaki*

An Examination of the Potential Vectors and Pathways of Spread for *Corbicula fluminea* in Ireland 202
***Rory Sheehan** and Frances Lucy, Institute of Technology Sligo; Joseph M. Caffrey, Inland Fisheries Ireland*

Factors Affecting the Distribution, Abundance and Condition of an Aquatic Invader (*Corbicula fluminea*) along a Thermal Gradient 203
*Anthony Ricciardi, Redpath Museum, McGill University; **Rowshyra Castaneda**, Groupe de recherche interuniversitaire en limnologie et en environnement aquatique (GRIL), Biology Department and Redpath Museum, McGill University; Anouk Simard, Ministère des Ressources naturelles et de la Faune*

Progression of Asian Clam (*Corbicula fluminea*) in the St. Lawrence River: Is the Species Restricted to the Thermal Plume of Gentilly Nuclear Station 204
***Anouk Simard**[1], Rémi Bacon[2], Rowshyra Castanada[3], Kayla Hamelin[3], Annie Paquet[1], Sophie Plante[1] and Anthony Ricciardi[3], [1]Ministère du Développement durable de l'Environnement de la Faune et des Parcs (MDDEFP); [2]Ministère des Ressources naturelles, Trois-Rivières; [3]Université McGill, Montréal*

A-9 – Live Bait Pathway III

Bait Worm Packaging as a Conduit for Organism Introductions: Research and Outreach Lead to Policy Considerations 205
***Nancy Balcom**[1,2], Charles Yarish[2], Christina Haska[3], George Kraemer[4], Senjie Lin[2], Robert Whitlatch[2], Noreen Blaschik[2], Huan Zhang[2], [1]Connecticut Sea Grant; [2]University of Connecticut; [3]Great Lakes Fishery Commission; [4]Purchase College*

Preventing AIS Introductions through Vector Management: The Value of Connections 206
***Fredrika Moser**[1], Susan Park[2], John Ewart[3], Sara Mirabilio[4], Peter Rowe[5], Sarah Whitney[6], Jenny Allen[1], [1]Maryland Sea Grant; [2]Virginia Sea Grant; [3]Delaware Sea Grant; [4]North Carolina Sea Grant; [5]New Jersey Sea Grant; [6]Pennsylvania Sea Grant*

Harvest to Hook: An Anthropological Look at the Worm Weed Vector for Aquatic Invasive Species 207
***Jeremy Trombley**, University of Maryland College Park*

Importation of Baitworms and their Live Algal Packing Materials to the Mid-Atlantic: Vector Characterization and Management 208
***Amy Fowler**[1], A. Whitman Miller[2], Fredrika Moser[3], April Blakeslee[4], Joao Canning-Clode[5], Gregory Ruiz[2], [1]Villanova University; [2]Smithsonian Environmental Research Center; [3]Maryland Sea Grant; [4]Long Island University; [5]University of Lisbon*

Importation of Baitworms and their Live Algal Packing Materials to the Mid-Atlantic: Experimental Treatment of Algae to Reduce Live Hitchhikers 209
***April Blakeslee**[1,2], Amy Fowler[1,3], A. Whitman Miller[1], Fredrika Moser[4], Joao Canning-Clode[1,5], Gregory Ruiz[1], [1]Smithsonian Environmental Research Cente ; [2]Long Island University; [3]Villanova University; [4]Maryland Sea Grant College; [5]University of Lisbon*

B-9 – Dreissenid Control III

Evaluation of New Coating Technologies for Mitigation of Zebra/Quagga Mussel Colonization – An Update 210
*Allen Skaja, **David Tordonato** and Bobbi Jo Merten, Bureau of Reclamation*

Zebra Mussel Control Using Zequanox® in an Irish Waterway 211
***Sara Meehan** and Frances Lucy, Institute of Technology Sligo; Bridget Gruber, Marrone Bio Innovations*

Zequanox® Demonstration Trials at DeCew II Generating Station at Ontario Power Generation to Control Dreissenid Mussels 212
***Tony Van Oostrom**, Ontario Power Generation; Bridget Gruber, Carolyn Link and Sarahann Rackl, Marrone Bio Innovations; Kelly Murray, ASI Group*

Strategies for Controlling Invasive Zebra and Quagga Mussels in Open Water Bodies 213
***Dave Roberts** and Megan Weber, Marrone Bio Innovations*

Effectiveness of an Algaecide for Killing Invasive Quagga Mussels and Preventing their Colonization 214
***David W.H. Wong**, Ashlie Watters and Shawn Gerstenberger, University of Nevada Las Vegas*

Taking No Prisoners: Beating Back Invasive Species 215
***Leonard Willett**, Bureau of Reclamation*

C-9 – Aquatic Plants III

Establishing Research and Management Priorities for Monoecious Hydrilla as it Invades Northern Tier States 216
***Michael Netherland**, U.S. Army Corps of Engineers, Engineer Research and Development Center; Mike Greer, U.S. Army Corps of Engineers Buffalo District*

The Distribution and History of *Myriophyllum spicatum* L. (Haloragaceae) in Southern Africa, with Reference to Potential Origins, Modes of Introduction and Spread 217
***Philip Weyl** and Julie Coetzee, Rhodes University*

Range and Survival of Two Alien Macrophytes (*Eichhornia Crassipes* and *Pistia Stratiotes*) in the Great Lakes 218
***Amanda Eyraud** and Hugh MacIsaac, University of Windsor, Great Lakes Institute for Environmental Research*

Linking Native and Exotic Aquatic Plant Palatability to Herbivores with Shared or Unshared Home Ranges: A Trait-Based Approach 219
***Bart M.C. Grutters** and Elisabeth S. Bakker, Netherlands Institute of Ecology, Department of Aquatic Ecology*

Effects of Supplemental Stocking of Milfoil Weevils (*Euhrychiopsis lecontei* Dietz) on Eurasian Watermilfoil (*Myriophyllum spicatum* L.) Density in a Heavily Infested Lake 220
***Paul M. Skawinski**, and Ronald Crunkilton, University of Wisconsin-Stevens Point, College of Natural Resources*

D-9 – Early Detection and Monitoring IV

Invasive Species Surveillance of the Great Lakes Basin Commercial Bait Trade Using Environmental DNA Surveillance 221
***Lucas Nathan**[1], Michelle Budny[2], Christopher Jerde[2], Andrew Mahon[1], [1]Central Michigan University; [2]University of Notre Dame*

DNA Shedding Rates of Asian Carps, for Use in Understanding Field Collections of eDNA 222
***Katy Klymus**, University of Missouri; Duane Chapman, U.S. Geological Survey, Columbia Environmental Research Center; Cathy Richter, U.S. Geological Survey; Craig Paukert, U.S. Geological Survey–University of Missouri*

A Real-Time PCR Assay with Internal Controls to Detect and Quantify the Fish Viral Hemorrhagic Septicemia Virus (VHSv): Conversion from StaRT-PCR 223
***Vrushalee Palsule**, Lindsey Pierce, Carol Stepien, James Willey, Jiyoun Yeo and Erin Crawford, University of Toledo*

First Discovery of Golden Star Tunicate in Conception Bay, Newfoundland and a Case Study Mitigation Attempt to Control its Spread 224
***Terri Wells**[1], Don Deibel[2], Cynthia McKenzie[1], Bob O'Donnell[2], Mark O'Flaherty[2], Andrew Perry[2], Brooks Pilgrim[1], Henry Coley[1], Ann Marie Tucker[1], Trevor Lewis[3], Ben Lowen[2], [1]Fisheries and Oceans Canada; [2]Memorial University of Newfoundland; [3]Foxtrap Marina Harbour Authority*

Early Warning Program to Manage the Introduction and Spread of Invasive Species in the Wadden Sea, a World Heritage Protected Ecosystem 225
***Andrea C. Sneekes**, N.H.B.M. Kaag, H. Van Pelt, B. van der Weidde, A. Gittenberger, K. Philippart, J. Boon, S. Rajagopal and J.M. Jansen, IMARES, Wageningen UR, Institute for Marine Resources and Ecosystem Studies*

Thursday, April 25, 2013

Plenary Session

Invited Keynote Presentation

Pathways for Introduction of Alien Invasive Species Exclusive of International Shipping: A Canadian Experience 226
***Hugh MacIsaac**, Professor, University of Windsor, Great Lakes Institute for Environmental Research and Director, NSERC Canadian Aquatic Invasive Species Network II*

A-10 – AIS Control I

Pilot Project to Eradicate Invasive Alien Smallmouth Bass Using a Piscicide from a Conservation Priority River in South Africa: Rationale, River Treatment and Way Forward 227
***Johannes Adriaan van der Walt** and Ben van Staden, CapeNature*

Biological Control of Golden Apple Snail by Black Carp in a Freshwater Wetland 228
***Kelvin K.L. Ip** and Qiu Jian Wen, Hong Kong Baptist University*

Management of Alien Invasive Algae in Kaneohe Bay, Oahu through the Use of Mechanical Removal and Bio-control Efforts 229
***Jonathan Blodgett** and Frank Mancini, Hawaii Department of Land and Natural Resources, Division of Aquatic Resources*

Reproductive Sterility as a Tool for Prevention and Control of Aquatic Invasive Species 230
***John Teem**, Florida Department of Agriculture and Consumer Services*

Developing a Theoretical and Experimental Framework for the Trojan Y Chromosome Eradication Strategy 231
***John Teem**, Florida Department of Agriculture and Consumer Services; Juan Gutierrez, University of Georgia*

Integrated Pest Management of the Common Carp in the American Midwest 232
***Peter Sorensen** and Przemek Bajer, University of Minnesota*

Invasive Species Fouling and Industrial Cooling Water Systems 233
***Sanjeevi Rajagopal**[1,2], Jeroen M. Jansen[2], Gerard van der Velde[1], [1]Radboud University Nijmegen, Institute for Wetland and Water Research, Department of Animal Ecology and Ecophysiology; [2]Wageningen University, Institute for Marine Resources and Ecosystem Studies (IMARES)*

B-10 – Other Pathways I

Non-Indigenous Species Transported on Tsunami Marine Debris: Learning and Informing Response to a Natural Disaster Driven Invasive Species Pathway of Emerging Concern 234
***Samuel Chan**, Oregon State University*

Are Anglers and Kayakers Acting as Vectors for Alien Invasive Species in UK Freshwaters? 235
***Lucy Anderson**[1], Piran White[3], Paul Stebbing[2], Grant Stentiford[2], Alison Dunn[1], [1]University of Leeds; [2]Centre for Environment, Fisheries & Aquaculture Science; [3]University of York*

Evaluating the Risk of Direct Movement of Fishes through the Welland Canal 236
***Nicholas Mandrak** and Jaewoo Kim, Fisheries and Oceans Canada*

Fish Behavior and Abundance at the Electric Dispersal Barrier in the Chicago Sanitary and Ship Canal, Illinois, USA 237
***Aaron Parker**, P. Bradley Rogers, Jeffrey Stewart, Samuel Finney and Robert Simmonds Jr., U.S. Fish & Wildlife Service*

Restoring the Natural Divide: Separating the Great Lakes and Mississippi River Basins in the Chicago Area Waterway System 238
***Erika Jensen** and Tim Eder, Great Lakes Commission; Dave Ullrich, Great Lakes and St. Lawrence Cities Initiative*

Addressing the Champlain Canal as a Vector of AIS 239
***Margaret Modley**, Lake Champlain Basin Program*

Examination of Asian Swamp Eels (Synbranchidae: *Monopterus* spp.) from Ethnic Food Markets in Florida, Georgia, New York and Four Wild Populations in New Jersey and Florida, for the Presence of Zoonotic Advanced L3 of *Gnathostoma* spp. (Nematoda) 240
*Anindo Choudhury[1], **Rebecca Cole**[2], Leo Nico[3], Kathryn Griffin[2], [1]St. Norbert College; [2]U.S. Geological Survey, National Wildlife Health Center; [3]U.S. Geological Survey, Southeast Ecological Science Center*

C-10 – Crustaceans IV

Interaction of a Chemical Stress and a Predation Risk on the Behaviour of Two Prolific Species: The 'Killer Shrimp' *Dikerogammarus villosus* and the Naturalised Amphipod *Gammarus roeseli* 241
***Jean-Nicolas Beisel**, Eric Gismondi, Pascal Sornom and Céline Véllinger, Laboratoire Interdisciplinaire des Environnements Continentaux (LIEC), Université de Lorraine*

Loss of Pathogens in an Island Population of the Killer Shrimp *Dikerogammarus villosus* 242
***Grant D. Stentiford**[1,2], Kelly S. Bateman[1,2], Jamie Bojko[2,3], Paul Stebbing[2], James Meatyard[4], Karolina Bacela-Spychalska[5], Alison M. Dunn[3], [1]European Union Reference Laboratory for Crustacean Diseases; [2]Centre for Environment, Fisheries and Aquaculture Science (CEFAS); [3]University of Leeds; [4]Anglian Water Central Laboratory, Biology Department; [5]University of Lodz, Department of Invertebrate Zoology & Hydrobiology*

Impact of Invasive Crayfish on Macrophytes: Are Some Species Worse than Others? 243
***Elisabeth S. Bakker** and Martijn Dorenbosch, Netherlands Institute of Ecology, Department of Aquatic Ecology*

D-10 – Shipping Pathways IV

Third Prototype Shipboard Filter Skid (p3SFS): Results of Shipboard Installation and Testing 244
***Timothy Wier**[1], Cameron Moser[2], Jonathan Grant[3], Matthew First[3], Stephanie Robbins-Wamsley[4], Scott Riley[4], Lisa Drake[2], [1]U.S. Naval Research Laboratory-Excet Incorporated; [2]U.S. Naval Research Laboratory; [3]Battenkill Technologies, Inc.; [4]SAIC, Inc.*

Life after Treatment: Detecting Viable, Aquatic Microorganisms Following Exposure to UV Light and Chlorine Dioxide 245
***Matthew First**[1], Lisa Drake[2], Scott Riley[1], Stephanie Robbins-Wamsley[1], [1]SAIC, Inc.; [2]U.S. Naval Research Laboratory*

What is the Uncertainty Associated with the Measurement of Living Organisms' Concentrations at Ballast Water Test Facilities? 246
***Lisa Drake**, U.S. Naval Research Laboratory; Scott Riley, Stephanie Robbins-Wamsley, Matthew First, SAIC, Inc.; Evan Parson, Vision Point Systems*

The 'Sample Port Calculator': A Design and Analysis Tool for Ballast Water Sampling Ports 247
***Jonathan Grant**, Battenkill Technologies, Inc.; Cameron Moser and Lisa Drake, U.S. Naval Research Laboratory; Timothy Wier, U.S. Naval Research Laboratory-Excet Incorporated*

Partner and Exhibitor Profiles 248

Presenter Biosketches 258

Author Index 296

Monday, April 22, Morning

Plenary Session: Great Room B/C

Session Chair: Robert G. Lambe, Conference Chair and Executive Director, Invasive Species Centre

8:30 AM
Welcoming Remarks
Chris Goddard, Executive Secretary, Great Lakes Fishery Commission and Vice-Chair, Invasive Species Centre

8:45 AM
Invited Keynote Presentation
Why Invasions Matter: A Response to Recent Criticisms of Invasion Biology
Anthony Ricciardi, Associate Professor, Redpath Museum & McGill School of Environment, McGill University

9:30 AM
Networking Break

Session A-1: Strategy Room 1

Early Detection and Monitoring I

Session Chair: Michael H. Hoff
U.S. Fish & Wildlife Service

10:00 AM
Invited Keynote Presentation
Surveys, Surveillance and Monitoring – Strategies for Early Detection and Long-term Management of Aquatic Invasive Species
Chad L. Hewitt, Pro Vice-Chancellor (Research) and Marnie L. Campbell, Chair in Ecological Security, Central Queensland University, School of Medical and Applied Sciences

10:40 AM
Strategy for Designing a Regional Network for AIS Monitoring, Detection, and Response
Bill Bolen, U.S. Environmental Protection Agency

11:00 AM
A Multi-Jurisdictional Approach to Asian Carp in the Upper Illinois River and Chicago Area Waterway System
Kevin Irons, Illinois Department of Natural Resources

11:20 AM
AIS Integration into Existing Monitoring Programs: Lessons Learned in Michigan
Sarah LeSage and Sue Tangora, Michigan Department of Environmental Quality

11:40 AM
Early Detection and Monitoring of Exotic Invasive Plants in Quebec: Building Networks with Citizen Scientists in the Context of Climate Change
Isabelle Simard, Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs, Québec

12:00 pm
Luncheon

Session B-1: Strategy Room 5/6

Crustaceans I

Session Chair: Jeff Brinsmead
Ontario Ministry of Natural Resources

10:00 AM
Invited Keynote Presentation
Crustacean Invaders: Past, Present and Future
Jaimie T.A. Dick, Professor of Invasion Ecology, Queen's University Belfast

10:40 AM
Bloody-red Shrimp (*Hemimysis anomala*) Populations in Montreal Harbour Waters, St. Lawrence River: Potential Risk of Species Transfer
Yves de Lafontaine, Environment Canada; Jérôme Marty, St. Lawrence River Institute

11:00 AM
Spatial and Temporal Variation in the Predatory Impact of an Invasive Mysid Shrimp (*Hemimysis anomala*)
Josephine Iacarella, GRIL and McGill University; Anthony Ricciardi, McGill University; Jaimie T.A. Dick and Mhairi Alexander, Queen's University Belfast

11:20 AM
Understanding the Invasion Success and Ecological Impacts of Invasive Species: A Comparative Functional Response Methodology
Daniel Barrios-O'Neill, Jaimie T.A. Dick, Mhairi Alexander, Mark Emmerson and Helene C. Bovy, Queen's University Belfast; Anthony Ricciardi, McGill University

11:40 AM
Novel and Emerging Tools to Assess the Impacts of Aquatic Invasive Species
Tim Johnson, Brent Metcalfe, Chris Wilson and Mike Yuille, Ontario Ministry of Natural Resources; Shelley Arnott, Meagan King and Kent McDonald, Queen's University; Linda Campbell, Saint Mary's University; Lucia Carreon, University of Windsor

12:00 pm
Luncheon

Session C-1: Strategy Room 2

Biology and Ecology of Asian Carps I

Session Chair: Philip B. Moy
Wisconsin Sea Grant

10:00 AM
Invited Keynote Presentations
Update on the Asian Carp Control Strategy Framework
John Goss, Asian Carp Director, White House Council on Environmental Quality
Note: Presented on John's behalf by Becky Cudmore

Asian Carps – Science and Management Interplay in Canada
Becky Cudmore, Acting Manager, Canadian Asian Carp Program; Manager, National Centre of Expertise for Aquatic Risk Assessment; Senior Science Advisor, Aquatic Invasive Species, Fisheries and Oceans Canada

10:40 AM
Preliminary Assessment of the Suitability of Canadian Great Lakes Tributaries for Asian Carp Spawning
Nicholas Mandrak, Fisheries and Oceans Canada

11:00 AM
A Stage-Structured Population Model for Bighead and Silver Carps in the Great Lakes
Kim Cuddington, University of Waterloo; Marten Koops and Warren Currie, Fisheries and Oceans Canada

11:20 AM
Movements and Habitat Use of Silver Carp in the Wabash River, Indiana (USA)
Alison Coulter, Elizabeth Bailey and Reuben Goforth, Purdue University; Doug Keller and Tom Stefanavag, Indiana Department of Natural Resources; Jon Amberg, U.S. Geological Survey

11:40 AM
Assessment of Non-Planktonic Food Sources for Bigheaded Carps in the Laurentian Great Lakes
Duane Chapman, Karl Anderson, Elizabeth Brothers, Michael Lucey and Karthik Massagounder, U.S. Geological Survey

12:00 pm
Luncheon

Session D-1: Strategy Room 3

Shipping Pathways I

Session Chair: Robert G. Lambe
Invasive Species Centre

10:00 AM
Invited Keynote Presentation
The Role that the Zebra Mussel and ICAIS Conferences Have Played in Reducing the Risk of AIS Being Discharged from Ships' Ballast Water
Christopher J. Wiley, Fisheries and Oceans Canada/Transport Canada Marine Safety

10:40 AM
Examining the Role of Domestic Shipping in the Spread of Nonindigenous Species
Sarah Bailey and Elizabeta Briski, Fisheries and Oceans Canada; Christopher J. Wiley, Transport Canada Marine Safety

11:00 AM
Hull Fouling on Domestic Vessels as a Vector for Secondary Spread of Marine Nonindigenous Species
Francisco Sylvester, Marco Meloni and Demetrio Boltovskoy, Universidad de Buenos Aires; Nancy Correa, Servicio de Hidrografía Naval; Fábio Pitombo, Universidade Federal Fluminense

11:20 AM
Estimating the Risk of Ship-mediated NIS Introductions into Marine and Freshwater Ecosystems of Canada
Oscar Casas-Monroy, Jennifer Adams, Robert Linley and Sarah Bailey, Fisheries and Oceans Canada; Farrah Chan, University of Windsor

11:40 AM
Risk Assessment for Ballast Water Exchange in the Canadian Eastern Arctic
Kimberly Howland, Shannon Nudds, Charles Hannah, Tim Siferd, Jeff Higdon, Robert Stewart, Margaret Treble and Christopher J. Wiley, Fisheries and Oceans Canada; Bruce Stewart, Arctic Biological Consultants

12:00 pm
Luncheon

Monday, April 22, Afternoon

Session A-2: Strategy Room 1

Early Detection and Monitoring II

Session Chair: Erik Pilgrim
U.S. Environmental Protection Agency

1:30 PM
How to Build an Effective Rapid Response Task Force in the Lake Champlain Basin
Margaret Modley, Lake Champlain Basin Program

1:50 PM
The U.S. Fish and Wildlife Service's Provisional, Early Detection Program for the Great Lakes
Michael H. Hoff, U.S. Fish & Wildlife Service, Fisheries Program

2:10 PM
Search Strategies and Network Design Issues for Early Detection of Aquatic Invasive Species
John B. (Jack) Kelly, Joel Hoffman, Anett Trebitz, Gregory Peterson and Erik Pilgrim, U.S. Environmental Protection Agency

2:30 PM
Estimating Sampling Effort for Early Detection of Non-Indigenous Benthic Species in the Toledo Harbor Region of Lake Erie
Jeffrey L. Ram, Fady Banno, Richard Gala, Jason P. Gizicki and Donna Kashian, Wayne State University

2:50 PM
Capturing Dispersal Patterns and Tolerance of Early Invaders with Enhanced SDMs: Applications for Design of Detection Programs
Paul Edwards and Brian Leung, McGill University; Sam Collin and Ladd E. Johnson, Université Laval

3:10 PM
Networking Break

Session B-2: Strategy Room 5/6

Crustaceans II

Session Chair: Nadine C. Folino-Rorem
Wheaton College

1:30 PM
'The Pump Don't Work, 'Cause the Vandals Took the Handles': Why 'Killer Shrimps' and Other Invasive Amphipods Threaten Freshwater Biological Water Quality Monitoring in the British Isles
Calum MacNeil, Isle of Man Government

1:50 PM
Dispersal of Invasive Species by Drifting
Mariëlle van Riel, Alterra, WUR; Gerard Van der Velde, Radboud University Nijmegen; Abraham bij de Vaate, Waterfauna Hydrobiologisch Adviesbureau

2:10 PM
Predicting Aquatic Invader Impacts and Testing Major Hypotheses in Invasion Biology with Comparative Functional Responses
Jaimie T.A. Dick, Mhairi Alexander, Jennifer Dodd, Calum MacNeil and Kevin Gallagher, Queen's University Belfast; Suncica Avlijas and Anthony Ricciardi, McGill University ; David Aldridge, Cambridge University

2:30 PM
Integrated Ecological Modelling as a Tool for Detection of Potential Hot Spots for Invasive Macroinvertebrates
Pieter Boets, Koen Lock and Peter Goethals, Ghent University

2:50 PM
Temporal and Spatial Community Dynamics of Invasive and Native Amphipods in the River Rhine and its Tributaries, Germany
Wei Chen, Frankfurt University; Martin Plath, Bruno Streit, Sebastian Klaus and Johann Wolfgang, Goethe-Universität

3:10 PM
Networking Break

Session C-2: Strategy Room 2

Biology and Ecology of Asian Carps II

Session Chair: Becky Cudmore
Fisheries and Oceans Canada

1:30 PM
Changes in Zooplankton Community of the Illinois River Since Establishment of Bighead and Silver Carp
Collin Hinz, Illinois Natual History Survey

1:50 PM
Preliminary Assessment of the Trophic Consequences of Asian Carp Establishment in Offshore Lake Ontario
Tom Stewart, Ontario Ministry of Natural Resources; Hongyan Zhang, University of Michigan; Warren Currie, Fisheries and Oceans Canada

2:10 PM
Assessing Risk of Asian Carp Invasion and Bioeconomic Impacts on the Food Web and Fisheries of Lake Erie
Edward Rutherford and D. Mason, NOAA, Great Lakes Environmental Research Laboratory; Hongyan Zhang and J. Breck, University of Michigan; Marion Wittmann and David Lodge, University of Notre Dame; J. Rothlisberger, U.S. Forest Service; R. Cooke, Resources for the Future; Tim Johnson, Ontario Ministry of Natural Resources; Xinhua Zu, Fisheries and Oceans Canada; D. Finnoff, University of Wyoming

2:30 PM
Phenotypic Plasticity in Life History Traits of Bigheaded Carps in Novel Environments
Reuben Goforth, Alison Coulter and Elizabeth Bailey, Purdue University; Jon Amberg, U.S. Geological Survey; Doug Keller, Indiana Department of Natural Resources

2:50 PM
Invasion History, Population Dynamics and Trophic Structure of Asian Carps on the Northwestern Front of the Invasion in the United States
Cari-Ann Hayer, Katie Bertrand and Brian Graeb, South Dakota State University

3:10 PM
Networking Break

Session D-2: Strategy Room 3

Shipping Pathways II

Session Chair: Sarah Bailey
Fisheries and Oceans Canada

1:30 PM
Canadian Implementation of the Ballast Water Convention
Colin Henein, Transport Canada Marine Policy

1:50 PM
A Multi-dimensional Approach to Invasive Species Prevention
Elizabeta Briski and Sarah Bailey, Fisheries and Oceans Canada; Lisa Allinger and Euan Reavie, University of Minnesota; Mary Balcer, Lana Fanberg, Tom Markee, Christine Polkinghorne, Kelsey Prihoda, Deanna Regan, Heidi Saillard, Heidi Schaefer and Matthew TenEyck, University of Wisconsin-Superior; Allegra Cangelosi and Nicole Mays, Northeast-Midwest Institute; Donald Reid, Consultant; Tyler Schwerdt, AMI Engineering; Christopher J. Wiley, Transport Canada Marine Safety

2:10 PM
Evaluating Efficacy of a Ballast Water Filtration System for Reducing Risk of Spread of Aquatic Species in the Great Lakes
Robert Linley, Elizabeta Briski, Jennifer Adams and Sarah Bailey, Fisheries and Oceans Canada

2:30 PM
Adenosine TriPhosphate: A Promising Tool for Ballast Water Compliance Monitoring
Cees van Slooten, Tom Wijers and Louis Peperzak, Royal Netherlands Institute for Sea Research, NIOZ

2:50 PM
Assessing the Utility of Vital Fluorescent Stains for Viability Analysis of Organisms Transported by Ballast Water
Jennifer Adams, Elizabeta Briski and Sarah Bailey, Fisheries and Oceans Canada

3:10 PM
Networking Break

Session A-3: Strategy Room 1

Early Detection and Monitoring III

Session Chair: Michael H. Hoff
U.S. Fish & Wildlife Service

3:40 PM
Early Detection of Non-native Fishes Using Fish Larvae
Joel Hoffman, Erik Pilgrim, Anett Trebitz, John Kelly and Gregory Peterson, U.S. Environmental Protection Agency

4:00 PM
Metagenomic Approaches to Detecting Invasive Species in Lake Superior
Erik Pilgrim, John Martinson, Joel Hoffman, Anett Trebitz, Gregory Peterson and John Kelly, U.S. Environmental Protection Agency

4:20 PM
Assessing the Role of Genomic Surveillance Methods in Mitigating the Erie Canal Corridor Invasion Risk
Andrew Mahon, Central Michigan University; W. Lindsay Chadderton and Andrew Tucker, The Nature Conservancy

4:40 PM
Environmental DNA Monitoring for Detecting Aquatic Invasive Species in Ontario
Chris Wilson, Kristyne Wozney, Jennifer Bronnenhuber and Caleigh Smith, Ontario Ministry of Natural Resources; Christopher Kyle, Trent University

5:00 PM
Evaluating Canadian Zooplankton Biodiversity through DNA Barcodes: Assessing Non-indigenous Species Presence to Provide a Framework for Future Monitoring
Robert Young and Sarah Adamowicz, University of Guelph; Cathryn Abbott and Tom Therriault, Fisheries and Oceans Canada

5:20 PM
Eurasian Ruffe –Implications of Recent eDNA Surveillance Efforts in the Laurentian Great Lakes
W. Lindsay Chadderton and Andrew Tucker, The Nature Conservancy; Christopher Jerde, Marion Wittmann and David Lodge, University of Notre Dame; Andrew Mahon, Central Michigan University; Jennifer Sieracki and John Bossenbroek, University of Toledo; Dmitry Beletsky, University of Michigan

Session B-3: Strategy Room 5/6

Crustaceans III

Session Chair: Pedro Quijon
University of Prince Edward Island

3:40 PM
Use of Functional Response Experiments and Modelling to Assess Intra-guild Interaction Between a Native and Invasive Amphipod in Northern Ireland
Mandy Bunke, Melanie Hatcher and Alison Dunn, University of Leeds; Mhairi Alexander and Jaimie T.A. Dick, Queen's University Belfast

4:00 PM
Predatory Functional Responses of Native vs. Exotic Amphipods: Effects of Predation Risk and Parasitism
Rachel Paterson, Marilyn Ennis and Jaimie T.A. Dick, Queen's University Belfast; Melanie Hatcher and Alison Dunn, University of Leeds

4:20 PM
Trophic Impacts of Two Invasive Decapods on Freshwater Communities
Paula Rosewarne, Chris Wing, Christopher Grocock, Robert Mortimer and Alison Dunn, University of Leeds

4:40 PM
Combined Effects of Food Abundance and Temperature on Large Bodied vs. Small Bodied Cladoceran Species Replacement
Irina Feniova and Yury Dgebuadze, Institute of Ecology and Evolution, Russian Academy of Sciences; Vladimir Razlutski, Anna Palash and Elena Sysova, The Scientific and Practical Center for Bioresources, National Academy of Sciences of Belarus; Jacek Tunowski, Institute of Inland Fishery; Andrew Dzialowski, Oklahoma State University

5:00 PM
Invasion of Asian Tiger Shrimp (*Penaeus monodon* Fabricius, 1798) in the Western Atlantic and Gulf of Mexico
Pamela Fuller, U.S. Geological Survey; David Knott, Poseidon Taxonomic Services, LLC; Peter Kingsley-Smith, South Carolina Department of Natural Resources; Leslie Hartman, Texas Parks & Wildlife Department; James Morris, NOAA Fisheries

5:20 PM
Early Life Stage Biology of a New Population of Green Crab (*Carcinus maenas*) in Placentia Bay & Implications for Mussel Culture in Newfoundland
Kiley Best and Cyr Couturier, Marine Institute of Memorial University of Newfoundland; Cynthia McKenzie, Fisheries and Oceans Canada

5:40 PM
Disruption of Essential Habitat by a Non-Indigenous Predator in Shoreline Habitats of the Southern Gulf of St. Lawrence
Pedro Quijon, Paula Tummon Flynn, Cassandra Mellish, Tyler Pickering and Andrey Malyshev, University of Prince Edward Island

Session C-3: Strategy Room 2

Management and Control of Asian Carps I

Session Chair: Philip B. Moy
Wisconsin Sea Grant

3:40 PM
Managing Asian Carp at the Detectable Population Front in the Illinois Waterway through Standardized Monitoring and Removal by Contracted Commercial Fishers
Victor Santucci, Kevin Irons and James Mick, Illinois Department of Natural Resources; David C. Glover, Southern Illinois University Carbondale, Center for Fisheries, Aquaculture and Aquatic Sciences

4:00 PM
The Use of Chemical Stimuli in the Control of Asian Carp
Edward E. Little, Robin D. Calfee, H. Puglis and E. Beahan, U.S. Geological Survey, Columbia Environmental Research Center; Peter Sorensen, University of Minnesota

4:20 PM
Asian Carp (*Hypophthalmichthys* spp.) and the Viability of a Vulnerable Native Fish: An Ecological Risk Analysis for Paddlefish (*Polyodon spathula*) in the Lower Mississippi River
Nicholas Friedenberg, Adam Laybourn and Jonathan Borelli, Applied Biomathematics; Jan J. Hoover, U.S. Army Corps of Engineers

4:40 PM
Development of a Microparticle Delivery System for the Delivery of Control Agents to Bighead Carp and Silver Carp
Jon J. Amberg, James A. Luoma, Terrance D. Hubert and Mark P. Gaikowski, U.S. Geological Survey, Upper Midwest Environmental Sciences Center

5:00 PM
Swimming Performance of Asian Carp
Jan Jeffrey Hoover, Alan Katzenmeyer, Larry Southern and Nicky Hahn, U.S. Army Corps of Engineers

5:20 PM
Session Wrap-up
Philip B. Moy, Wisconsin Sea Grant

Session D-3: Strategy Room 3

Shipping Pathways III

Session Chair: Christopher J. Wiley
Transport Canada Marine Safety

3:40 PM
Organism Patchiness in Ballast Water Tanks – Implications for Ballast Water Management Compliance Control Sampling
Stephan Gollasch, GoConsult; Matej David, David Consult

4:00 PM
'Fouling Begets Fouling': Can Species-Based Biofouling Biosecurity Management Work for Ships?
John Polglaze, PGM Environment

4:20 PM
Does Transport Pathway Influence the Relationship between Colonization Pressure and Propagule Pressure of Zooplankton in Ballast Water of Ships?
Farrah Chan and Hugh MacIsaac, University of Windsor, Great Lakes Institute for Environmental Research; Elizabeta Briski and Sarah Bailey, Fisheries and Oceans Canada

4:40 PM
Hybrid Treatment to Control Plankton Densities in Ballast Water Tanks
Esteban M. Paolucci[1], Marco C. Hernandez[1], Alexei Potapov[2], Hugh J. MacIsaac[1], [1]University of Windsor, Great Lakes Institute for Environmental Research; [2]University of Alberta, Center for Mathematical Biology, Department of Mathematical and Statistical Sciences

Poster Session, 6:00 pm to 7:30 pm: Great Room A

Taxonomic relatedness and functional traits as predictors of establishment success after a massive freshwater fish invasion in Neotropics
Felipe Skóra and Jean Ricardo Simões Vitule, Universidade Federal do Paraná; Vinícius Abilhoa, Museu de História Natural Capão da Imbuia

Alien Marine Invertebrates in the Gulf of California, Mexico
José María Aguilar Camacho, María Ana Tovar-Hernández and Tulio Fabio Villalobos Guerrero, Geomare; Beatriz Yáñez Rivera, Unidad Académica Mazatlán; Antonio Martín Low Pfeng, Instituto Nacional de Ecología

An Integrative Approach to the Study of Introduced Marine Invertebrates in the Gulf of California (Mexico)
María Ana Tovar-Hernández, Beatriz Yáñez Rivera, Tulio Fabio Villalobos Guerrero and José María Aguilar Camacho, Geomare; Antonio Martín Low Pfeng, Instituto Nacional de Ecología

Assessing Compliance with Ballast Water International Regulations in Argentina
María Fernanda Ávila Velandia, Francisco Sylvester and Demetrio Boltovskoy, Universidad de Buenos Aires; Pablo Almada, Prefectura Naval Argentina

Ballast Tank Biofilms are Protected Reservoirs of Microspecies that Challenge Native Biodiversity
Robert Baier, Robert Forsberg, Joseph Zambon and Anne Meyer, SUNY at Buffalo

Mechanisms of Aquatic Species Invasions Across the South Atlantic States, USA
Amy Benson, Robert Dorazio, Fred Johnson, Michael Turtora and Pamela Fuller, U.S. Geological Survey

Determinants of Rapid Response Success for Alien Invasive Species in Aquatic Ecosystems
Boris Beric and Hugh J. MacIsaac, University of Windsor, Great Lakes Institute for Environmental Research

Ponto-Caspian Predatory Cladocerans *Cercopagis pengoi* (Ostroumov 1891) and Evadne anonyx G.O. Sars 1897 in the Gulf of Gdańsk (Baltic Sea)
Luiza Bielecka, Stella Mudrak-Cegiołka and Marcin Kalarus, University of Gdańsk, Institute of Oceanography, Department of Marine Plankton Research

Functional Responses as Predictors of Invasive Species Impacts: An Examination of Inter-population Variation in an Invasive Predator's Functional Response
Helene C. Bovy, Jaimie T.A. Dick and Mark Emmerson, Queen's University Belfast

A Cellular Automata Model for the Spread of the Golden Mussel (*Limnoperna fortunei*)
Vinícius Carvalho Resende[1], Mônica de Cássia Souza Campos[1,2], Fabiano Alcísio e Silva[1], Hellen Regina Mota[3], Marcela David de Carvalho[3], Antônio Valadão Cardoso[1,2], [1]Centro de Bioengenharia de Espécies Invasoras de Hidrelétricas (CBEIH); [2]Fundação Centro Tecnológico de Minas Gerais (CETEC); [3]Companhia Energética de Minas Gerais (CEMIG)

Effects of the Presence of Saxitoxin and Microcystin in the Grazing Rate of *Limnoperna fortunei*
Vinicius Sergio Rodrigues Diniz[1], Antônio Valadão Cardoso[1,2], Mônica de Cássia Souza Campos[1,2], Hellen Regina Mota[3], Marcela David de Carvalho[3], Patrícia Pimentel[2], [1]Centro de Bioengenharia de Espécies Invasoras de Hidrelétricas (CBEIH); [2]Fundação Centro Tecnológico de Minas Gerais (CETEC); [3]Companhia Energética de Minas Gerais (CEMIG)

The Non-indigenous Aquatic Species Program: Past, Present, and Future
Matt Cannister, Pamela Fuller, Amy Benson and Matthew Neilson, U.S. Geological Survey

Watchlist Species: Assessing Risk for Future Invaders of the Great Lakes
Alisha A. Dahlstrom, Abigail J. Fusaro and Donna R. Kashian, Wayne State University

Is a Recirculating Aquaculture System an Option for Non-native Species Management in the Polish Coastal Zone of the Baltic Sea?
Barbara Dmochowska and Anna Szaniawska, University of Gdańsk, Institute of Oceanography

Developing a Risk Assessment Model for Identifying Potential Invasive Aquatic Weeds in Texas
Elizabeth Edgerton and Lucas Gregory, Texas Water Resources Institute; Michael Masser, Texas A&M University

Parasite Effects on the Feeding Behaviour and Functional Response of the Invasive Amphipod *Gammarus pulex*. (Crustacea; Amphipoda)
Marilyn Ennis, Jaimie T.A. Dick, Mhairi Alexander, Rachel Paterson and Sheena Cotter, Queen's University Belfast

Program to Control Exotic Species in the Area of Usina Hidrelétrica Serra do Facão
Daniel Simões, Maria Beatriz Ferreira, Norma Dulce de Campos Barbosa and Maria Edith Rolla, Usina Hidrelétrica Serra do Facão (SEFAC)

Zebra Mussel Habitat Preference, Growth, and Mortality within and among Lakes in Northeast Wisconsin and Upper Michigan
Maureen Ferry and Tim Ginnett, University of Wisconsin-Stevens Point; Gregory Sass and K. Gauthier, Wisconsin Department of Natural Resources

Phylogeography of the Invasive Ctenophore *Mnemiopsis leidyi* in Eurasia
Sara Ghabooli, Aibin Zhan, Melania Cristescu and Hugh J. MacIsaac, University of Windsor, Great Lakes Institute for Environmental Research; Tamara Shiganova, P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences; Elizabeta Briski, Fisheries and Oceans Canada

The Response to Water Chestnut in Tonawanda Creek, NY
Michael Goehle and Denise Clay, U.S. Fish and Wildlife Service

Are there Benthic Non-indigenous Species in the Canadian Arctic?
Jesica Goldsmit and Philippe Archambault, Université du Québec à Rimouski; Kimberly Howland, Fisheries and Oceans Canada

Moving Faster than a Snail's Pace: Trends and Consequences of Invasive Freshwater Snails
Danielle M. Haak, Noelle M. Chaine, Daniel R. Uden and Bruce J. Stephen, University of Nebraska-Lincoln, School of Natural Resources; Karie Decker, Nebraska Game and Parks Commission; Craig R. Allen and Kevin L. Pope, U.S. Geological Survey – Nebraska Cooperative Fish and Wildlife Research Unit; Valery E. Forbes, University of Nebraska-Lincoln, School of Biological Sciences

Effects of Thermal Effluent on Exotic Benthic Invertebrates in the St. Lawrence River
Kayla Hamelin and Anthony Ricciardi, McGill University

Are Non-native species More Likely to Become Pests?
Ahdia Hassan, Groupe de recherche interuniversitaire en limnologie et en environnement aquatique (GRIL) and Redpath Museum, McGill University and Anthony Ricciardi, Redpath Museum, McGill University

Protecting the Great Lakes from Internet Trade of Aquatic Invasive Species
Erika Jensen, Great Lakes Commission

The Experimental Evaluation of Habitat Preferences of the Ponto-Caspian Gammarid *Pontogammarus robustoides*
Lukasz Jermacz and Jaroslaw Kobak, Nicolaus Copernicus University

Underwater Evaluation of Habitat Partitioning between Non-native Invader (Racer Goby) and a Threatened Native Fish (European Bullhead) in a European River
Jaroslaw Kobak, Tomasz Kakareko, Malgorzata Poznanska and Lukasz Jermacz, Nicolaus Copernicus University; Gordon Copp, CEFAS

The Regional Euro-Asian Biological Invasions Centre (REABIC) Information System
Frances Lucy, Institute of Technology Sligo; Vadim Panov and Vladimir Shestakov, REABIC

Out with the Old, in with the New: Dealing with Aquatic Weed Succession in South Africa
Grant Martin, Julie Coetzee and Martin Hill, Rhodes University

The Successful Biological Control of Parrot's Feather, *Myriophyllum aquaticum* (Vell.) Verdc. (Haloragaceae) in South Africa by the Flea Beetle, *Lysathia* sp. (Chrysomelidae)
Grant Martin, Martin Hill and Julie Coetzee, Rhodes University

Exploring Management Alternatives for an Invasive Species in Atlantic Canada: Chemical Analysis and the Basis for a Fishery of the European Green Crab
Cassandra Mellish, Paula Tummon Flynn, Mary McNiven, Sophie St. Hilaire and Pedro Quijon, University of Prince Edward Island

Third Prototype Shipboard Filter Skid (p3SFS): An Automated, Flow-Through Ballast Water Sampling Device
Cameron Moser and Lisa Drake, U.S. Naval Research Laboratory; Timothy Wier, U.S. Naval Research Laboratory-Excet Incorporated; Jonathan Grant, Battenkill Technologies, Inc.

Poster Session continued: Great Room A

Containment of Knifefish (*Chitala ornata*) Infestation in Laguna De Bay, Philippines
Adelaida Palma, Bureau of Fisheries and Aquatic Resources

Evaluating Incentive Programs as an Effective Tool to Control Invasive Species
Susan Pasko, National Oceanic and Atmospheric Administration – ERT; Jason Goldberg, U.S. Fish and Wildlife Service

Ecological Determinants of Parasite Acquisition by Exotic Fish Species
Rachel Paterson, Queen's University Belfast; Colin Townsend and Robert Poulin, University of Otago; Daniel Tompkins, Landcare Research

Developing and Refining a Rapid DNA Test for Invasive Fish Species
Carson Prichard, Von Sigler and Carol Stepien, University of Toledo

An Unexpected Role for an Invasive Seaweed: Uprooted Rockweeds Act as Key Subsidies of Food and Habitat for Sandy Beach Invertebrates
Pedro Quijon, Mitchell MacMillan, Tyler Wheeler and Terrie Hardwick, University of Prince Edward Island

An Investigation of the Risk Posed by Recreational Boating as a Vector in the Introduction and Spread of Aquatic Invasive Species in Newfoundland
Bobbi Rees, Government of Newfoundland and Labrador; Terri Wells, Cynthia Mackenzie, Vanessa Reid, Michael Hurley and Kyle Matheson, Fisheries and Oceans Canada; Robert O'Donnell, Memorial University of Newfoundland; Darrell Green, Newfoundland Aquaculture Industry Association

RAMP: A Tool for Quickly Determining a Species Current and Potential Climate Envelope
Scott Sanders and Michael H. Hoff, U.S. Fish & Wildlife Service

Modeling the Population Dynamics of the Species *Limnoperna fortunei* in Reservoirs Influenced by the Presence of Predatory Fish
Fabiano Alcísioe Silva[1], Roberto Lopes[1], Newton Gontijo[1], Mônica de Cássia Souza Campos[1,2], Hellen Regina Mota[3], Marcela David de Carvalho[3], Antônio Valadão Cardoso[1,2], [1]Centro de Bioengenharia de Espécies Invasoras de Hidrelétricas (CBEIH); [2]Fundação Centro Tecnológico de Minas Gerais(CETEC); [3]Companhia Energética de Minas Gerais (CEMIG)

Development of the Computational Tool TerraME for Modeling the Process of Invasion by the Species *Limnoperna fortunei*
Fabiano Alcísioe Silva[1], Thalisson Correia[1], Newton Gontijo[1], Roberto Lopes[1], Mônica de Cássia Souza Campos[1,2], Hellen Regina Mota[3], Marcela David de Carvalho[3], Antônio Valadão Cardoso[1,2], [1]Centro de Bioengenharia de Espécies Invasoras de Hidrelétricas (CBEIH); [2]Fundação Centro Tecnológico de Minas Gerais(CETEC); [3]Companhia Energética de Minas Gerais (CEMIG)

Autonomy Mediates the Impact of an Invasive Predator: Injury Patterns and Feeding Rates in Prince Edward Island Green Crab (*Carcinus maenas*) Populations
Paula Tummon Flynn, Cassandra Mellish, Tyler Pickering and Pedro Quijon, University of Prince Edward Island

Utilizing Different Eradication Methods to Manage Alien Fish Populations in the Cape Floristic Region Biodiversity Hotspot: South Africa
Megan van der Bank and Johannes Adriaan van der Walt, CapeNature

Plenary Session: Great Room B/C

Session Chair: Frances Lucy, Lecturer and Researcher, Institute of Technology Sligo and Board Member, Inland Fisheries Ireland

8:45 AM
Invited Keynote Presentation
Practical Management of Aquatic Invasive Species in Ireland
Joseph M. Caffrey, Senior Research Officer, Inland Fisheries Ireland

9:30 AM
Networking Break

Session A-4: Strategy Room 1

Other Fishes I

Session Chair: Tim Haxton
Ontario Ministry of Natural Resources

10:00 AM
Invited Keynote Presentation
Invasive Fishes: What's Next?
Nicholas Mandrak, Executive Director, Centre of Expertise for Aquatic Risk Assessment, Fisheries and Oceans Canada

10:40 AM
Influence of Phylogenetic Community Structure on Fish Introductions in the Southeast United States
Matthew L. Nuhn and Pamela Fuller, U.S. Geological Survey

11:00 AM
Biological and Ecological Features, Enough to Predict Invasion – The Round Goby Case
Mariusz Sapota, University of Gdańsk

11:20 AM
In the Driver's Seat? Disentangling the Influence of Habitat Degradation and Round Goby Invasion on the Structure and Function of Benthic Communities in the St. Lawrence River
Katherine Pagnucco, GRIL and McGill University and Anthony Ricciardi, McGill University

11:40 AM
Rapid Recent Expansion of the Round Goby (*Neogobius melanostomus*) and the Western Tubenose Goby (*Proterorhinus semilunaris*) in Flanders (Belgium)
Hugo Verreycken and Luc De Bruyn, Research Institute for Nature and Forest; Merlijn Mombaerts and Tine Huyse, Katholieke Universiteit Leuven; Jan Ostermeyer, Universiteit Antwerpen

12:00 PM
Luncheon

Session B-4: Strategy Room 2

Dreissenid Research I

Session Chair: Frances Lucy
Institute of Technology Sligo

10:00 AM
Invited Keynote Presentation
Spread, Population Dynamics, and Ecosystem Impacts of Zebra Mussels versus Quagga Mussels: What Do We Know and What Do We Not?
Alexander Y. Karatayev, Director and Lyubov E. Burlakova, Research Scientist, Great Lakes Center, Buffalo State College; Diana K. Padilla, Stony Brook University, Department of Ecology and Evolution

10:40 AM
Behavioural Responses of the Zebra Mussel (*Dreissena polymorpha*) to the Presence of Various Gammarid Species Inhabiting its Colonies
Jaroslaw Kobak, Malgorzata Poznanska and Tomasz Kakareko, Nicolaus Copernicus University

11:00 AM
***Dreissena* Impacts on Unionidae: General Trends in North America and Europe and Recent Findings from the Lower Great Lakes**
Lyubov Burlakova, Alexander Karatayev, Brianne Tulumello, Buffalo State College; David Zanatta, Central Michigan University; Frances Lucy, Institute of Technology Sligo; Sergey Mastitsky, RNT Consulting Inc.

11:20 AM
Could Zebra Mussels Help Unravel the Mysterious Life Cycle of an Introduced and Virulent Parasite of Oysters?
Daniel Molloy, SUNY at Albany; Nancy Stokes, Virginia Institute of Marine Science; Laure Giamberini and Bénedicte Sohm-Rederstorff, University of Lorraine

11:40 AM
Evolutionary and Biogeographic Relationships of Dreissenid Mussels, with Revision of Component Taxa
Carol Stepien, University of Toledo

12:00 PM
Luncheon

Session C-4: Strategy Room 3

Risk Assessment I

Session Chair: Marc Gaden
Great Lakes Fishery Commission

10:00 AM
Invited Keynote Presentation
Emerging Integration of Risk Assessments in an Aquatic Invasive Species Program
Becky Cudmore, Acting Manager, Canadian Asian Carp Program; Manager, National Centre of Expertise for Aquatic Risk Assessment; Senior Science Advisor, Aquatic Invasive Species, Fisheries and Oceans Canada

10:40 AM
Managing an Establishment Pathway Using Import Records and Biological Data
Johanna Bradie and Brian Leung, McGill University

11:00 AM
Anticipating Bioinvasion Risks in a Coastal Context
Daniel Kluza, New Zealand Ministry for Primary Industries

11:20 AM
Global Changes and Biological Invasion of Aquatic Alien Species: The Case in Russia
Yury Yu. Dgebuadze, A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences

11:40 AM
A Risk Analysis of Australia's Marine Ornamental Value Chain Focusing on Biosecurity (Diseases and Pathogens) Concerns
Kevin Erickson, Marnie Campbell, Chad Hewitt and Nicole Flint, Central Queensland University

12:00 PM
Luncheon

Session D-4: Strategy Room 5/6

Outreach and Policy I

Session Chair: Francine MacDonald
Ontario Ministry of Natural Resources

10:00 AM
Invited Keynote Presentation
Is AIS Spread Inevitable: Fact or Fiction?
Douglas Jensen, Aquatic Invasive Species Program Coordinator, University of Minnesota Sea Grant Program

10:40 AM
Curbing Invasion Pathways: A Sea Grant-U.S. Coast Guard Auxiliary Pilot Partnership to Assess and Enhance Aquatic Invasive Species Awareness among Coastal Anglers and Boaters
Nancy Balcom, Connecticut Sea Grant/ University of Connecticut; William Nelson, U.S. Coast Guard Auxiliary; Eric C. Dyson, Community College of Rhode Island

11:00 AM
Education and Outreach: Changing Angler and Boater Behavior Over Time
Matt Smith, Ontario Federation of Anglers and Hunters

11:20 AM
Understanding Motivations Behind the Live Release of Organisms
Debrupa Pathak, Ontario Ministry of Natural Resources

11:40 AM
Lake Simcoe Aquatic Invasive Species Community-Based Social Marketing Project
Sophie Monfette, Ontario Federation of Anglers and Hunters; Erika Weisz, Ontario Ministry of Natural Resources; David Dilks and Jeff Garkowski, LURA Consulting

12:00 PM
Luncheon

Session A-5: Strategy Room 1

Other Fishes II

Session Chair: Hugo Verreycken
Research Institute for Nature and Forest

1:30 PM
Does the Racer Goby, a Ponto-Caspian Invader of Continental European Waters, Pose a Threat to the Endangered Native European Bullhead? – An Experimental Approach
Gordon Copp, Centre for Environment, Fisheries and Aquaculture Science; Joanna Grabowska, Dagmara Blonska and Miroslaw Przybylski, University of Lodz; Tomasz Kakareko, Jaroslaw Kobak, Malgorzata Poznanska and Lukasz Jermacz, Nicolaus Copernicus University

1:50 PM
Identifying Drivers of Pumpkinseed Sunfish Invasiveness Using Population Models
Hein van Kleef, Bargerveen Foundation; Eelke Jongejans, Radboud University Nijmegen

2:10 PM
Community Dynamics of an Invaded Ecosystem: Investigation of a *Pterygoplichthys disjunctivus* Invasion in the Nseleni River System, KwaZulu Natal, South Africa
Jaclyn Hill and Martin Hill, Rhodes University; Roy Jones, Ezemvelo KZN Wildlife; Olaf Weyl, South African Institute for Aquatic Biodiversity

2:30 PM
Reconciling Large-scale Model Predictions with Small-scale – Impacts and Interactions of the Invasive Smallmouth Bass (*Micropterus dolomieu*) with Native Species in British Columbian Lakes
Martina Beck, University of Victoria; John Volpe, University of Victoria; Leif-Matthias Herborg, BC Ministry of Environment

2:50 PM
Evolutionary and Biogeographic Patterns of an Emerging Quasispecies: The Fish Viral Hemorrhagic Septicemia Virus (VHSv)
Carol Stepien, Lindsey Pierce and Jacob Blandford, University of Toledo

3:10 pm
Break

Session B-5: Strategy Room 2

Dreissenid Research II

Session Chair: Elizabeth Wright
Ontario Ministry of Natural Resources

1:30 PM
Predicting the Zebra Mussel Spread: What Can We Learn From 200 Years of Continuous Invasion?
Alexander Karatayev and Lyubov Burlakova, Buffalo State College; Sergey Mastitsky, RNT Consulting Inc.; Dianna Padilla, Stony Brook University

1:50 PM
Invasion of Western Europe by *Dreissena rostriformis bugensis*
Jonathan Marescaux and Karine Van Doninck, University of Namur

2:10 PM
Rapid Range Expansion of the Invasive Quagga Mussel in Relation to Zebra Mussel Presence in Western Europe
Rob Leuven, Jon Matthews, Gerard Van der Velde, Frank P.L. Collas and Remon (K.R.) Koopman, Radboud University Nijmegen; Abraham bij de Vaate, Waterfauna Hydrobiologisch Adviesbureau

2:30 PM
Exotic Species Replacement in Relation to Small-scale Environmental Heterogeneity
Lisa Jones and Anthony Ricciardi, McGill University

2:50 PM
Comparative Variation in Growth of Two Invasive Mussels in the St. Lawrence River: Do Differences in Filtering Apparatus Matter?
Jordan Ouellette-Plante, GRIL and McGill University; Anthony Ricciardi, McGill University; Ladd E. Johnson, Université Laval

3:10 pm
Break

Session C-5: Strategy Room 3

Risk Assessment II

Session Chair: Mark Burrows
International Joint Commission

1:30 PM
The Utility of Hub and Spoke Network Models to Analyse Pre-border and Post-border Dispersal of Introduced Marine Species
Marnie L Campbell and Chad L. Hewitt, Central Queensland University, School of Medical and Applied Sciences; Fauziah Azmi, University of Tasmania, National Centre for Marine Conservation and Resource Sustainability

1:50 PM
Incorporating Biotic Interactions in Species Distributions: Community Distribution Modeling of the Invasive Species *Bythotrephes longimanus*
Kristina Enciso and Brian Leung, McGill University

2:10 PM
Improving Model Transferability and Generality for Predictive Modeling on Invasive Species: A Case Study on *Bythotrephes longimanus*
Lifei Wang and Donald A. Jackson, University of Toronto

2:30 PM
Implications of Uncertainty: Bayesian Modelling of Aquatic Invasive Species Spread
Corey Chivers and Brian Leung, McGill University

2:50 PM
Response to Biofouled Marine Debris Generated by the 2011 Japan Tsunami
Margaret M. (Peg) Brady and Susan Pasko, U.S. National Oceanic & Atmospheric Administration

3:10 pm
Break

Session D-5: Strategy Room 5/6

Outreach and Policy II

Session Chair: David Copplestone
Ontario Ministry of Natural Resources

1:30 PM
Go Giddy Over Guidelines for Recreational Activities
Douglas Jensen, University of Minnesota Sea Grant Program; Laura Norcutt, U.S. Fish & Wildlife Service

1:50 PM
An Ounce of Prevention: AIS Education, Evaluation, and Communication in Illinois and Indiana
Sarah Zack, Lainey Pasternak and Patrice Charlebois, Illinois-Indiana Sea Grant & Illinois Natural History Survey; Erin Seekamp, North Carolina State University

2:10 PM
Working With Fishing Tournaments to Prevent the Spread of Aquatic Invasive Species
Philip B. Moy, Wisconsin Sea Grant

2:30 PM
Mitigating the Threats Posed by Freshwater Invasive Species in Ireland
Joseph M. Caffrey, Inland Fisheries Ireland

2:50 PM
Nab the Aquatic Invader! – Young Stewards Prevent the Spread of AIS
Marte Kitson and Douglas Jensen, University of Minnesota Sea Grant Program; Robin Goettel, Illinois-Indiana Sea Grant

3:10 pm
Break

Session A-6: Strategy Room 1

Other Fishes III

Session Chair: Becky Cudmore
Fisheries and Oceans Canada

3:40 PM
Dispersion, Impact and Abundance Mitigation Study of Round Goby (*Neogobius melanostomus*) and Chinese Sleeper (*Perccottus glenii*) in Lithuania
Saulius Stakėnas, Tomas Virbickas, Vytautas Rakauskas and Andrius Steponėnas, Nature Research Centre, Institute of Ecology

4:00 PM
Detecting the Invasive Snakehead: DNA Barcoding as a First Step in Developing Species Specific Primers and Probes for Environmental DNA Detection
Natasha Serrao, Trent University, Department of Environmental Life Sciences; Dirk Steinke and Robert Hanner, University of Guelph, Biodiversity Institute of Ontario

4:20 PM
Morphological Responses to Competition in Native and Non-Native Fish
Stan Yavno and A. Rooke, Trent University, Environmental and Life Sciences Graduate Program; M.G. Fox, Trent University, Environmental and Resource Studies Program and Department of Biology

4:40 PM
Thermal and Biotic Influences on Life-History Traits of Pumpkinseed Introduced in Europe
Michael G. Fox[1], E. Valente[2], G. Masson[2], Gordon H. Copp[3], [1]Trent University, Department of Biology and Environmental and Resource Studies Program; [2]Université de Lorraine, Laboratoire Interactions Ecotoxicologie Biodiversité Écosystèmes ; [3]Cefas, Salmon & Freshwater Team and Environmental and Trent University, Life Sciences Graduate Program

Session B-6: Strategy Room 2

Dreissenid Research III

Session Chair: Lyubov Burlakova
Buffalo State College

3:40 PM
Modelling the Occurrence of Zebra Mussel Parasites According to Contamination in France and the USA
Laure Giamberini and Laëtitia Minguez, University of Lorraine; Simon Devin, Pascal Poupin and Francois Guerold, University of Metz; Daniel Molloy, State University of New York at Albany

4:00 PM
A Non-Destructive Method for Monitoring Dreissenid Settlement and Evaluating Treatment Efficacy
Carolyn Link, Marrone Bio Innovations

4:20 PM
Potential Use of the Calcite Saturation Index as an Indicator of Environmental Suitability for Dreissenid Mussel Survival
Katherine Prescott and Renata Claudi, RNT Consulting Inc.; Jeffrey Janik and Tanya Veldhuizen, California Department of Water Resources

4:40 PM
Objective Method for Determining Mortality in Larval and Juvenile Lifestages of Dreissenid Mussels
Carolyn Link, Marrone Bio Innovations; Renata Claudi and Carolina Taraborelli, RNT Consulting Inc.

5:00 PM
Dreissenid Veliger Detection and Enumeration Technology Enhanced to Improve Reliability and Sample Processing Using a Continuous Imaging Particle Analyzer (FlowCAM®)
Victoria Kurtz, Harry Nelson and Ben Spaulding, Fluid Imaging Technologies; Denise Hosler and Kevin Bloom, Bureau of Reclamation

Session C-6: Strategy Room 3

Risk Assessment III

Session Chair: Victor Serveiss
International Joint Commission

3:40 PM
Evaluating the Risk of Non-native Aquatic Species Range Expansions in a Changing Climate in Pennsylvania
Sara Grisé, Pennsylvania Sea Grant; Theo Light, Shippensburg University

4:00 PM
An Empirical Analysis of the Causes, Consequences and Predictors of Aquatic Invasive Species in Inland, Freshwater Lakes in Southern Ontario
Tim Haxton, Sarah Nienhuis and Tal Dunkley, Ontario Ministry of Natural Resources

4:20 PM
Invasive Species, Climate Change, and Emerging Infectious Disease Threats
David Bruce Conn, Berry College

4:40 PM
Predicting Invasional Vulnerability Using Abundance-Body Mass Spectra
Yajun Sun and Mathew Wells, University of Toronto, Department of Physical and Environmental Sciences

5:00 PM
Modelling the Likelihood of Introduction and Establishment of Marine Non-native Species in the UK and Ireland
Paul Stebbing, Fiona Pearce and Edmund Peeler, Centre for Environment, Fisheries and Aquaculture Science

Session D-6: Strategy Room 5/6

Outreach and Policy III

Session Chair: Donna Wales
Ontario Ministry of Natural Resources

3:40 PM
A National Status Report on Aquatic Invasive Species in Canada
Åsa Kestrup and David Browne, Canadian Wildlife Federation

4:00 PM
Assessing Needs and Developing Regulatory and Outreach Strategies for Preventing the Spread of Aquatic Invasive Species through Boating
Samuel Chan, Oregon State University

4:20 PM
Aquatic Invasive Species Outreach for Water Gardeners and Aquarium Hobbyists
Greg Hitzroth, Illinois-Indiana Sea Grant; Patrice Charlebois, Illinois-Indiana Sea Grant & Illinois Natural History Survey; Erin Seekamp, North Carolina State University

4:40 PM
GLANSIS Enhancements
Rochelle Sturtevant, Abigail Fusaro and Edward Rutherford, NOAA, Great Lakes Environmental Research Laboratory

5:00 PM
Outreach on Great Lakes OIT Risk Assessments
Patrice Charlebois, Illinois-Indiana Sea Grant & Illinois Natural History Survey; Greg Hitzroth, Illinois-Indiana Sea Grant; Danielle Hilibrich, University of Illinois; Mark Farley, Oregon Sea Grant; Bob Kirschner, Chicago Botanic Garden; Reuben Keller, University of Notre Dame

5:20 PM
Self-management: The Bane or Saviour of Non-Indigenous Marine Species Management?
Marnie L. Campbell and Chad L. Hewitt, Central Queensland University, School of Medical and Applied Sciences; Dominic E.P. Bryant, University of Tasmania, National Centre for Marine Conservation and Resource Sustainability

Wednesday, April 24, Morning

Plenary Session: Great Room B/C

Session Chair: David F. Reid, Consultant

8:45 AM

Invited Keynote Presentation

Aquatic Invasive Species in Inland Lakes: Distribution, Abundance, Impact

M. Jake Vander Zanden, Professor, University of Wisconsin-Madison, Center for Limnology

9:30 AM

Networking Break

Session A-7: Strategy Room 1

Live Bait Pathway I

Session Chair: Susan Park
Virginia Sea Grant

10:00 AM

Invited Keynote Presentation

Preventing Aquatic Invasive Species through Management of the Live Bait Pathway: An Introduction

Amy Fowler, Post-Doctoral Teaching Fellow, Biology Department, Villanova University and Susan Park, Assistant Director for Research, Virginia Sea Grant

10:40 AM

Estimating Bycatch Risk: The Role of Selective Fishing in Species Invasions

Andrew Drake and Nicholas Mandrak, Fisheries and Oceans Canada

11:00 AM

Bycatch, Bait, Anglers, and Roads: Quantifying Vector Activity and Species Introduction Risk across Lake Ecosystems

Andrew Drake and Nicholas Mandrak, Fisheries and Oceans Canada

11:20 AM

One of These Things is not Like the Others – Prevalence of Non-target Species in Commercial Baitfish in Ontario

Jeff Brinsmead, Brenda Koenig, David Copplestone and Darryl Mitchell, Ontario Ministry of Natural Resources; Andrew Drake and Nicholas Mandrak, Fisheries and Oceans Canada

11:40 AM

Bait Fish in Quebec: New Regulatory Guidelines

Isabelle Desjardins, Ministère du Développement Durable, de l'Environnement, de la Faune et des Parc du Québec and Catherine Brisson-Bonenfant, Ministère des Ressources naturelles et de la Faune

12:00 PM

Luncheon

Session B-7: Strategy Room 2

Dreissenid Control I

Session Chair: Cherie-Lee Fietsch
Bruce Power

10:00 AM

Invited Keynote Presentation

A Perspective on the Use of Biological Control Methods for *Dreissena* Management: The Past, the Present, the Future

Daniel P. Molloy, Research Scientist and Adjunct Professor, State University of New York at Albany

10:40 AM

Quagga Mussels and Lake Mead: Recent Trends and Mitigation

Todd Tietjen, Eric Wert, Julia Lew and Peggy Roefer, Southern Nevada Water Authority

11:00 AM

UV Irradiation as a Means of Minimizing Downstream Settlement of Quagga Mussel Veligers

Renata Claudi and Thomas Prescott, RNT Consulting Inc.; Yzhak Rosenberg, Benzi Shoval and Yariv Abramovich, Atlantium Technologies Inc.

11:20 AM

Water Level Manipulation During Harsh Environmental Conditions as a Tool for Mitigating Effects of Invasive Dreissenid Mussels in Impounded River Sections

Rob Leuven, Frank P.L. Collas, Remon (K.R.) Koopman, Jon Matthews and Gerard. Van der Velde, Radboud University Nijmegen

11:40 AM

Watercraft Interception Programs for Dreissenid Mussels in the Western United States

Stephen Phillips, Pacific States Marine Fisheries Commission

12:00 PM

Luncheon

Session C-7: Strategy Room 3

Aquatic Plants I

Session Chair: Lyn Gettys, University of Florida, Institute of Food and Agricultural Sciences (IFAS), Center for Aquatic and Invasive Plants (CAIP)

10:00 AM

Invited Keynote Presentation

Critical Keys to Success Learned from Florida's Aquatic and Wetland Invasive Plant Management Program in Public Natural Areas and Why Invasive Plant Research and Outreach are Essential for Advancement

Don Schmitz, Research and Outreach Program Manager, Invasive Plant Management Section, Florida Fish and Wildlife Conservation Commission

10:40 AM

Registration of Minor Use Pesticides for Control of Aquatic Nuisance Species

William Haller and Lyn Gettys, University of Florida, IFAS CAIP

11:00 AM

Application of the Aquatic Weed Risk Assessment Model to Manage Aquatic Weeds

Paul Champion and John Clayton, National Institute for Water & Atmospheric Research (NIWA)

11:20 AM

Pet Stores, Aquarists and the Internet Trade as Modes of Introduction and Spread of Invasive Macrophytes in South Africa

Grant Martin and Julie Coetzee, Rhodes University

11:40 AM

Do Codes-of-Conduct Increase Public Awareness and Engagement in Problems with Aquatic Invasive Plants?

Laura Verbrugge, Rob Leuven and Riyan van den Born, Radboud University Nijmegen

12:00 PM

Luncheon

Session D-7: Strategy Room 5/6

Other Bivalves I

Session Chair: Maria Edith Rolla
Usina Hidrelétrica Serra do Facão (SEFAC)

10:00 AM

Invited Keynote Presentation

How Other Freshwater Exotic Bivalves Differ from Invasive Ones, or Why they are Not Invasive

Gerald L. Mackie, Professor Emeritus, University of Guelph and Owner, Water Systems Analysts

10:40 AM

Forecasting the Invasion of *Limnoperna fortunei* in Brazil: Experimental Knowledge Versus Environmental Niche Modeling

André Alves Andrade[1], Mônica de Cássia Souza Campos[1,2], Fabiano Alcisioe Silva[1], Hellen Regina Mota[3], Marcela David de Carvalho[3], Antônio Valadão Cardoso[1,2], [1]Centro de Bioengenharia de Espécies Invasoras de Hidrelétricas (CBEIH); [2]Fundação Centro Tecnológico de Minas Gerais (CETEC); [3]Companhia Energética de Minas Gerais (CEMIG)

11:00 AM

Forecasting the Invasion of *Limnoperna fortunei* at a Global Scale

Bárbara Gomes Kunzmann[1], Danielle Diniz Galvão[1], Mônica de Cássia Souza Campos[1,2], Fabiano Alcísioe Silva[1], André Felipe Alves de Andrade[1], Hellen Regina Mota[1], Marcela David de Carvalho[3], Antônio Valadão Cardoso[1,2], [1]Centro de Bioengenharia de Espécies Invasoras de Hidrelétricas (CBEIH); [2]Fundação Centro Tecnológico de Minas Gerais (CETEC); [3]Companhia Energética de Minas Gerais (CEMIG)

11:20 AM

Comparing Spatial Distribution Models to Predict the Potential Invasion Area of the *Limnoperna fortunei* (Dunker 1857)

Danielle Diniz Galvão[1]; Bárbara Gomes Kunzmann[1], Mônica de Cássia Souza Campos[1,2], Fabiano Alcísio e Silva[1], André Felipe Alves de Andrade[1], Hellen Regina Mota[3]; Marcela David de Carvalho[3], Antônio Valadão Cardoso[1,2], [1]Centro de Bioengenharia de Espécies Invasoras de Hidrelétricas (CBEIH); [2]Fundação Centro Tecnológico de Minas Gerais(CETEC); [3]Companhia Energética de Minas Gerais (CEMIG)

11:40 AM

Characterization of the Foot of Invasive Species *Limnoperma fortunei* (Dunker, 1857) by Electron Microscopy

Mônica de Cássia Souza Campos[1,2], Arnaldo Filho Nakamura[1], João Locke Ferreira de Araújo[1], Hellen Regina Mota[3], Marcela David de Carvalho[3], Antônio Valadão Cardoso[1,2], [1]Centro de Bioengenharia de Espécies Invasoras de Hidrelétricas (CBEIH); [2]Fundação Centro Tecnológico de Minas Gerais (CETEC); [3]Companhia Energética de Minas Gerais (CEMIG)

12:00 PM

Luncheon

Wednesday, April 24, Afternoon

Session A-8: Strategy Room 1

Live Bait Pathway II

Session Chair: Amy Fowler
Villanova University

1:30 PM

The HACCP Approach to Prevent the Spread of Aquatic Invasive Species by Aquaculture and Baitfish Operations

Ronald Kinnunen, Michigan State University; Jeffrey Gunderson, University of Minnesota

1:50 PM

Arkansas Certified Commercial Bait and Ornamental Fish Program: A Method to Prevent Aquatic Invasive Species Introductions

Anita Kelly and Nathan Stone, University of Arkansas at Pine Bluff

2:10 PM

Live Bait as a Potential Vector for Crayfish Introductions in Pennsylvania: Problem and Potential Solutions

David A. Lieb, Pennsylvania Fish & Boat Commission and Western Pennsylvania Conservancy; John R. Wallace, Millersville University, Department of Biology

2:30 PM

Live Bait in Maryland: What We Know, Don't Know, but Need to Know to Effectively Manage this Invasive Species Vector

Jay Kilian and Ronald Klauda, Maryland Department of Natural Resources, Resource Assessment Service

2:50 PM

Bait Shop "Toolkit" and Outreach: Engaging Bait Shops as Opinion Leaders in the Prevention of Aquatic Invasive Species

Bret Shaw and Allison Howell, University of Wisconsin

3:10 PM

Networking Break

Session B-8: Strategy Room 2

Dreissenid Control II

Session Chair: Stephen Phillips
Pacific States Marine Fisheries Commission

1:30 PM

Integrated Approach to Managing Mussels – Resources and Benefits

Stanley B. Pickles, Bruce Power

1:50 PM

Evaluating Aquatic Herbicides for Potential Control of Quagga and Zebra Mussels

Carolina Taraborelli and Renata Claudi, RNT Consulting Inc.; Scott O'Meara, Bureau of Reclamation; Jeffrey Janik and Tanya Veldhuizen, California Department of Water Resources

2:10 PM

Release Coatings Combat Fouling in Power Generation and Water Treatment Facilities – Four Case Histories

Steve Escaravage, FUJIFILM Hunt Smart Surfaces, LLC

2:30 PM

Control of Dreissenid Mussels through pH Adjustment

Renata Claudi and Thomas Prescott, RNT Consulting Inc.

2:50 PM

Protecting Irrigation Systems from Dreissenid Mussel Infestation – Case Study

CANCELLED

Andrew Jamieson, Agriculture and Agri-Food Canada

3:10 PM

Networking Break

Session C-8: Strategy Room 3

Aquatic Plants II

Session Chair: William Haller
University of Florida, Institute of Food and Agricultural Sciences (IFAS), Center for Aquatic and Invasive Plants (CAIP)

1:30 PM

Invasion Pathways for Invasive Aquatic Species: Case Studies from Florida (USA)

Lyn Gettys, William Haller and Kathryn Wilson, University of Florida, IFAS CAIP

1:50 PM

Patterns of Impact of Three Invasive Plant Species on Freshwater Ecosystems

Iris Stiers and Ludwig Triest, Vrije Universiteit Brussel

2:10 PM

Decrease of Macrophyte Species Diversity of Pond Ecosystems by an Invasive Wetland Plant: *Alternanthera philoxeroides*

Anindita Chatterjee and Anjana Dewanji, Indian Statistical Institute

2:30 PM

Monitoring the Spread of *Alternanthera philoxeroides* in the Indian Context

Anjana Dewanji, Anindita Chatterjee and Achyut K. Banerjee, Indian Statistical Institute

2:50 PM

A Mathematical Approach for Predicting the Spread of Alligator Weed (*Alternanthera philoxeroides*) in Wular Lake, India

Ather Masoodi and Fareed A. Khan, Aligarh Muslim University; Anand Sengupta, Indian Institute of Technology; Gyan P. Sharma, University of Delhi

3:10 PM

Networking Break

Session D-8: Strategy Room 5/6

Other Bivalves II

Session Chair: Gerald L. Mackie
Professor Emeritus, University of Guelph and Owner, Water Systems Analysts

1:30 PM

The Invasive Bivalve Genus *Corbicula* as a Key Model to Androgenesis

Karine Van Doninck, Emilie Etoundi and Lise-Marie Pigneur, University of Namur

1:50 PM

The Key to Being a Successful Invader? Be Asexual?! The Case of *Corbicula* Clams

Emilie Etoundi, Lise-Marie Pigneur, Jonathan Marescaux and Karine Van Doninck, University of Namur; Nina Yasuda, University of Miyazaki; David Aldridge, Cambridge University

2:10 PM

An Examination of the Potential Vectors and Pathways of Spread for *Corbicula fluminea* in Ireland

Rory Sheehan and Frances Lucy, Institute of Technology Sligo; Joseph M. Caffrey, Inland Fisheries Ireland

2:30 PM

Factors Affecting the Distribution, Abundance and Condition of an Aquatic Invader (*Corbicula fluminea*) along a Thermal Gradient

Rowshyra Castaneda and Anthony Ricciardi, McGill University; Anouk Simard, Ministère des Ressources naturelles et de la Faune

2:50 PM

Progression of Asian Clam (*Corbicula fluminea*) in the St. Lawrence River: Is the Species Restricted to the Thermal Plume of Gentilly Nuclear Station

Anouk Simard[1], Rémi Bacon[2], Rowshyra Castaneda[3], Kayla Hamelin[3], Annie Paquet[1], Sophie Plante[1] and Anthony Ricciardi[3], [1]Ministère du Développement durable de l'Environnement de la Faune et des Parcs (MDDEFP); [2]Ministère des Ressources naturelles, Trois-Rivières; [3]Université McGill, Montréal

3:10 PM

Networking Break

Session A-9: Strategy Room 1

Live Bait Pathway III

Session Chair: Susan Park
Virginia Sea Grant

3:40 PM
Bait Worm Packaging as a Conduit for Organism Introductions: Research and Outreach Lead to Policy Considerations
Nancy Balcom, Connecticut Sea Grant/University of Connecticut; Charles Yarish, Senjie Lin, Senjie Lin, Robert Whitlatch, Noreen Blaschik and Huan Zhang, University of Connecticut; Christina Haska, Great Lakes Fishery Commission; George Kraemer, Purchase College

4:00 PM
Preventing AIS Introductions through Vector Management: The Value of Connections
Jenny Allen and Fredrika Moser Maryland Sea Grant; John Ewart, Delaware Sea Grant; Sara Mirabilio, North Carolina Sea Grant; Susan Park, Virginia Sea Grant; Peter Rowe, New Jersey Sea Grant; Sarah Whitney, Pennsylvania Sea Grant

4:20 PM
Harvest to Hook: An Anthropological Look at the Worm Weed Vector for Aquatic Invasive Species
Jeremy Trombley, University of Maryland College Park

4:40 PM
Importation of Baitworms and their Live Algal Packing Materials to the Mid-Atlantic: Vector Characterization and Management
Amy Fowler, Villanova University; Fredrika Moser, Maryland Sea Grant; April Blakeslee, Long Island University; Joao Canning-Clode, University of Lisbon; A. Whitman Miller and Gregory Ruiz, Smithsonian Environmental Research Center

5:00 PM
Importation of Baitworms and their Live Algal Packing Materials to the Mid-Atlantic: Experimental Treatment of Algae to Reduce Live Hitchhikers
April Blakeslee, Smithsonian Environmental Research Center and Long Island University; Amy Fowler, Smithsonian Environmental Research Center and Villanova University; A. Whitman Miller, Smithsonian Environmental Research Center; Fredrika Moser, Maryland Sea Grant College; Joao Canning-Clode, Smithsonian Environmental Research Center and University of Lisbon; Gregory Ruiz, Smithsonian Environmental Research Center

Session B-9: Strategy Room 2

Dreissenid Control III

Session Chair: Rob Leuven
Radboud University Nijmegen

3:40 PM
Evaluation of New Coating Technologies for Mitigation of Zebra/Quagga Mussel Colonization – An Update
David Tordonato, Allen Skaja and Bobbi Jo Merten, Bureau of Reclamation

4:00 PM
Zebra Mussel Control Using Zequanox® in an Irish Waterway
Sara Meehan and Frances Lucy, Institute of Technology Sligo; Bridget Gruber, Marrone Bio Innovations

4:20 PM
Zequanox® Demonstration Trials at DeCew II Generating Station at Ontario Power Generation to Control Dreissenid Mussels
Tony Van Oostrom, Ontario Power Generation; Sarahann Rackl, Bridget Gruber and Carolyn Link Marrone Bio Innovations; Kelly Murray, ASI Group

4:40 PM
Strategies for Controlling Invasive Zebra and Quagga Mussels in Open Water Bodies
Dave Roberts and Megan Weber, Marrone Bio Innovations

5:00 PM
Effectiveness of an Algaecide for Killing Invasive Quagga Mussels and Preventing their Colonization
David W.H. Wong, Ashlie Watters and Shawn Gerstenberger, University of Nevada Las Vegas

5:20 PM
Taking No Prisoners: Beating Back Invasive Species
Leonard Willett, Bureau of Reclamation

CANCELLED

Session C-9: Strategy Room 3

Aquatic Plants III

Session Chair: Lyn Gettys
University of Florida, Institute of Food and Agricultural Sciences (IFAS), Center for Aquatic and Invasive Plants (CAIP)

3:40 PM
Establishing Research and Management Priorities for Monoecious Hydrilla as it Invades Northern Tier States
Michael Netherland, U.S. Army Engineer Research and Development Center; Mike Greer, U.S. Army Corps of Engineers Buffalo District

4:00 PM
The Distribution and History of *Myriophyllum spicatum* L. (Haloragaceae) in Southern Africa, with Reference to Potential Origins, Modes of Introduction and Spread
Philip Weyl and Julie Coetzee, Rhodes University

4:20 PM
Range and Survival of Two Alien Macrophytes (*Eichhornia Crassipes* and *Pistia Stratiotes*) in the Great Lakes
Amanda Eyraud and Hugh MacIsaac, University of Windsor, Great Lakes Institute for Environmental Research

4:40 PM
Linking Native and Exotic Aquatic Plant Palatability to Herbivores with Shared or Unshared Home Ranges: A Trait-Based Approach
Bart M.C. Grutters and Elisabeth S. Bakker, Netherlands Institute of Ecology, Department of Aquatic Ecology

5:00 PM
Effects of Supplemental Stocking of Milfoil Weevils (*Euhrychiopsis lecontei* Dietz) on Eurasian Watermilfoil (*Myriophyllum spicatum* L.) Density in a Heavily Infested Lake
Paul M. Skawinski and Ronald Crunkilton, University of Wisconsin - Stevens Point, College of Natural Resources

Session D-9: Strategy Room 5/6

Early Detection and Monitoring IV

Session Chair: Margaret (Peg) Brady
NOAA

3:40 PM
Invasive Species Surveillance of the Great Lakes Basin Commercial Bait Trade Using Environmental DNA Surveillance
Lucas Nathan and Andrew Mahon, Central Michigan University; Michelle Budny and Christopher Jerde, University of Notre Dame

4:00 PM
DNA Shedding Rates of Asian Carps, for Use in Understanding Field Collections of eDNA
Katy Klymus, University of Missouri; Duane Chapman, U.S. Geological Survey, Columbia Environmental Research Center; Cathy Richter, U.S. Geological Survey; Craig Paukert, U.S. Geological Survey–University of Missouri

4:20 PM
A Real-Time PCR Assay with Internal Controls to Detect and Quantify the Fish Viral Hemorrhagic Septicemia Virus (VHSv): Conversion from StaRT-PCR
Vrushalee Palsule, Lindsey Pierce, Jiyoun Yeo, Erin Crawford, James Willey and Carol Stepien, University of Toledo

4:40 PM
First Discovery of Golden Star Tunicate in Conception Bay, Newfoundland and a Case Study Mitigation Attempt to Control its Spread
Terri Wells, Cynthia McKenzie, Brooks Pilgrim, Henry Coley and Ann Marie Tucker, Fisheries and Oceans Canada; Don Deibel, Ben Lowen, Bob O'Donnell, Mark O'Flaherty and Andrew Perry, Memorial University of Newfoundland; Trevor Lewis, Foxtrap Marina Harbour Authority

5:00 PM
Early Warning Program to Manage the Introduction and Spread of Invasive Species in the Wadden Sea, a World Heritage Protected Ecosystem
Andrea C. Sneekes, N.H.B.M. Kaag, H. Van Pelt, B. vd Weidde, A. Gittenberger, K. Philippart, J. Boon, S. Rajagopal and J.M. Jansen, IMARES, Wageningen UR, Institute for Marine Resources and Ecosystem Studies

Plenary Session: Great Room B/C

Session Chair: Robert G. Lambe, Conference Chair and Executive Director, Invasive Species Centre

8:30 AM
Invited Keynote Presentation
Pathways for Introduction of Alien Invasive Species Exclusive of International Shipping: A Canadian Experience
Hugh J. MacIsaac, Professor, University of Windsor, Great Lakes Institute for Environmental Research and Director, NSERC Canadian Aquatic Invasive Species Network II

9:15 AM
Conference Synthesis
Robert G. Lambe, Conference Chair and Executive Director, Invasive Species Centre

9:30 AM
Networking Break

Session A-10: Strategy Room 1

AIS Control I

Session Chair: Sanjeevi Rajagopal
Radboud University Nijmegen

9:50 AM
Pilot Project to Eradicate Invasive Alien Smallmouth Bass Using a Piscicide from a Conservation Priority River in South Africa: Rationale, River Treatment and Way Forward
Johannes Adriaan van der Walt and Ben van Staden, CapeNature

10:10 AM
Biological Control of Golden Apple Snail by Black Carp in a Freshwater Wetland
Kelvin K.L. Ip and Qiu Jian Wen, Hong Kong Baptist University

10:30 AM
Management of Alien Invasive Algae in Kaneohe Bay, Oahu through the Use of Mechanical Removal and Bio-control Efforts
Jonathan Blodgett and Frank Mancini, Hawaii Department of Land & Natural Resources, Division of Aquatic Resources

10:50 AM
Reproductive Sterility as a Tool for Prevention and Control of Aquatic Invasive Species
John Teem, Florida Department of Agriculture and Consumer Services

11:10 AM
Developing a Theoretical and Experimental Framework for the Trojan Y Chromosome Eradication Strategy
John Teem, Florida Department of Agriculture and Consumer Services; Juan Gutierrez, University of Georgia

11:30 AM
Integrated Pest Management of the Common Carp in the American Midwest
Peter Sorensen and Przemek Bajer, University of Minnesota

11:50 AM
Invasive Species Fouling and Industrial Cooling Water Systems
Sanjeevi Rajagopal[1,2], Jeroen M. Jansen[2], Gerard van der Velde[1], [1]Radboud University Nijmegen, Institute for Wetland and Water Research, Department of Animal Ecology and Ecophysiology; [2]Wageningen University, Institute for Marine Resources and Ecosystem Studies (IMARES)

Session B-10: Strategy Room 2

Other Pathways I

Session Chair: Debrupa Pathak
Ontario Ministry of Natural Resources

9:50 AM
Non-Indigenous Species Transported on Tsunami Marine Debris: Learning and Informing Response to a Natural Disaster Driven Invasive Species Pathway of Emerging Concern
Samuel Chan, Oregon State University

10:10 AM
Are Anglers and Kayakers Acting as Vectors for Alien Invasive Species in UK Freshwaters?
Lucy Anderson[1], Piran White[3], Paul Stebbing[2], Grant Stentiford[2], Alison Dunn[1], [1]University of Leeds; [2]Centre for Environment, Fisheries & Aquaculture Science; [3]University of York

10:30 AM
Evaluating the Risk of Direct Movement of Fishes through the Welland Canal
Jaewoo Kim and Nicholas Mandrak, Fisheries and Oceans Canada

10:50 AM
Fish Behavior and Abundance at the Electric Dispersal Barrier in the Chicago Sanitary and Ship Canal, Illinois, USA
Aaron Parker, P. Bradley Rogers, Jeffrey Stewart, Samuel Finney and Robert Simmonds Jr., U.S. Fish & Wildlife Service

11:10 AM
Restoring the Natural Divide: Separating the Great Lakes and Mississippi River Basins in the Chicago Area Waterway System
Erika Jensen and Tim Eder, Great Lakes Commission; Dave Ullrich, Great Lakes and St. Lawrence Cities Initiative

11:30 AM
Addressing the Champlain Canal as a Vector of AIS
Margaret Modley, Lake Champlain Basin Program

11:50 AM
Examination of Asian Swamp Eels (Synbranchidae: *Monopterus* spp.) from Ethnic Food Markets in Florida, Georgia, New York and Four Wild Populations in New Jersey and Florida, for the Presence of Zoonotic Advanced L3 of *Gnathostoma* spp. (Nematoda)
Rebecca Cole and Kathryn Griffin, U.S. Geological Survey, National Wildlife Health Center; Leo Nico, U.S. Geological Survey, Southeast Ecological Science Center; Anindo Choudhury, St. Norbert College

CANCELLED

Session C-10: Strategy Room 5/6

Crustaceans IV

Session Chair: Darryl Mitchell
Ontario Ministry of Natural Resources

9:50 AM
Interaction of a Chemical Stress and a Predation Risk on the Behaviour of Two Prolific Species: The 'Killer Shrimp' *Dikerogammarus villosus* and the Naturalised Amphipod *Gammarus roeseli*
Jean-Nicolas Beisel, Eric Gismondi, Pascal Sornom and Céline Véllinger, Université de Lorraine, Laboratoire Interdisciplinaire des Environnements Continentaux (LIEC)

10:10 AM
Loss of Pathogens in an Island Population of the Killer Shrimp *Dikerogammarus villosus*
Grant D. Stentiford and Kelly S. Bateman, European Union Reference Laboratory for Crustacean Diseases and Centre for Environment, Fisheries and Aquaculture Science (CEFAS); Jamie Bojko, CEFAS and University of Leeds; Paul Stebbing, CEFAS; James Meatyard, Anglian Water Central Laboratory, Biology Department; Karolina Bacela-Spychalska, University of Lodz, Department of Invertebrate Zoology & Hydrobiology; Alison M. Dunn, University of Leeds, Faculty of Biological Sciences

10:30 AM
Impact of Invasive Crayfish on Macrophytes: Are Some Species Worse than Others?
Elisabeth S. Bakker and Martijn Dorenbosch, Netherlands Institute of Ecology, Department of Aquatic Ecology (NIOO-KNAW)

Session D-10: Strategy Room 3

Shipping Pathways IV

Session Chair: Christopher J. Wiley
Transport Canada Marine Safety

9:50 AM
Third Prototype Shipboard Filter Skid (p3SFS): Results of Shipboard Installation and Testing
Timothy Wier, U.S. Naval Research Laboratory-Excet Incorporated; Cameron Moser and Lisa Drake, U.S. Naval Research Laboratory; Jonathan Grant, Battelle Technologies, Inc.; Matthew First, Stephanie Robbins-Wamsley and Scott Riley, SAIC, Inc.

10:10 AM
Life after Treatment: Detecting Viable, Aquatic Microorganisms Following Exposure to UV Light and Chlorine Dioxide
Matthew First, Stephanie Robbins-Wamsley and Scott Riley, SAIC, Inc.; Lisa Drake, U.S. Naval Research Laboratory

10:30 AM
What is the Uncertainty Associated with the Measurements of Living Organisms Concentrations at Ballast Water Test Facilities?
Lisa Drake, U.S. Naval Research Laboratory; Matthew First, Stephanie Robbins-Wamsley and Scott Riley SAIC, Inc.; Evan Parson, Vision Point Systems

10:50 AM
The 'Sample Port Calculator': A Design and Analysis Tool for Ballast Water Sampling Ports
Jonathan Grant, Battelle Technologies, Inc.; Cameron Moser and Lisa Drake, U.S. Naval Research Laboratory; Timothy Wier, U.S. Naval Research Laboratory-Excet Incorporated

CANCELLED

Strategy Room 3

How to Create and Operate a Successful Cooperative Invasive Species Management Area (CISMA)

The North American Invasive Species Network (NAISN) is hosting this workshop. Pre-registration is required. Complete the registration form on the ICAIS website or contact the Conference Administrator by telephone or email.

1:30 pm to 5:00 pm

This workshop will be conducted by Mr. Tony Pernas, Co-Chair, Everglades Cooperative Invasive Species Management Area (ECISMA) and Coordinator, U.S. National Park Service. ECISMA was awarded the U.S. Department of Interior's 2012 Partners in Conservation Award for outstanding conservation achievements attained through collaboration and partnership with others. ECISMA has over 200 partners that tackle tough invasive species issues such as multiple public landowners with different management mandates and missions and a large diverse invasive species flora and fauna. Additional speakers may also present information at this workshop.

Topics to be discussed include:

- How to choose an initial leader or champion
- The importance of establishing trust, finding common ground
- Building support, developing an agreement
- The importance of a steering committee
- Developing an overall strategic plan
- Why communication is critical to success
- Developing successful education and outreach efforts
- Why cooperative work projects help erase bureaucratic barriers and foster team building
- Sharing resources in a multi-jurisdictional environment

Plenary Session

Why Invasions Matter: A Response to Recent Criticisms of Invasion Biology

***Anthony Ricciardi**, Associate Professor, Redpath Museum and McGill School of Environment, McGill University*

In recent years, there have appeared several opinion articles in the scientific literature and the popular media that downplay the impacts of biological invasions and, furthermore, question the scientific merit of attempting to prevent incursions of non-native species. Collectively, these articles assert that 1) modern invasions are "nothing new", i.e. the magnitude and impacts of recent invasions are similar to those that have occurred prehistorically – and, thus, the role of humans in the modern mass invasion event and concern over its consequences has been over stated; 2) with rare exceptions, non-native species are innocuous passengers, rather than drivers, of changes to biodiversity and ecosystem functioning; and 3) non-native species are no more likely than natives to cause undesirable impacts, and so the biogeographic origins of species are not relevant to conservation and resource management. I will show that each of these assertions is refuted by a growing body of empirical evidence. Using examples drawn largely from freshwater and marine invasion studies, I will demonstrate the importance of incorporating biogeographic and evolutionary context in the risk assessment of invasions.

NOTES

Surveys, Surveillance and Monitoring – Strategies for Early Detection and Long-term Management of Aquatic Invasive Species

Chad L. Hewitt, *Pro Vice-Chancellor (Research) and Marnie L. Campbell, Chair in Ecological Security, Central Queensland University, School of Medical and Applied Sciences*

Aquatic introductions have occurred throughout the world's freshwater and ocean systems and represent a significant factor in human-mediated global change. An evaluation of globally recognised marine and estuarine introductions number more than 2700 species; with recognition that numerous species are in transit daily which have either failed to establish or have not been detected in receiving environments. Aquatic biosecurity is the protection of the aquatic environment from impacts of non-indigenous species, and typically focusses on risk based allocation of resources across three stages of response and management: 1) pre-border or quarantine activities emphasise prevention of the entry (transport pathway treatment); 2) border activities that include early detection and border surveillance for pests and diseases, short-term response to detections; and 3) post-border activities including eradication and long-term control of established pests (e.g., integrated pest management).

Key to understanding risk and allocating resources is the knowledge of species arrivals and distributions, particularly in light of each biosecurity stage. This requires a baseline understanding of native and previously introduced biodiversity, against which new additions to the biota can be assessed.

Here we adapt the terminology of Hellawell (1991):

- Survey is an exercise in which a set of observations is made without any pre-conception of what the finding ought to be;
- Surveillance is the replication of surveys using similar methods to assess changes against an established baseline; and
- Monitoring for biosecurity is the systematic collection of data or information over time to ascertain the extent of compliance with a pre-determined standard or position, typically focussed on target species or locations.

Many surveys attempt to establish a field baseline, against which all subsequent surveillance and monitoring can be compared and allowing sampling designs to be optimised thus increasing our ability to detect invasion patterns and biotic/abiotic relationships. The linkages between baseline evaluations and further surveillance and monitoring activities provides the ability to further understanding of invasion ecology as well as development of appropriate biosecurity outcomes including: knowledge based, pro-active (pre-border) approaches to transport pathways (eg ship related ballast water and biofouling, aquaculture); rapid border responses to newly detected incursions through surveillance and monitoring activities; post-border evaluations of policy and management interventions (such as control and eradication strategies) including the effectiveness and validity of actions.

We discuss the considerations, design strategies and techniques for baseline surveys, surveillance and monitoring of non-indigenous aquatic species, relying specifically on approaches in Australia and New Zealand over the last 15 years.

NOTES

Strategy for Designing a Regional Network for AIS Monitoring, Detection, and Response

Bill Bolen*, U.S. Environmental Protection Agency*

The establishment of an integrated program for aquatic invasive species (AIS) detection, monitoring, and response presents a number of challenges. First and foremost is the need to bring together a diverse group of governmental agencies that may have far different jurisdictional authorities, funding sources, mission statements, and policies. The most effective network requires coordination across local, state, tribal, federal, and at times, binational boundaries. The goal of this presentation is to showcase several key regional and binational examples that are either under development or have been implemented to date. A particular emphasis will be place on hurdles and lessons learned so that attendees can gain an appreciation of what they may encounter as they engage in similar activities in their geographic domain.

NOTES

A Multi-Jurisdictional Approach to Asian Carp in the Upper Illinois River and Chicago Area Waterway System

***Kevin Irons**, Illinois Department of Natural Resources*

Agencies from bi-national, federal, state, provincial, local, and non-governmental agencies are collaborating in a state of the science approach to stop the advancement of an aquatic nuisance species. Bighead and silver carp have been spreading from the southern U.S. states and throughout the Mississippi River watershed (including the Missouri, Ohio, and Illinois rivers) since their introduction into the U.S. in the mid-1970s. Although monitoring and concerted state and local efforts were working on this issue, a concerted effort with national support began in 2010. The Asian carp Regional Coordinating Committee organized multi-jurisdictional agencies from NGO, local, state, and federal entities to manage these species spread, even to the point of including Canadian provincial and federal agencies. From multi-million dollar response efforts using pesticides to regimented monitoring and communication efforts, these groups are working together in unprecedented ways to prevent an aquatic nuisance species access to the next great ecosystem. This method may be providing a framework for responses in the natural resource world to be modeled and emulated. This framework embraces Incident command and rapid responses, coordinating funding and support, as well as managing time and schedules to achieve a focused research and management need. It also allows for a multi-disciplinary team to address engineering, safety, command, science, and management in a concerted effort. This talk will document the ongoing efforts and suggest this may change the way natural resources are managed as economically any one agency would struggle to do it all in the future.

NOTES

AIS Integration into Existing Monitoring Programs: Lessons Learned in Michigan

***Sarah LeSage** and Sue Tangora, Michigan Department of Environmental Quality*

Cost effective approaches to monitoring and early detection of AIS are essential. A number of government agencies, non-government organizations, organized volunteers, and private citizens monitor Michigan's waters. Many of these programs were designed for purposes other than AIS early detection and rapid response (EDRR) and utilize both active and passive mechanisms.

Challenges exist in integrating AIS awareness and monitoring into existing programs, especially focusing on EDRR species. The lack of easily accessible and relevant information is a barrier for groups and individuals to focus on EDRR species. Many groups are impacted by widespread AIS and attention is placed on control of those species versus EDRR species. Multiple reporting repositories and a lack of communication among programs and groups add to the challenges.

Michigan is using Great Lakes Restoration Initiative (GLRI) funding sources to help develop and implement a strategy to coordinate and enhance existing programs, with special attention to engaging local stakeholders. The building of this monitoring network increases capacity to detect new aquatic invasive species in Michigan and allows for better collaboration with neighboring states and countries.

NOTES

Early Detection and Monitoring of Exotic Invasive Plants in Quebec: Building Networks with Citizen Scientists in the Context of Climate Change

***Isabelle Simard**, Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs, Québec*

Early detection of exotic invasive species is crucial in limiting their negative impacts and reducing the costs of control and eradication. Building efficient detection networks is essential given the limited resources. Stakeholders and citizen scientists are the key players in these networks. The results of a successful monitoring program for invasive plants in the wetlands of the St. Lawrence will be presented, along with new tools and networks that will be rolled out in 2013. Attention will be focused on the detection and monitoring of invasive plants in the context of climate change. The province of Quebec has to some degree been protected by a more rigorous climate, but global warming will be beneficial for many invasive plants. It is essential to detect these new invaders quickly and to monitor their spread towards ecosystems further north where the invaders are already apparent. Priority species, vectors, pathways and regional networks will be discussed.

NOTES

Crustacean Invaders: Past, Present and Future

***Jaimie T.A. Dick**, Professor of Invasion Ecology, Queen's University Belfast*

Crustaceans feature as aquatic invaders on a global scale and impact on native species through many direct mechanisms, such as competition, predation, hybridization and aggression. Further, invasive crustaceans impact recipient communities through more indirect mechanisms, such as disease transmission, trophic cascades and trait-mediated indirect interactions. Such invaders can also directly alter the physical and abiotic environment and directly impact human endeavours and economies. Here, I review the range of impacts of crustacean invaders and explore current knowledge and understanding of their myriad impacts. I then focus on the 'holy grail' of invasion ecology, that of prediction of the identities and likely impacts of emerging and new invaders. There are several fruitful avenues to explore with regards to such forecasting, such as invasion history, invader taxonomy, trait and functional group analyses, donor hotspots and analyses of invader resource usage compared to native species. Examples of these current approaches will be given, such as predictions of the ecological impacts of the ongoing invasion of Europe and North America by the 'bloody red shrimp' and the latest threats posed by the 'killer' and 'demon' shrimps in Europe and possibly further afield.

NOTES

Bloody-red Shrimp (*Hemimysis anomala*) Populations in Montreal Harbour Waters, St. Lawrence River: Potential Risk of Species Transfer

***Yves de Lafontaine**, Environment Canada; Jérôme Marty, St. Lawrence River Institute*

To access the level of variation in the potential risk of uptake and transfer of the bloody-red shrimp Hemimysis anomala (HA) by shipping, we describe the seasonal variation in population abundance and size structure of HA in Montreal Harbour waters, St. Lawrence River (Canada). Biweekly nighttime sampling showed seasonal variation from very low abundance of large-sized HA in early spring to very high densities of HA juveniles in late-August-early-September. Maximum densities exceeded 10 000 ind./m³ at the time of seasonal peak in water temperature. Variation of size structure of HA over time indicated the production of two reproductive cohorts in a year. Spatial survey conducted in early-fall revealed high level of spatial heterogeneity in HA distribution with high densities in port basins characterized by long residence time of water. We conclude that the potential risk of HA uptake and transfer by shipping will vary seasonally, being lowest during winter months and maximal in late summer and early-fall.

NOTES

Spatial and Temporal Variation in the Predatory Impact of an Invasive Mysid Shrimp (*Hemimysis anomala*)

*Mhairi Alexander[1], Anthony Ricciardi[2], Jaimie T.A. Dick[1], **Josephine Iacarella**[2,3], [1]Queen's University Belfast; [2]Redpath Museum, McGill University; [3]Groupe de recherche interuniversitaire en limnologie et en environnement aquatique (GRIL)*

Effective prioritization of invasion threats is hindered by context-dependent variation in the invader's impacts over space and time. Contributing to this variation are differences in the evolutionary experience (or lack thereof, i.e. naiveté) of native prey, and differences in behavior amongst individuals in the invading population. Colonists along invasion fronts are thought to be more aggressive than well-established individuals. The Eurasian freshwater mysid *Hemimysis anomala* is an invasive predator whose populations are expanding in northern Europe and the Great Lakes region. Little is known about its potential impact. A functionally-similar native species (*Mysis salemaai*) overlaps the invader's range in Ireland, whereas in North America the invader is segregated from its native counterpart. We tested the following hypotheses along temporal gradients of invasion in the Shannon River Basin, Ireland, and in the St. Lawrence River, North America (NA): 1) the predation rate of *H. anomala* is higher at the invasion front; 2) prey are more naïve (and thus vulnerable) to the invader in North America than in Ireland; and 3) differences in zooplankton communities will vary with time since invasion in NA, but not in Ireland where communities have experience with the functionally-similar native mysid. In reciprocal transplant experiments, individual *H. anomala* from the invasion front were placed in mesocosms at sites where it is well established, and vice versa. The mesocosms contained native zooplankton assemblages and the predation impact of *H. anomala* on these assemblages was measured after 8hrs. The experiments were conducted in Ireland and NA during summer 2012. In Ireland, zooplankton were also sampled at an additional site not yet invaded by *H. anomala* but containing the native mysid. The predation impact was further compared in the laboratory by measuring the functional responses of *H. anomala* from all experimental sites. These experiments revealed that *H. anomala* from the NA and Ireland invasion fronts are more efficient predators at lower prey densities. Individuals at the invasion front had high clearance rates on a wider range of natural zooplankton densities in NA and on densities of the preferred cladoceran prey in Ireland, concordant with its higher attack rates in the lab. Therefore, *H. anomala* may have a higher impact on low-density zooplankton at newly invaded sites than at sites where the mysid has been established longer.

NOTES

Understanding the Invasion Success and Ecological Impacts of Invasive Species: A Comparative Functional Response Methodology

Daniel Barrios-O'Neill[1], *Jaimie T.A. Dick*[1], *Mhairi Alexander*[1], *Helene C. Bovy*[1], *Anthony Ricciardi*[2], *Mark Emmerson*[1], [1]*Queen's University Belfast;* [2]*Redpath Museum, McGill University*

A key objective in invasion ecology is the development of new methodologies for rapidly and reliably assessing which non-native species have the potential to establish in new habitats and alter recipient communities. One promising approach, with the potential for practical and versatile application, involves comparative analysis of the relationships between resource availability and resource acquisition by species, i.e. their functional responses. Several recent studies have demonstrated that successful invaders show consistently higher functional responses towards mutual resources when compared to ecologically similar natives. To illustrate the potential application of this methodology, we present the results of several functional response studies on two highly invasive crustaceans which are currently spreading through Northern Europe; the mysid shrimp, *Hemimysis anomala* and the corophiid amphipod, *Chelicorophium curvispinum*. Our results demonstrate that: 1) the differences between the functional responses of two native and invasive consumers of the same trophic level are conserved even in the presence of higher predators; 2) laboratory-derived functional response curves generally corroborate field-derived functional response curves for the same species, although the latter can reveal subtle spatial and temporal variations that may be important when assessing impact; and 3) the functional responses of resident predators towards non-native species may also provide a useful method for assessing biotic resistance, but such experiments need to explicitly consider species-specific behaviours and ecological context.

NOTES

Novel and Emerging Tools to Assess the Impacts of Aquatic Invasive Species

Tim Johnson[1], *Shelley Arnott*[2], *Linda Campbell*[3], *Lucia Carreon*[4], *Meagan King*[1], *Kent McDonald*[1], *Brent Metcalfe*[1], *Mike Yuille*[1], *Chris Wilson*[1], [1]*Ontario Ministry of Natural Resources;* [2]*Queen's University;* [3]*Saint Mary's University;* [4]*University of Windsor*

When aquatic invasive species are first detected in novel ecosystems, scientists and managers are challenged to assess potential threat and impact associated with these organisms in a timely manner. *Hemimysis anomala* is a cryptic, nocturnally active zooplankton that has rapidly spread through the Laurentian Great Lakes and connecting waters in the past few years. Tasked with identifying potential threats to native biota, food webs, and contaminant dynamics we employed a variety of techniques to describe the distribution, ecology, and role of *Hemimysis* in the Lake Ontario food web. Standardised methods were developed to describe distribution and demographics at established sites, and eDNA was employed to investigate movement along the invasion front. Conventional diet analyses of predators resulted in low detection, in part related to rapid digestion rates. We developed DNA-based genetic screening tools for fish stomachs, and utilised stable isotopes to infer predation rates across a gradient of *Hemimysis* density. Bioenergetic models, combined with empirical observations of resident prey composition and abundance allowed us to predict growth response under different scenarios of *Hemimysis* establishment. Empirical models relating trophic position with mercury concentration enabled us to investigate effects on contaminant biomagnification. Finally, physiologic tolerance experiments allowed us to identify strategies to mitigate spread via recreational boating vectors. Overall, our studies utilised and adapted novel and emerging techniques to assess the potential impact of *Hemimysis anomala* on invaded ecosystems.

NOTES

Update on the Asian Carp Control Strategy Framework

***John Goss**, Asian Carp Director, White House Council on Environmental Quality*

The migration of Asian carp toward Lake Michigan is one of the most serious invasive species threats facing the Great Lakes today. Asian carp are voracious eaters and heavy breeders. Some varieties can grow to more than 60 pounds and are capable of eating 20 percent of their body weight in a day, stripping the food web of key sources for native species.

Since 2010, the Obama Administration has invested more than $150 million dollars to protect the Great Lakes from Asian carp. The scale of the effort has been unprecedented for invasive species prevention and unifies Federal, State, and local actions, employs a comprehensive approach to prevent a self-sustaining Asian carp population, and develops longer-term biological controls. This talk will provide an update on the Asian Carp Control Strategy Framework, which outlines the priority actions planned and under way to address the threat of Asian carp invading the Great Lakes, including both management actions to prevent Asian carp introduction and establishment, and research to develop permanent controls on Asian carp populations. The ACRCC is moving from the research and development phase towards implementation. The Framework can be found at www.asiancarp.us.

The U.S. Army Corps of Engineers is developing an assessment of the alternatives for permanent ecological separation with different types of barriers in the Chicago waterway system. USACE will report to Congress in late 2013 on the costs and effectiveness of the best options for blocking the transfer by water connections of all aquatic invasive species into and out of the Great Lakes. In 2014, the next challenge will be to develop a bi-national consensus on the preferred barrier system and to agree on a funding package to complete the task.

NOTES

Asian Carps – Science and Management Interplay in Canada

***Becky Cudmore**, Acting Manager, Canadian Asian Carp Program; Manager, National Centre of Expertise for Aquatic Risk Assessment; Senior Science Advisor, Aquatic Invasive Species, Fisheries and Oceans Canada*

Assessing the risk of potential aquatic invasive species allows for effective and efficient activities to be enacted. Proactive risk assessments have been conducted with respect to the Canadian and Great Lake Asian carp threat. In 2004, a national level risk assessment was conducted to determine the risk to Canadian waters and identify the pathways of greatest concern. This led to the federal Government of Canada support for the Province of Ontario ban of the possession and sale of live Asians carps. In 2011, a binational risk assessment was conducted that focused on the threat Bighead and Silver carps posed to the Great Lakes basin. This latest risk assessment used recent, up-to-date research conducted in the United States and Canada to refine the advice asked for by management agencies. The importance of science advice and research to inform effective policy and management activities, and the need to understand management needs and learn from management activities form the premise of the ICAIS Asian Carp Session. A brief overview of Canada's new Asian Carp Program will also be presented.

NOTES

Preliminary Assessment of the Suitability of Canadian Great Lakes Tributaries for Asian Carp Spawning

***Nicholas Mandrak**, Fisheries and Oceans Canada*

Grass Carp (*Ctenopharyngodon idella*), Bighead Carp (*Hypothalmichthys nobilis*), Silver Carp (*H. molitrix*), and Black Carp (*Mylopharyngodon piceus*), collectively known as Asian carps, are invasive species that have become established in the Mississippi River basin of North America and have had significant ecological and socio-economic impacts on its ecosystem. Previous risk assessments identified broad, potential risks to Canada and the United States, including the Great Lakes. These risk assessments included assessing the likelihood of establishment based on the availability of spawning and nursery habitats. Kocovsky et al. (2012) used more detailed data on thermal and hydrologic conditions to predict the suitability of eight tributaries in the western Lake Erie basin for Asian carp spawning. The objective of this study is to refine the predictions of suitable spawning tributaries in the Canadian Great Lakes basin (bound downstream in the St. Lawrence River at 45°N) using a predictive decision-tree based on the reproductive biology of Asian carps and methods of Kocovsky et al. (2012). Spawning conditions were determined to be very suitable or highly suitable in 12 of 14 Erie tributaries with sufficient gauging data, 20 of 29 Huron tributaries, 18 of 39 Ontario tributaries, three of four St. Lawrence tributaries in Ontario, and six of 12 Superior tributaries.

NOTES

A Stage-Structured Population Model for Bighead and Silver Carps in the Great Lakes

*Warren Currie and Marten Koops, Fisheries and Oceans Canada; **Kim Cuddington**, University of Waterloo*

We predicted the establishment probability of Bighead and Silver Carps in the Great Lakes using stage-structured models parameterized with literature data. In this system, there are rather few rivers that can be used for spawning (long rivers with turbulent mixing), but counter-intuitively, the small number of rivers increases the probability of finding mates. The population model, using realistic parameters, suggests that positive population growth is the expectation, and that this growth is most sensitive to juvenile survivorship and age at first reproduction. Various types of introduction were considered including single releases of subadults or adults or a continually leaky barrier. We examined various scenarios including advanced age-at-maturity, variable number of suitable spawning rivers, and different magnitudes of environmental stochasticity. The models suggest that even a single event where a few individuals are accidentally introduced into one of the Great Lakes has, under most conditions, a significant probability of establishing a population of Asian carps. The number of adult fish in a single release required for greater than 75% establishment probability in 20 years depended on the exact scenario, but was usually less than 20 (10 males and 10 females).

NOTES

Movements and Habitat Use of Silver Carp in the Wabash River, Indiana (USA)

Alison Coulter[1]*, Doug Keller*[2]*, Tom Stefanavag*[2]*, Jon Amberg*[3]*, Elizabeth Bailey*[1]*, Reuben Goforth*[1]*, [1]Purdue University; [2]Indiana Department of Natural Resources; [3]U.S. Geological Survey*

As Asian carp (*Hypopthalmichthys* spp.) continue to spread through the Midwestern United States, it is necessary to examine and evaluate their impacts on aquatic ecosystems. Movements and habitat use can give insight regarding a variety of potential influences and impacts. Recent recognition of the potential for introduction of Asian carp to the Maumee River basin via the Wabash River, Indiana, USA, has caused great concern given the Maumee River's connection to Lake Erie. In 2011, telemetry data showed that Asian carp are within 20 miles of the Maumee-Wabash connection. 163 individuals were tracked through 2011 and 2012 in the Wabash River and its tributaries using surgically implanted with Vemco V16 acoustic tags. Movements of these individuals were monitored with a combination of Vemco VR2W stationary receivers positioned in the main channel as well as tributaries. Manual tracking was also done using a Vemco VR100 receiver. Their movements appear to show seasonal variation, including potential spawning runs, as well as areas of aggregation.

NOTES

Assessment of Non-Planktonic Food Sources for Bigheaded Carps in the Laurentian Great Lakes

Michael Lucey, ***Duane Chapman****, Elizabeth Brothers, Karl Anderson and Karthik Massagounder, U.S. Geological Survey*

In recent years concern has mounted over the potential for invasive bighead (*Hypophthalmichthys nobilis*) and silver carps (*H. molitrix*) (together the bigheaded carps) to colonize the Great Lakes. Bioenergetics models have indicated that planktonic foods may be inadequate for bigheaded carps to successfully invade large portions of the Great Lakes. Bigheaded carps are primarily planktivores but in some cases switch to non-planktonic food such as detritus. We evaluated *Cladophora* and dreissenid mussel psuedofeces as potential food sources abundant in the Great Lakes that might be used by bigheaded carps in lieu of plankton. *Cladophora* is a filamentous alga that is common in the littoral zones of the Great Lakes and has become much more abundant since the dreissenid mussel invasion. Dreissenid mussel pseudofeces are fine, organically enriched particles that are highly available and also result from the dreissenid invasion. We used feeding experiments, underwater video and bomb calorimetry to evaluate fish growth and feeding behavior and caloric content to test the viability of these alternative foods. Results show that bigheaded carps can maintain their weight on both *Cladophora* and dreissenid mussel psuedofeces suggesting that alternative foods exist in the Great Lakes.

NOTES

The Role that the Zebra Mussel and ICAIS Conferences Have Played in Reducing the Risk of AIS Being Discharged from Ships' Ballast Water

Christopher J. Wiley, *Fisheries and Oceans Canada/Transport Canada Marine Safety*

It began in the 1990s with the Zebra Mussel Conferences, which evolved into the International Conferences on Aquatic Invasive Species, and collectively these conferences have played a key role in providing the opportunity for a two-way dialogue between scientists and regulators in regards to the introduction and spread of aquatic invasive species through the shipping vector.

This is unique within the maritime industry. No other conference or series of conferences has given scientists a direct conduit to the regulators, manufacturers of technology and the commercial shipping industry, which in turn has led to advances in science that have driven the development of processes and technologies to deal with the wide range of ballast water issues. Over the 22-year time span of these conferences, regulators have used them as a means for outreach and policy development. Those involved with ballast water technology have used them as the primary forum to announce (and in some cases to display) the most recent technological developments for ballast water management and treatment. From the early days of ships being identified as "the problem" to the many steps in the evolution of "the global solution", these conferences have and will continue to track the process.

NOTES

Examining the Role of Domestic Shipping in the Spread of Nonindigenous Species

Sarah Bailey *and Elizabeta Briski, Fisheries and Oceans Canada; Christopher J. Wiley, Transport Canada Marine Safety*

Due to the vast volume and area of the Great Lakes, our ability to detect the initial introduction of new aquatic nonindigenous species is overshadowed by the rate of spread, or secondary transfer, to new locations in the basin. Secondary vectors, such as ballast water carried by domestic commercial ships, have the potential to spread aquatic species at rates many orders of magnitude greater than would be expected by natural mechanisms (such as downstream drift). We randomly surveyed unmanaged ballast water moved by domestic vessels within the Great Lakes and compared the results with that of exchanged ballast water from transoceanic vessels to assess invasion risk of zooplankton transported by these two types of vessels. Total abundance was two magnitudes greater, and species richness threefold greater in domestic vessels compared with transoceanic vessels. We documented 89 species transported by domestic vessels of which 31 had restricted distribution and eight were nonindigenous. Beside the risk of spread of NIS between lakes, domestic shipping can act as a vector for homogenization of indigenous taxa, with at least 21 native species (99 events) being moved outside their historical distribution. Our study indicates that management of invasive species should consider ecological, not geographical or political boundaries. Domestic vessels operating within a limited geographic region have high potential to introduce or spread species with restricted distribution, demonstrating importance of intraregional ballast water management.

NOTES

Hull Fouling on Domestic Vessels as a Vector for Secondary Spread of Marine Nonindigenous Species

Marco Meloni[1], Nancy Correa[2], Fábio Pitombo[3], Demetrio Boltovskoy[1], ***Francisco Sylvester****[1], [1]Universidad de Buenos Aires; [2]Servicio de Hidrografía Naval; [3]Universidade Federal Fluminense*

Vessel hull fouling is a well recognized vector for the introduction of nonindigenous species (NIS), although its role in regional species dispersal has received less attention. We assessed hull fouling communities attached to an oceanographic vessel serving routes from Brazil to Antarctica. We sampled both in the water using divers and in dry-dock in the Argentine port of Mar del Plata. Video and 20x20 cm quadrat samples were obtained from exterior surfaces of the bow thruster, bulbous bow, dry-dock support strips, propeller, rope guard, rudder, bilge keel, waterline, and main hull. Bryozoans, hydroids, and nematodes accounted for >80% of total invertebrates in the samples. Other taxa found, in order of decreasing abundance, included tunicates, copepods, amphipods, polychaetes, and bivalves. Comparatively rare barnacles accounted for a large percentage of the biomass and likely provided habitat for mobile invertebrates. A few crabs, isopods, sea spiders, cladocerans, hirudinians, cumaceans, and ascidian larvae were also sampled. Preliminary taxonomic identifications revealed the presence of a few species not reported for the Southern Atlantic such as the isopods *Paracerceis sculpta* and *Dynamene sp.* Established NIS such as *Gonothyraea loveni* (Hydrozoa) and *Hydroides elegans* (Polychaeta) were also transported in hull-fouling assemblages. A significantly larger number of invertebrates were obtained from quadrats sampled in dry-dock than in the water. While total richness might be properly estimated using either sample set, rare species may be overlooked during in-water sampling of hull-fouling communities. Overall, our results suggest that hull fouling on domestic vessels can accelerate NIS regional dispersal using ports as pickup locations. Faster dispersal rates than those attained naturally through water currents can be important for the colonization of remote habitats such as Antarctica. With international legislation regulating ballast water discharges, hull fouling should be the focus of future research,

NOTES

Estimating the Risk of Ship-mediated NIS Introductions into Marine and Freshwater Ecosystems of Canada

Oscar Casas-Monroy*[1], Farrah Chan[2], Jennifer Adams[1], Robert Linley[1], Sarah Bailey[1], [1]Fisheries and Oceans Canada; [2]University of Windsor, Great Lakes Institute for Environmental Research*

Ballast water has been identified as a major vector of introduction of aquatic invasive species (AIS) into new areas of Canada, while hull fouling is recognized as a sub-vector for the introduction of AIS in marine ecosystems worldwide. Recent studies have shown that a number of high impact aquatic invasive species have established in the East and West coasts of Canada and in the Great Lakes. While no AIS have been reported from Canadian Arctic waters, future increases in shipping activity and effects of climate change may make this ecosystem more vulnerable to introduction AIS. We conducted a National Risk Assessment (NRA) to better understand the relative invasion risk for all regions of Canada (East coast, West coast, the Great Lakes and the Arctic) by different shipping pathways (e.g., transoceanic, coastal, domestic). This NRA assess the relative risk of shipping vectors (ballast water and hull fouling), based on the probability of introduction and the magnitude of consequences (impacts) of introduction, including assessments of shipping traffic (ballast volume discharged), environmental similarity between donor and recipient ports and effects of mitigation strategies (ballast water exchange - BWE).

Preliminary results indicated that international transoceanic merchant vessels pose the relative highest risk for hull fouling and ballast-mediated introductions across Canada, even after BWE. Additional shipping pathways posed an intermediate risk, but were regionally specific (e.g., non-merchant vessels by hull fouling in the Atlantic region or domestic vessels by ballast water in the Great Lakes). Relative risk assessment does not assign a fixed numerical value to the probability of an invasion, however, it is a useful tool to identify and prioritize research needs, resource allocation and policy decisions. It should be noted that it was not possible to calibrate the relative risk ratings against a set of know invasions data, therefore, ranking of "lower" or "lowest" should not be considered zero risk.

NOTES

Risk Assessment for Ballast Water Exchange in the Canadian Eastern Arctic

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Mid-ocean exchange of ballast water is recommended for international vessels entering Canadian waters. However in the event that this cannot be accomplished due to weather conditions or other circumstances, designated alternate ballast water exchange zones (ABWEZs) within the Canadian Exclusive Economic zone may be used. These zones also have the potential for use by ballasted domestic vessels. ABWEZs should ideally be positioned to minimize the potential risk of ballast-mediated aquatic invasive species introductions. We developed a semi-quantitative model to assess relative risk of ballast water dispersion along major vessel tracks in the Canadian Eastern Arctic with the objective of evaluating suitability of existing ABWEZs in this region. In this model we simulated ballast water exchange as the release of particles at various segments of a given vessel track into the surface layer of circulation models for Baffin Bay – Davis Strait – Labrador Sea and Lancaster Sound. The following metrics were individually computed and then combined to assess level of risk: 1) arrival time or the time it takes particles to reach a given zone and 2) frequency of occurrence or the percentage of total particle-days spent within a given zone. Zones within the region of interest were delineated based on a combination of depth characteristics (coast, shelf, and deep-shelf) and ecology/zoogeography (Arctic and sub-Arctic) expected to have different levels of invasion risk in the event of introductions. Since the relationship between different zones and level of invasion risk has not been empirically demonstrated in this region, we used different weighting schemes to test the sensitivity of the model to these parameters. We found that our model was robust to different weighting schemes and consistently identified the same regions as being high risk. Our results suggest that existing ABWEZs in the Lancaster Sound and Hudson Strait areas are at highest relative risk for introductions of invasive species and lower risk portions of major vessels tracks should be considered as alternatives. Lower risk alternatives include the Labrador Sea portion of all vessel tracks, and along the Baffin Bay – Davis Strait deep offshore vessel track at depths of greater than 1000m.

NOTES

How to Build an Effective Rapid Response Task Force in the Lake Champlain Basin

Margaret Modley, *Lake Champlain Basin Program*

The Lake Champlain Basin Aquatic Invasive Species Rapid Response Action Plan was approved by the Lake Champlain Basin Program Steering Committee in May 2009. The Plan was developed to enable the mobilization of resources and expertise in the basin in response to a new aquatic invasive species introduction or the spread of an existing aquatic invasive species to a new body of water, regardless of its location in the basin. The Plan also called for the appointment of Rapid Response Task Force members from state and provincial agencies with regulatory authority over waters in the Lake Champlain Basin in New York, Vermont, and Quebec. No matter where a new infestation of an aquatic invasive species is found in the basin, all three jurisdictions would respond by following a clear process which includes species identification and confirmation, delineation of the population, a risk assessment, rapid response containment and eradication and/or spread prevention management, and monitoring. The Rapid Response Task Force has been activated three times since members were appointed in 2010 to respond. The Task Force has determined whether rapid response containment and eradication was technically and scientifically feasible for variable leaf milfoil in the south lake of Lake Champlain, spiny water flea in the Champlain and Glenns Falls Feeder Canals, and spiny water flea in Lake George, NY. Each time the Task Force responds, improvements have been made to the process.

NOTES

The U.S. Fish and Wildlife Service's Provisional, Early Detection Program for the Great Lakes

***Michael H. Hoff**, U.S. Fish & Wildlife Service, Fisheries Program*

The Great Lakes Restoration Initiative Action Plan set a goal of developing and implementing, by 2014, a comprehensive program for detecting and tracking newly identified invasive species in the Great Lakes. That program is intended to provide up-to-date critical information needed by decision makers for evaluating potential rapid response actions, and for evaluating implementation of other risk management actions. No such comprehensive program has been developed, but parts of that program have been developed, and are being implemented and evaluated. The U.S. Fish and Wildlife Service has developed a provisional program for early detection of invasive species in the Great Lakes. Our program targets detection of fishes and benthic macroinvertebrates that may be introduced into the Great Lakes via ballast water, and bighead and silver carps. Our 2012 sampling program was vetted with Great Lakes states and other partners, and includes sampling in specific areas of each Great Lake, using eDNA water sampling, electrofishing, gill netting, trawling, benthic sled sampling, and some other gears. Details of specifically where, when, and how and how often we sample will be presented. Our program will be adapted through time: after analyzing data we collect and interpreting implications about needed modifications to sampling design, and by collaborating with others to develop a biologically, ecologically, and statistically tenable early detection program for aquatic invasive species in the Great Lakes.

NOTES

Search Strategies and Network Design Issues for Early Detection of Aquatic Invasive Species

***John R. (Jack) Kelly**, Joel Hoffman, Anett Trebitz, Gregory Peterson and Erik Pilgrim, U.S. Environmental Protection Agency*

We conducted a series of field and related modeling studies (2005-2012) to evaluate search strategies for Great Lakes coastal ecosystems that are at risk of invasion by non-native aquatic species. Applying species-area theory to our field data, we confirmed that detection of species which are rare in abundance and/or limited in spatial distribution requires substantial effort. We have compared different sampling strategies to see if we can improve search efficiency. In developing a network, we should design to achieve an acceptable limit of detection (non-detection is a significant issue), as well as maximize search efficiency to detect invasive species while they are still uncommon. We have used our empirical studies to assess some factors which may improve the efficiency of a search for detection of "new," rare, but potentially invasive species. Factors include: use of multiple sampling gears; different spatial design approaches to spread or stratify sampling effort across habitats, vector pressure, and other scales/boundaries represented within a given area; and the efficacy of morphological and molecular identification techniques of different biological groups and life stages. Intensive case studies in Lake Superior (Duluth-Superior Harbor [DSH], MN-WI, USA; Isle Royale [IR], MI, USA) were selected to contrast strategies for systems that have a mosaic of diverse habitats, are speciose and highly invaded (DSH), with other areas that have simpler habitat structure, lower species richness and are less invaded (IR). We also sampled extensively across the entire nearshore of the Great Lakes to enable comparison of similar sampling efforts spread at different spatial scales—from the intensive case study efforts in individual embayments, to a set of embayments within a somewhat localized region, to the coastal waters along an entire Great Lake's coastline. Data analyses are ongoing from just-completed 2012 sampling; this presentation will identify technical issues we can highlight to date as important to consider in developing options for a Great Lakes-wide network.

NOTES

Estimating Sampling Effort for Early Detection of Non-Indigenous Benthic Species in the Toledo Harbor Region of Lake Erie

***Jeffrey L. Ram**, Fady Banno, Richard Gala, Jason P. Gizicki and Donna Kashian, Wayne State University*

Toledo Harbor (Maumee River and Maumee Bay) is a "port of concern" for introduction of non-indigenous species into the Great Lakes due to the large amounts of ballast water from outside the Great Lakes discharged at the port, the amenable habitat for many potential invasives, and the large amount of ballast water transported from Toledo to other Great Lakes ports, making Toledo a potential source of invasives throughout the entire region. To estimate sampling intensity needed to detect rare or new non-indigenous species, 27 benthic grab samples from 13 locations near Toledo Harbor were collected during fall, 2010. Benthic organisms were identified, and sampling intensity needed to detect rare or new non-indigenous species was evaluated via a Chao asymptotic richness estimator. Morphological taxonomic criteria and cytochrome oxidase I (COI) sequence barcodes identified 29 different taxons (20 to species level) in the samples, including six non-indigenous taxons (*Branchiura sowerbyi, Bithynia tentaculata, Corbicula fluminea, Dreissena polymorpha, Dreissena bugensis, Lipiniella* sp.). While all the non-indigenous species had previously been reported in Lake Erie or nearby Ohio waters, several North American species are not previously listed in Ohio. Richness estimates indicate that >75% of the benthic species in the area were encountered and that 90% of the species could be detected with less than a doubling of collecting effort. Since sampling for this study occurred only in the fall and detectable life stages of benthic organisms may vary seasonally, additional species may be observed with more extensive sampling over a broader seasonal range.

NOTES

Capturing Dispersal Patterns and Tolerance of Early Invaders with Enhanced SDMs: Applications for Design of Detection Programs

***Paul Edwards** and Brian Leung, McGill University; Ladd E. Johnson and Sam Collin, Université Laval*

We aim to improve upon current small-scale detection and monitoring programs for aquatic invasive species (AIS). We investigate the combination of dispersal characteristics and environmental tolerances at this scale, and the appropriate form of such models. We build a joint species distribution model at small scale and show how it can be used to generate monitoring programs with explicit probabilities of detection.

We modified a traditional Generalized Linear Model to incorporate the biological processes of dispersal and recruitment. This model was then fit to adult locations and recruitment data from early invasion of the vase tunicate, *Ciona intestinalis*, in Boughton River. We simulated and compared different monitoring scenarios based on these results.

Our fitted model was better able to capture patterns of recruitment as a function of temperature and distance from the source population, rather than other variables examined, e.g. salinity. Examination of larval recruitment with distance from adults showed a clear hump-shaped dispersal kernel. Extrapolation of these results to Rustico Bay identified localized areas where predicted probability of recruitment was highest and, therefore, where monitoring would be most effective. Comparisons with simulated monitoring designs based on random sampling efforts indicate that monitoring programs informed by our joint SDM improved their probability of detection.

This model approach is based around a simple framework that can be easily adapted to different species characteristics (e.g., dispersal patterns, larval behaviour) and different environments. From a fairly modest dataset collected over two weeks, we were able to capture basic mechanics of dispersal of a harmful invader and integrate these findings into a more efficient monitoring program for areas currently at risk.

NOTES

'The Pump Don't Work, 'Cause the Vandals Took the Handles': Why 'Killer Shrimps' and Other Invasive Amphipods Threaten Freshwater Biological Water Quality Monitoring in the British Isles

***Calum MacNeil**, Isle of Man Government*

The 'killer shrimp' *Dikerogammarus villosus* (Crustacea: Amphipoda) invaded the British Isles in 2010. This eastern European shrimp invader is highly predatory of a wide range of freshwater macroinvertebrate taxa. It can quickly become 'super-abundant' within invaded sites, dominating resident assemblages in terms of numbers and biomass. Although, the vast majority of past and current research on *D. villosus* has focused on the impacts of *D. villosus* invasion on native biodiversity, I consider the usually overlooked, or even ignored, implications of such invasions for biological water quality monitoring and ecological assessment. I show how past invasions of British freshwaters by other shrimps such as *Gammarus pulex* and *Crangonyx pseudogracilis*, currently undermine the ability of macroinvertebrate derived biotic indices to reliably reflect changes in water quality. I predict the impacts of the *D. villosus* invasion on British freshwater systems will be greater than any previous shrimp invasion and indeed potentially of any other freshwater macroinvertebrate invasion thus far. With *D. villosus* continuing to spread throughout the British Isles, I use ecological impact data from recent Central European invasions, to show how this species could radically alter biodiversity and resident assemblage structure, especially in areas of rocky/stoney substrate or where artificail concrete structures are present. I suggest realistic ways forward for future water quality monitoring and ecological assessment within watercourses invaded by *D. villosus*.

NOTES

Dispersal of Invasive Species by Drifting

***Mariëlle van Riel**, Alterra, WUR; Abraham bij de Vaate, Waterfauna Hydrobiologisch Adviesbureau; Gerard Van der Velde, Radboud University Nijmegen*

Drifting can be an effective way for aquatic organisms to disperse and colonise new areas. Increasing connectivity between European large rivers facilitates invasion by drifting aquatic macroinvertebrates. The present study shows that high abundances of invasive species drift in the headstream of the river Rhine. *Dikerogammarus villosus* and *Chelicorophium curvispinum* represented up to 90% of the total of drifting macroinvertebrates. Drift activity shows seasonal and diel patterns. Most species started drifting in spring and were most abundant in the water column during the summer period. Drift activity was very low during the winter period. Diel patterns were apparent; most species, including *D. villosus*, drifted during the night. Drifting macroinvertebrates colonised stony substrate directly from the water column. *D. villosus* generally colonised the substrate at night, while higher numbers of *C. curvispinum* colonised the substrate during the day. It is very likely that drifting functions as a dispersal mechanism for crustacean invaders. Once waterways are connected, these species are no longer necessarily dependent on dispersal vectors other than drift for extending their distribution range.

NOTES

Predicting Aquatic Invader Impacts and Testing Major Hypotheses in Invasion Biology with Comparative Functional Responses

Jaimie T.A. Dick[1], *Mhairi Alexander*[1], *Anthony Ricciardi*[2], *Jennifer Dodd*[1], *Calum MacNeil*[1], *Kevin Gallagher*[1], *Suncica Avlijas*[2], *David Aldridge*[3], [1]*Queen's University Belfast;* [2]*Redpath Museum, McGill University;* [3]*Cambridge University*

Aquatic invasion biology faces major challenges that require fresh approaches and methodologies. In particular, predicting which species will become invasive and the ecological impacts of such species has seen little progress. Also, several major hypotheses in invasion ecology, such as the 'biotic resistance' and 'enemy release' hypotheses, have received equivocal support, perhaps due to inappropriate tests. We present a methodology that has broad application in invasion ecology and great potential in tackling these major issues. We contend that invaders are characterised by their ability to rapidly and efficiently utilise resources. A classic way to measure this is to derive the 'functional response' of a consumer, defined as the relationship between resource consumption rate and resource density (e.g., predator eating prey). Deriving and comparing the functional responses of invaders and analogous native species may provide understanding and prediction of aquatic invader impacts. For example, the invasive freshwater mysid *Hemimysis anomala* (the bloody red shrimp) has functional responses towards prey species that are consistently higher than those of native mysid species, both in Ireland and Canada. Further, the prey species most impacted in the field were those that experienced the greatest differential in functional responses in the laboratory. We find similar patterns for another known damaging aquatic invader, the 'killer shrimp' *Dikerogammarus villosus*. We also show how comparative functional responses can allow robust tests of major hypotheses in invasion ecology. For example, two predatory amphipods in Europe are negatively associated in the field with one of their prey, a North American invasive amphipod (i.e., the natives appear to show 'biotic resistance' to the invader). Experiments revealed that invader prey populations are de-stabilised by the native predators, as revealed by consistent Type II predatory functional responses, whereby prey have no refuge from the predator at low prey densities. Further, the native that shows the strongest negative association with the invader in the field had the greater functional response towards the invader. Thus, a major strength of our methodology is that we can both understand and predict the population level outcomes of interactions among invader and native species. We conclude by encouraging other researchers to adopt our functional response methods in their study systems, as functional responses can be derived in many ways in the laboratory and field and their derivation is not limited by taxonomic or trophic group.

NOTES

Integrated Ecological Modelling as a Tool for Detection of Potential Hot Spots for Invasive Macroinvertebrates

Pieter Boets*, Koen Lock and Peter Goethals, Ghent University*

In this research, we investigated to which extent the establishment and spread of alien invasive macroinvertebrates is determined by habitat, water quality, biotic interactions and shipping. Based on integrated ecological models, we predicted the future dispersal of alien invasive macroinvertebrates in inland waters. For this, we analysed over 3,000 biological and physical-chemical samples, which were scattered over different water types in Flanders (Belgium). In general, it was found that navigable waterways, harbours and brackish waters were hotspots for alien macroinvertebrates. Modelled changes of oxygen and nutrient concentrations due to planned installation of waste water treatment plants in combination with a data-driven model predicting the presence or absence of alien macroinvertebrates, indicated that a further increase in the prevalence of these alien macroinvertebrates can be expected, especially in those water bodies evolving from a bad or poor to a moderate water quality. However, waters with a high ecological water quality were found to be less prone to invasions. Among the invaders, alien macrocrustaceans are known to be very successful invertebrates that colonise new habitats rapidly. When investigating the dispersal of alien macrocrustaceans, it was found that conductivity and shipping in combination with chemical water quality were the major factors determining the prevalence of alien macrocrustaceans. Brackish water conditions in combination with high levels of ship traffic seemed to be favourable for alien macrocrustaceans to establish and to reproduce. The predictions of our integrated model indicated that the prevalence and species richness of alien macrocrustaceans is likely to increase with improving chemical water quality, whereas their abundance will probably decrease slightly. At the species level, it was found that that the highly invasive species *Dikerogammarus villosus* mainly occurs in rivers with an artificial bank structure, a high oxygen saturation and a low conductivity, which corresponds with canals with a good chemical water quality. Based on an integrated model taking into account the spatial-temporal spread we predicted the future dispersal of the species in Flanders. It is expected that with improving water quality all main rivers and canals will be colonised by the year 2027. From our analysis, it is clear that models are a useful tool for management of invasive species and that decision makers should focus on vulnerable areas such as brackish water areas and areas with intensive ship traffic in order to prevent the further introduction and spread of alien invasive species.

NOTES

Temporal and Spatial Community Dynamics of Invasive and Native Amphipods in the River Rhine and its Tributaries, Germany

***Wei Chen**, Martin Plath, Bruno Streit and Sebastian Klaus, Frankfurt University; Johann Wolfgang, Goethe-Universität*

The River Rhine ranks among the most dynamic and most heavily invaded freshwater ecosystems in the world. Especially the opening of the Rhine-Main-Danube canal in 1992 resulted in a massive influx of Ponto-Caspian amphipod species into Western Europe, such as *Dikerogammarus villosus, Dikerogammarus haemobaphes, Echinogammarus ischnus, Echinogammarus trichiatus, Chelicorophium curvispinum*, and *Chelicorophium robustum*. After the arrival of invasive amphipods, native *Gammarus roeseli, Gammarus pulex* and some old established invaders rapidly decreased in abundance and were often replaced entirely. Indeed, the continuous replacement of one or few temporarily dominant amphipod species by recently invading species is appears to be a preeminent phenomenon in the Rhine and some of its tributaries. We sampled amphipods seasonally at five rivers along a 250 km stretch of the Upper and Middle Rhine, and in four of its tributaries (35 sites) between Jul. 2011 and Sep. 2012. Our study shows (1) an as yet unrecognized clear geographic separation between native and invasive amphipods with invasive amphipods having replaced native amphipods in the Rhine, but (2) stable invasion fronts between the River Rhine and its tributaries, where native amphipods prevail. (3) Temporal fluctuation and thus, turnover dynamics of species compositions seem to be low, and (4) only in one (navigable) tributary do invasive species co-occur with native amphipods from the confluence to middle-stream.

NOTES

Changes in Zooplankton Community of the Illinois River Since Establishment of Bighead and Silver Carp

***Collin Hinz**, Illinois Natural History Survey*

Bighead carp *Hypophthalmichthys nobilis* and silver carp *Hypophthalmichthys molitrix* (Asian carp) where first detected in La Grange reach of the Illinois River in the mid 1990's with an abundant population established by 2000. Both species are highly efficient planktivores with the potential to affect plankton that drives much of the productivity in the Illinois River. To evaluate this potential threat, data from 27 fixed sites in the main channel have been sampled bimonthly from May through October. The abundance and biomass of small bodied rotifers were significantly greater in the lower river where Asian carp densities are highest compared to the upper river where Asian carp densities are lowest. In addition to this geographic response pattern, comparisons to pre-Asian carp data (1994-2000) show that zooplankton biomass decreased significantly with community composition shifting towards small bodied rotifers. Despite the change in biomass and composition, total zooplankton density remained equivalent from pre- to post-Asian carp establishment. These results demonstrate that, at a minimum, an abundant Asian carp population can strongly influence the planktonic base of river productivity. Another practical conclusion would be that, in river systems that do not have the benefit of an extensive Asian carp focused monitoring program, zooplankton characteristics may serve as an indicator of the status of Asian carp abundance and ecological impact.

NOTES

Preliminary Assessment of the Trophic Consequences of Asian Carp Establishment in Offshore Lake Ontario

***Tom Stewart**, Ontario Ministry of Natural Resources; Hongyan Zhang, University of Michigan; Warren Currie, Fisheries and Oceans Canada*

In this paper, the establishment of Asian carp in offshore Lake Ontario is simulated using mass balanced flow networks implemented with Ecopath software. Two mass balanced descriptions of Lake Ontario offshore food web, representative of the 2001-2005 time period were developed assuming differing levels of dreissenid mussel biomass. New flow networks that included Asian carp were parameterized assuming a range of Asian carp diet assumptions and varying levels of Asian biomass from 0.1 to 1.5 g $C \cdot m^{-2}$. Mass balance solutions were derived by randomly selecting alternative fish biomass levels while fixing diets and biomass of all other species-groups. The highest levels of modeled Asian carp biomass required reductions in alewife biomass from approximately 3 to 38% to maintain food web mass balance. At these highest levels, Chinook salmon biomass was variable but predation pressure on Alewife generally increased, with maximum levels close to double (> 90 %). Higher levels of alewife predation increase the risk of Alewife population collapse which would result in a collapse of the Chinook salmon population and a severe decline in the associated recreational fishery. This very simple and preliminary analysis suggests that Asian carp may be able to thrive in offshore Lake Ontario by exploiting novel pathways of carbon flow. Asian carp may be able to sustain high levels of biomass and disrupt lower trophic level pathways of carbon flow with unpredictable food web consequences to all trophic levels.

NOTES

Assessing Risk of Asian Carp Invasion and Bioeconomic Impacts on the Food Web and Fisheries of Lake Erie

***Edward Rutherford** and D. Mason, NOAA, Great Lakes Environmental Research Laboratory; Hongyan Zhang and J. Breck, University of Michigan; Marion Wittmann and David Lodge, University of Notre Dame; J. Rothlisberger, U.S. Forest Service; R. Cooke, Resources for the Future; Tim Johnson, Ontario Ministry of Natural Resources; Xinhua Zu, Fisheries and Oceans Canada; D. Finnoff, University of Wyoming*

Bighead and silver carp ('AC') threaten to invade the Great Lakes. We used an Ecopath with Ecosim (EwE) food web model (modified to incorporate uncertainty in parameter values) linked to a regional economic model (Computable General Equilibrium) to evaluate the potential bioeconomic impacts of AC in Lake Erie. Data available from 1999-2003 were used to configure and balance the food web in Ecopath, and Ecosim was used to simulate potential AC impacts under current conditions of nutrient loading, fish stocking and harvest. Uncertainties for parameter inputs were quantify using expert judgment solicitation. Model simulations were used to determine: 1) sensitivity of forecasts to various parameters, 2) biomass of AC necessary for strong impacts on the food web, 3) direction of biomass response by food web groups, 4) synergistic affects of AC biomass, nutrient loading and fishery management scenarios, and 5) potential regional economic response. This novel and integrated approach includes feedbacks between ecological and economic systems, thereby quantifying the value of ecosystem goods and services.

NOTES

Phenotypic Plasticity in Life History Traits of Bigheaded Carps in Novel Environments

Reuben Goforth *and Alison Coulter, Purdue University; Jon Amberg, U.S. Geological Survey; Elizabeth Bailey, Purdue University; Doug Keller, Indiana Department of Natural Resources*

Control and prevention of the spread of silver and bighead carp (*Hypopthalmichthys molitrix* and *H. nobilis*, respectively) are high priorities given their potential to affect global freshwater biodiversity. Extensive efforts are being made to predict when, how, and where introductions may occur and lead to successful establishment, including models based on published life history and ecology information for the species. However, the great invasion success of silver and bighead carps undoubtedly reflects high phenotypic plasticity in both species. We have observed several heretofore unreported behaviors exhibited by Asian carp in the Wabash River, Indiana, that may have significant implications for efforts to model, control, and prevent the spread of Asian carp. For example, we have detected evidence of atypical spawning activity as late as 1-September-11 without a concomitant hydrograph change. In addition, Asian carp eggs were detected as far upstream as Wabash River Mile 390, at which point the river is < 30 m wide, the watershed area is 4,579 km^2, and mean discharge during the month of sampling was 115 m^3/s. Finally, Wabash River Asian carp have exhibited movements and habitat use inconsistent with those previously reported for the Illinois River. Our findings provide evidence of considerable phenotypic plasticity in bigheaded carps in novel environments compared to habitats within their native ranges. Thus, the range of freshwaters that may be susceptible to invasion and establishment is likely greater than previously thought.

NOTES

Invasion History, Population Dynamics and Trophic Structure of Asian Carps on the Northwestern Front of the Invasion in the United States

Cari-Ann Hayer*, Katie Bertrand and Brian Graeb, South Dakota State University*

South Dakota prairie streams are on the northwestern front of the Asian carp (i.e., bighead and silver carp) invasion in the United States. The invasion of three Great Plains streams that are tributaries to the Missouri River began in 2008, coincident with the beginning of this project. Long-term effects of Asian carps in prairie streams are difficult to predict, but we expect altered food web structure and potentially detrimental levels of competition with native filter feeders. The objectives of this project are to document the distribution and population dynamics (e.g., growth, recruitment, mortality) of bighead and silver carp, as well as to estimate their trophic position in the prairie stream food web using stable isotope and diet analysis. Standardized boat electrofishing occurred seasonally (e.g., spring, summer, and fall) at ten sites across the study area from 2009-2012. Over the four year period, silver carp expanded their distribution approximately 700 river kilometers (rkms) and percent of total catches that were silver carp increased from 1 in 2010 to 45 in 2012. There was record flooding in 2010 and 2011, which allowed for unimpeded movement upstream over the more than 230 low head dams; however, flooding may have negatively affected reproduction and survival of young-of-year Asian carps. Ninety-two percent of catches were from the 2010 year class, and the 2011 year class was missing from 2012 collections, even though young-of-year silver carp were collected in 2011. Flooding was followed by severe drought in 2012; however, catches of silver carp continued to increase. Ages of silver carp ranged from 0-5 and size and age structure was variable among river basins with the James River primarily composed of younger fish, suggesting differences in the timing of the invasion. Bighead carp collections were widespread, but catch per unit effort remained low throughout the duration of the study. Isotope analysis revealed that native filter feeders, (i.e., gizzard shad, bigmouth buffalo, and emerald shiner) and Asian carps, were feeding at approximately the same trophic level ranging from 13.70 to 15.63 δ15 N. Silver and bighead carps were more depleted in δ13 C than native filter feeders indicating that bighead and silver carp were acquiring more energy from pelagic resources (i.e., phytoplankton) than native filter feeders which were more benthic; however, there was high variability in δ13 C values across all species. Based on both δ15 N and δ13 C, there was trophic overlap between bighead carp and gizzard shad, indicating the potential for competition for food resources. Stomach contents of both bighead and silver carp consisted of diatoms, detritus, and inorganic matter despite ample zooplankton (e.g. rotifers) within water samples. This study represents a unique opportunity to study already harsh and disturbed (e.g. land use, channelization, wetland drainage) prairie streams at the beginning of an invasion, unlike most studies that begin research after an invasion has occurred and deleterious effects have taken place. Information on how an invasive species spreads and population characteristics during an invasion will help managers in uninvaded areas potentially prevent future invasion.

NOTES

Canadian Implementation of the Ballast Water Convention

***Colin Henein**, Transport Canada Marine Policy*

Canada has taken steps to mitigate the risk of aquatic species introductions, including close co-operation with the United States in a joint program that inspects 100 percent of overseas vessels before they enter the Great Lakes to prevent discharges of unmanaged foreign ballast water. In April 2010, seeing a need for uniform international implementation of compatible ballast water requirements, Canada ratified the *International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004* (the Convention). The United States, which is not expected to ratify the Convention, has a number of ballast water regulators who take different approaches to the issue.

As the requirements for the Convention to enter into force have almost been met, Transport Canada has begun to prepare for a full implementation of the Convention in Canadian regulations. Transport Canada developed a proposed regulatory approach for ballast water to respond to Canada's obligations as a contracting party to the convention, while taking into account the need for compatibility with the United States. Transport Canada has identified five key policy considerations for development of its final regulatory approach.

NOTES

A Multi-dimensional Approach to Invasive Species Prevention

***Elizabeta Briski**[1], Lisa Allinger[2], Mary Balcer[3], Allegra Cangelosi[4], Lana Fanberg[3], Tom Markee[3], Nicole Mays[4], Christine Polkinghorne[3], Kelsey Prihoda[3], Euan Reavie[3], Deanna Regan[3], Donald Reid[5], Heidi Saillard[3], Tyler Schwerdt[6], Heidi Schaefer[3], Matthew TenEyck[3], Christopher J. Wiley[7], Sarah Bailey[1], [1]Fisheries and Oceans Canada; [2]University of Minnesota; [3]Universitiy of Wisconsin-Superior; [4]Northeast-Midwest Institute; [5]Consultant; [6]AMI Engineering; [7]Transport Canada Marine Safety*

Non-indigenous species (NIS) cause global biotic homogenization and extinctions, with commercial shipping being a leading vector for spread of aquatic NIS. To reduce transport of NIS by ships, regulations requiring ballast water exchange (BWE) have been implemented by numerous countries. In the near future, ships will be required to undertake ballast water treatment (BWT) to meet numeric performance standards, and BWE will be phased out of use. While the risk of treated ballast water is generally expected to be lower than that of exchanged ballast water, there are concerns that BWT systems may not operate reliably in fresh and/or turbid water, or that proposed performance standards are not stringent enough. Consequently, it has been proposed that BWE could be used in combination with BWT, thus retaining the positive benefits of both management strategies. Therefore, we compared the efficacy of 'BWE plus BWT' with 'BWT alone' on planktonic and microbial organisms. The management strategies were simulated and tested at the Great Ships' Initiative land-based testing facility located on the Duluth-Superior Harbor in the Laurentian Great Lakes. Our comparative evaluation showed that 'BWT alone' reduced abundance of organisms in the 50 µm and 10 to < 50 µm groups by 98.61 and 91.69 %, respectively, while 'BWE plus BWT' reduced organisms in the same groups by 99.99 and 99.38 %, respectively. Even though 'BWT alone' significantly reduced abundances of all tested organism groups except total heterotrophic bacteria, the 'BWE plus BWT' strategy significantly reduced abundances for all groups, including total heterotrophic bacteria, and furthermore resulted in significantly lower abundances of most groups when compared to 'BWT alone'. Our study clearly demonstrates potential benefits of combining BWE with BWT to reduce invasion risk of freshwater organisms transported in ships' ballast water.

NOTES

Evaluating Efficacy of a Ballast Water Filtration System for Reducing Risk of Spread of Aquatic Species in the Great Lakes

Robert Linley, *Jennifer Adams, Sarah Bailey and Elizabeta Briski, Fisheries and Oceans Canada*

Domestic shipping is often implicated with secondary invasion and spread of aquatic non-indigenous species; often causing significant ecological and economic consequences. A possible industry response is filtering ballast water to mitigate the risk of entraining invasive species in ballast tanks. Here we field test the efficacy of a mechanical filter installed on a coastal class vessel (MV Richelieu) to reduce aquatic species entering ballast tanks at three freshwater locations in the Great Lakes-St. Lawrence River. We collected ballast water samples before and after the filter during three phases of the ship's ballast cycle (beginning, middle, end of ballasting operations) and enumerated zooplankton and phytoplankton. We evaluate filter performance with regard to its ability to reduce viable zooplankton and phytoplankton density and diversity, and examine the particle size distribution in samples using a high resolution Laser Optical Plankton Counter (LOPC). The filter system appears to be highly effective for eliminating cladocerans, and is largely effective in reducing copepods, though it is largely ineffective with ostracods, rotifers, and phytoplankton. Preliminary results suggest there is a change in the size spectrum of particles in ballast water collected before and after filtration. Our initial results suggest that filtration is effective for larger organisms, but filtration alone would not prevent transfers of smaller organisms.

NOTES

Adenosine TriPhosphate: A Promising Tool for Ballast Water Compliance Monitoring

Cees van Slooten*, Tom Wijers and Louis Peperzak, Royal Netherlands Institute for Sea Research, NIOZ*

From 2014-2016 onwards most ballast water carrying vessels will have to comply with the U.S. Coast Guard or International Maritime Organization (IMO) ballast water discharge standard. These standards limit the amount of viable organisms that are allowed to be discharged in ballast water. To effectively enforce the ballast water discharge standards, a reliable compliance method has to be developed that effectively monitors ballast water onboard ships in a quick, simple and accurate manner. The measurement of Adenosine TriPhosphate (ATP) as a compliance monitoring tool was investigated because ATP is the universal energy currency of all living organisms. It can be easily quantified using the luciferin/luciferase method, which takes only minutes to perform.

Various experiments were carried out to investigate the influence of salinity, temperature and pH on the ATP method. In addition, several sample preparation methods were examined in order to enhance the ATP signal and to increase sensitivity. Furthermore, ATP concentrations were determined during land-based testing of a UV ballast water treatment system that underwent the IMO G8 test protocol at the NIOZ test facility. In this manner ATP levels could be linked to a large number of biotic and abiotic properties of the test water.

It will be shown that abiotic properties of the test water can have a dramatic effect on the detection of ATP. However, a novel sample preparation technique eliminates these effects and makes the ATP-method applicable under a wide range of environmental circumstances. The practical use of this quick and simple ATP test for ballast water compliance testing will be discussed.

NOTES

Assessing the Utility of Vital Fluorescent Stains for Viability Analysis of Organisms Transported by Ballast Water

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In 2004, the International Maritime Organization (IMO) adopted the International Convention for the Control and Management of Ships' Ballast Water and Sediments, which governs the maximum allowable densities of viable organisms in ballast water to be discharged at any port. Methods for rapid assessment of viable organisms present in ballast water, such as live-dead staining of microorganisms, are needed to assess compliance with the Convention. We tested the efficiency and utility of fluorescein diacetate (FDA) alone and in combination with 5-chloromethylfluorescein diacetate (CMFDA), on benthic invertebrate monocultures, ambient zooplankton (>50 µm) and phytoplankton (10-50 µm) communities from Hamilton Harbour, and ballast water samples. Stains were tested on live and dead organisms, and treatments were chosen to represent traditional lab trials such as heat, as well as to mimic current ballast water treatments such as exposure to chlorine or sodium hydroxide. Organisms were then exposed to vital stains post-treatment and examined. Laboratory trials included control testing of untreated samples, as well as the examination of unstained, treated samples.

Results indicate little difference in staining intensity and longevity between FDA and FDA+CMFDA. Staining results have been positive for small size classes of organisms (10-50 µm; primarily phytoplankton). However, for zooplankton and benthic organisms, results are much more varied and prone to false positives. Soft-bodied organisms, such as Annelids and Rotifers, displayed false positive error rates of 0% and 15%, respectively. Crustaceans, such as copepods, nauplii, *Daphnia* sp., *Hemimysis anomala* and *Hyalella azteca*, displayed false positive error rates ranging from 45% to 100%, depending on species; *Bosmina* appeared as the exception, with only 7% false positive errors. Insect larvae, such as *Hexagenia* sp. and *Chironomus riparius* also had a relatively higher rate of false positives, albeit lower than for most Crustaceans. It is hypothesized that the presence of a carapace or exoskeleton in arthropods is related to the errors seen when using the vital stain after treatment. There appeared to be no difference in rates of false positives between treatments. In summary, the use of the vital stains FDA and/or FDA+CMFDA as methods of viability assessment for ballast water should be used with caution with larger size classes, as a high degree of false positives are likely to occur.

NOTES

Early Detection of Non-native Fishes Using Fish Larvae

***Joel Hoffman**, Erik Pilgrim, Anett Trebitz, John Kelly and Gregory Peterson, U.S. Environmental Protection Agency*

Our objective was to evaluate the use of fish larvae for early detection of non-native fishes, comparing traditional and molecular taxonomy approaches to investigate potential efficiencies. Fish larvae present an interesting opportunity for non-native fish early detection. First, as ichthyoplankton, fish larvae can function as propagules for non-native species introductions, and thus the capture of a novel species may indicate a first introduction. Second, because most Osteichthyan fishes (i.e., bony fishes) produce many eggs, the larvae of an introduced fish population at the early stage of establishment will be much more abundant than adults, and thus possibly easier for us to capture than the adults. Our approach was to intensively sample a Great Lakes non-native species introduction hotspot and then compare the success and efficiency of fish larvae taxonomic characterization between traditional taxonomy and community level DNA sequencing, a relatively novel molecular taxonomic method. We intensively sampled the Duluth-Superior harbor, the Great Lakes largest freshwater port, using a spatially balanced design to equally allocate catch effort across the harbor. To maximize the number of species encountered, we sampled at different time periods throughout the spring spawning period and used multiple types of sampling effort: daytime tucker trawls, daytime beach seining, nighttime neuston tows, and nighttime light traps. Success was measured as the sample-based probability of encountering a given non-native species. Efficiency was measured using species-area theory, as well as using comparative measures of effort required to yield a taxonomic characterization of the fish assemblage. We will present the results from our 2012 sampling effort, discuss the comparison between the two taxonomic approaches, and evaluate the performance of either approach compared to sampling juvenile and adult fish using traditional catch and identification methods.

NOTES

Metagenomic Approaches to Detecting Invasive Species in Lake Superior

***Erik Pilgrim**, Joel Hoffman, John Kelly, Gregory Peterson, Anett Trebitz and John Martinson, U.S. Environmental Protection Agency*

The effectiveness of any invasive species monitoring network is determined by its ability to detect rare, non-native individuals against the natural aquatic community. Standard field collection methods often require very large sample volumes to detect individuals of rare species, and these methods are often labor intensive, time consuming, and require significant expertise for taxonomic identification of specimens. Ongoing advances in molecular taxonomy and DNA sequencing technology (such as eDNA for Asian carp) present new opportunities for developing sensitive invasive species detection methods which could also reduce some of the time, cost, and effort involved with processing these samples. Next-generation DNA sequencing allows for DNA extraction, PCR amplification, and DNA sequencing from bulk, unsorted samples. When compared against genetic databases, this DNA sequence data can be used to generate community profiles from each sample which in turn provide a novel means for detecting rare individuals from these bulk samples. While eDNA approaches target specific taxa of concern, we have chosen to investigate community-level data sets that have the potential to detect any non-native individuals, targeted or otherwise, thereby supplying a molecular genetic method for detecting new invasions from new, unknown species. We will present results from our 2012 fish/benthos sampling efforts in Lake Superior and compare the molecular detection sensitivity to standard methods. We will discuss the strengths and weaknesses of such a community molecular genetic approach to invasive species detection, some of the requirements for its use (e.g., building DNA sequence databases), and its potential utility in a Great Lakes-wide detection network.

NOTES

Assessing the Role of Genomic Surveillance Methods in Mitigating the Erie Canal Corridor Invasion Risk

***Andrew Mahon**, Central Michigan University; W. Lindsay Chadderton and Andrew Tucker, The Nature Conservancy*

The Erie Canal Corridor (ECC) is the second largest artificial canal system in the Great Lakes basin (GLB) providing a continuous connection between Lake Champlain Basin (LCB), and the Mohawk - Hudson River Basin (MHRB). Officially opened in 1825, it was the first connection between the Atlantic seaboard and the Great Lakes that did not require portage, and was an important factor in the economic develop of the U.S. interior. It has also served as an important route for spread of invasive species, including sea lamprey, alewife, water chestnut, zebra mussel, and white perch. It is also considered the single most important invasion pathway for Lake Champlain. However, while management attention is focused on the threat posed by Asian carp and the Chicago Area Waterway system, the ECC has the potential to undermine efforts to prevent future introductions into the GLB by providing a back door invasion pathway that directly links the GLB to New York City, one of North America's largest international shipping ports and points of entry for imports from the commercial trades in live organisms. The lower MHRB and NYC contain populations of a number of AIS of concern to the GLB (e.g. northern snakehead, Hydrilla, Brazilian elodea), whereas round goby and Asian clam are spreading down the ECC into the MHRB. Here, we examine the current and future potential invasion risk posed by the EEC, and we assess how new genomic surveillance methods can be used to augment existing surveillance efforts and help refine management options.

NOTES

Environmental DNA Monitoring for Detecting Aquatic Invasive Species in Ontario

Caleigh Smith, Kristyne Wozney, ***Chris Wilson*** *and Jennifer Bronnenhuber, Ontario Ministry of Natural Resources; Christopher Kyle, Trent University*

Early detection of aquatic invasive species (AIS) is essential for developing and implementing rapid response strategies. In aquatic environments, detection of rare species can be complicated by site accessibility, sampling gear, and capture efficiency, with direct observation being difficult at best. Discriminating between detection failure (null) versus true absence (zero) can be problematic, and will have significant consequences for species and habitat management. Long term monitoring programs would benefit from a reliable, efficient method to ascertain species presence and abundances. Environmental DNA (eDNA) detection provides a sensitive method for targeted early detection of aquatic invasive species. We assessed the efficacy of eDNA to detect the presence or true absence of species using multi-species controls under semi-natural conditions, applying species-specific eDNA primers to test the effects of biomass, density, distance, and temporal occupancy on detection sensitivity. These methods were then applied to test for the presence of bighead carp (*Hypophthalmichthys nobilis*) and silver carp (*H. molitrix*) in the Great Lakes, using regular and quantitative PCR to assess eDNA field samples from Ontario waters of Lake Erie and Lake Ontario. In addition to targeted detection, environmental DNA sampling provides the opportunity to detect previously unreported invasive species. Community assessments were performed using universal CO-I "mini-barcode" primers to amplify mitochondrial DNA of local multi-species assemblages from water samples and run on a next-generation DNA sequencer to determine local species composition. Our results indicate that environmental DNA is a reliable method for species detection in freshwater systems, and can be used as an effective sampling technique for detecting both known and previously unrecognized invasive freshwater species. These combined approaches allow for sensitive detection of AIS at low abundances, to augment and focus conventional sampling efforts for their rapid detection.

NOTES

Evaluating Canadian Zooplankton Biodiversity through DNA Barcodes: Assessing Non-indigenous Species Presence to Provide a Framework for Future Monitoring

Robert Young[1]*, Cathryn Abbott*[2]*, Tom Therriault*[2]*, Sarah Adamowicz*[1]*,* [1]*University of Guelph;* [2]*Fisheries and Oceans Canada*

Knowledge of the taxonomic placement and historical phylogeography of Canada's invertebrate zooplankton port species is crucial to understanding Canada's current indigenous and non-indigenous biodiversity and dispersal routes. Zooplankton are key components in aquatic systems, transferring energy from phytoplankton up to higher trophic levels; therefore, disruption to the functioning of an ecosystem's indigenous zooplankton population by invasive species can have widespread ecological consequences. Human-mediated habitat destruction through physical perturbations and pollutants, combined with the introduction of non-indigenous species, has made the assessment of current port biodiversity more critical and important for future comparisons and evaluations.

To gain more knowledge of the taxonomic placement and phylogeography of Canadian port invertebrates, zooplankton has been collected by the Canadian Aquatic Invasive Species Network (CAISN II) using 250µm and 80µm plankton nets at 16 Canadian ports in four regions: Pacific, Atlantic, Great Lakes, and northern Canadian marine locations. We sampled six replicate sites in two seasons for each port with samples pooled prior to analysis. In each of the four regions a minimum of one port was selected for preliminary biodiversity analysis. Preserved zooplankton was subsampled through microscopic examination and, where possible, 4-6 specimens representing unique morpho-species were selected for molecular analysis and morphologically identified to the lowest possible taxonomic level.

The animal DNA barcode region of the mitochondrial gene cytochrome *C oxidase* subunit I (COI) was sequenced for molecular and phylogenetic analysis. The species richness of ports was estimated and compared across species definitions, specifically morpho-species versus molecular operational taxonomic units (MOTUs), which were defined using both threshold-based and cluster-based analyses. Preliminary results indicate a correlation between molecular and morphological approaches but with a greater diversity being elucidated using molecular approaches. Accurate knowledge of biodiversity sets the framework for future monitoring and for understanding the factors leading to successful invasive potential. In addition, presented results provide evidence that the use of a molecular barcoding approach is an efficient method for the analysis of port zooplankton biodiversity.

NOTES

Eurasian Ruffe – Implications of Recent eDNA Surveillance Efforts in the Laurentian Great Lakes

W. Lindsay Chadderton[1], *Andrew Mahon*[2], *John Bossenbroek*[3], *Jennifer Sieracki*[3], *Andrew Tucker*[1], *Christopher Jerde*[4], *David Lodge*[4], *Marion Wittmann*[4], *Dmitry Beletsky*[5], [1]*The Nature Conservancy;* [2]*Central Michigan University;* [3]*University of Toledo;* [4]*University of Notre Dame;* [5]*University of Michigan*

First detected in St. Louis River, Duluth in 1986, a non-native fish, Eurasian ruffe (*Gymnocephalus cernuus*) has steadily spread along the southern shoreline of Lake Superior. More recently, ruffe has invaded Green and Thunder Bays in Lakes Michigan and Huron, probably as a result of ballast water mediated dispersal events. The status of ruffe in northern Lake Huron is uncertain because surveillance suggests the Thunder Bay population failed to establish, whereas it is now considered to be widespread in Green Bay. Recent assessments of natural dispersal suggest ruffe larvae have likely spread out of Green Bay and should be starting to invade the western shoreline of Lake Michigan. Analyses of Great Lakes shipping patterns indicate that Lake Erie and ports in Southern Lake Michigan may be vulnerable to introductions from ballast water taken up from invaded ports within Lake Superior or Green Bay. Here we report on the initial results of environmental DNA surveillance efforts aimed at identifying the extent of Eurasian ruffe populations in lakes Michigan, Huron and Erie. Sampling focused on the putative leading edge of the invasion in western regions of lakes Michigan and Huron, as well as ports considered to be most at risk from potential ballast water introductions in southern Lake Michigan and western Lake Erie. We discuss the management implications of potential ruffe establishment in Lake Erie and the Southern Basin of Lake Michigan.

NOTES

Use of Functional Response Experiments and Modelling to Assess Intra-guild Interaction between a Native and Invasive Amphipod in Northern Ireland

Mandy Bunke[1], *Mhairi Alexander*[2], *Jaimie T.A. Dick*[2], *Alison Dunn*[1], *Melanie Hatcher*[1], [1]*University of Leeds;* [2]*Queen's University Belfast*

Interaction between native and invasive species is an important point to consider in the field of invasive species. This may be especially the case if both species belong to the same trophic guild. In Northern Ireland the two crustacean amphipods *Gammarus duebeni celticus* and *G. pulex* are a good example of native and invasive species which occupy the same guild. *G. pulex* was knowingly introduced into Northern Ireland in the 1970s and has since been found to alter the species biodiversity in streams and rivers. Interactions between the native and invasive species are likely to have an impact on population dynamics of either species. However, other factors such as parasitism are known to also have an influence on these dynamics. This study investigated the combined effects of parasitism and intra-guild interaction on the native and invasive species population. A combined approach of empirical prey choice and functional response experiments to investigate the intra-guild predation occurring between the two species was used. The experimental results where then incorporated into models allowing an investigation into the effect these interactions have on the species' population dynamics.

NOTES

Predatory Functional Responses of Native vs. Exotic Amphipods: Effects of Predation Risk and Parasitism

Rachel Paterson[1], *Marilyn Ennis*[1], *Melanie Hatcher*[2], *Alison Dunn*[2], *Jaimie T.A. Dick*[1], [1]*Queen's University Belfast;* [2]*University of Leeds*

Increasingly, predatory functional response techniques are used to assess the impact of exotic species on native communities, and also the potential for parasites to alter the predatory impacts of their hosts. However, simple laboratory predator-prey systems with or without parasites may fail to reveal the full extent of an exotic species' predatory role. The presence of higher trophic predators in the natural environment may alter an exotic species' predatory function as a result of the exotic species' own predation risk and behaviour modifications induced by trophically transmitted parasites. Our study focused on two freshwater amphipods in Ireland, the native *Gammarus duebeni celticus* infected with a microsporidian, *Pleistophera mulleri*, and the exotic *Gammarus pulex* infected with a trophically transmitted fish acanthocephalan, *Echinorhynchus truttae*. This exotic amphipod is known to displace native amphipods and alter native invertebrate assemblages in invaded regions. We used a four-species module approach (fish predator; amphipod predator; parasite; prey) to simultaneously investigate the influence of parasitism and predation risk on the predatory response of both amphipod species to a variety of invertebrate prey. Our results suggest that native and exotic amphipods may make different foraging choices dependent on the combined influences of predation risk and parasitism, and that this behaviour is likely to be community context dependent.

NOTES

Trophic Impacts of Two Invasive Decapods on Freshwater Communities

Paula Rosewarne, Chris Wing, Christopher Grocock, Robert Mortimer and ***Alison Dunn****, University of Leeds*

The Chinese mitten crab (*Eriocheir sinensis*) and signal crayfish (*Pacifastacus leniusculus*) are large aquatic decapods which since the 1950s have developed worldwide introduced distributions, and are both listed within the top 100 worst invaders. Predicting the impacts of invaders on communities is crucial to drive forward policy and direct strategic control measures to minimise loss of native biodiversity.

Range expansion means that signal crayfish and Chinese mitten crab increasingly co-occur in freshwater habitats, yet little is understood about how these two apparently opportunistic omnivores may interact to impact existing communities. We used a variety of approaches including mesocosms, prey-choice trials, gut contents and stable isotope analyses to investigate trophic impacts of signal crayfish and Chinese mitten crab on benthic invertebrates and the eggs of several coarse fish species. We compare prey preferences of these two invasive predators, and use predatory functional responses to compare their predatory impact on key prey items including keystone shredders in the ecosystem and economically important fish.

NOTES

Combined Effects of Food Abundance and Temperature on Large Bodied vs. Small Bodied Cladoceran Species Replacement

Irina Feniova *and Yury Dgebuadze, Institute of Ecology and Evolution, Russian Academy of Sciences; Vladimir Razlutski, Anna Palash and Elena Sysova, the Scientific and Practical Center for Bioresources, National Academy of Sciences of Belarus; Jacek Tunowski , Institute of Inland Fishery; Andrew Dzialowski, Oklahoma State University*

Cladoceran species are often used as model species in the studies of mechanisms of successful introduction of alien species in the new environment. Temperature and food abundance are known to be important factors responsible for cladoceran species success in the community, but the combined effects of these two factors on large and small bodied cladoceran species are not well understood. Large and small cladoceran species represent two different ecological groups differing in life survival strategies. The aim of the study was to determine how species composition and biomass of cladoceran communities varied in dependence of the combined effects of temperature regime and food conditions. Three eutrophic Polish lakes located close to each other, yet, differing in temperature regime were under study. There is potential exchange of species between the lakes, however their species composition was different. In the heated Lake Lichenskie large bodied *Daphnia* sp. were absent during the warmest period in July and they constituted only 4% of the total cladoceran biomass at lower temperature in late summer – early autumn. Cladoceran community in this heated lake in July was represented only by three small bodied species *Ceriodaphnia reticulata* (Jurine), *Diaphanosoma brachyurum* (Liéven), and *Bosmina longirostris* (O.F. Müller). In the other two colder lakes (Skulska Wies and lesiskie), *Daphnia* sp. contributed much more to the total biomass of the cladoceran communities and species richness was higher than it was in the heated lake. Analysis of phytoplankton suggests that cyanobacteria did not suppress *Daphnia* as the highest relative abundance of Daphnia was observed in Skulska Wies, which also had the highest relative abundance of cyanobacteria. There was also no indication that food depletion was greater in the heated lake than it was in the other two lakes. The mortality of cladoceran species in all studied lakes was not related to food deficit as fecundity was high providing evidence that there were sufficient food resources for reproduction and hence for survival. We suggested that there may be a direct effect of temperature that was responsible for species composition in these lakes. For estimation of the effects of temperature at various food conditions, a set of laboratory experiments with competing large and small cladoceran species was conducted at different temperatures and resource levels. Small bodied species were found to replace large bodied species under the enhanced temperature and lower food supply, yet, when temperature goes down and food abundance increases, superiority shifts to large bodied species. The mechanism of such shift is shown to be associated with the different response of the ingestion rates to the changes of temperature in small and large bodied species in an additional set of experiments. This mechanism of species replacement along environmental gradients helps to sustain the total biomass of cladoceran communities throughout a season. Thus, introduction of newcomers in the community may be an adequate response of the community to the changes of temperature and food conditions.

NOTES

Invasion of Asian Tiger Shrimp (*Penaeus monodon* Fabricius, 1798) in the Western Atlantic and Gulf of Mexico

Leslie Hartman, Texas Parks & Wildlife Department; ***Pamela Fuller,*** *U.S. Geological Survey; David Knott, Poseidon Taxonomic Services, LLC; James Morris, NOAA Fisheries; Peter Kingsley-Smith, South Carolina Department of Natural Resources*

Penaeus monodon is a shrimp species native to the Indo-West Pacific oceans, including East Africa, South Asia, Southeast Asia, the Philippines and Australia. It has been cultured since 1968, and at one time its production exceeded all other shrimp species in the world. It still ranks second in global production, with nearly 800,000 tons produced in 2009 and 2010. In the New World, this species was formerly cultured in the United States, although the last permitted facility in Florida (2004) failed to harvest a crop. Tiger shrimp are still cultured in northern South America and the Caribbean.

In August 1988, roughly 2,000 *P. monodon* were accidentally released from an aquaculture facility in South Carolina. Nearly 300 of those were collected off the coasts of South Carolina, Georgia and Florida in the following three months. After going undetected in the northwestern Atlantic for 18 years, *Penaeus monodon* began to reappear there and, for the first time ever, in the Gulf of Mexico. The species has now been found from North Carolina to Texas. The USGS Nonindigenous Aquatic Species program is tracking reports of the shrimp's occurrence, which showed an increase greater than 20-fold between 2010 and 2011. Some of this increase may be attributed to more extensive reporting following wide-spread media coverage and greater public outreach efforts; however, shrimp fishermen report catching them more frequently and in larger numbers.

Potential sources of this invasion include discharge of ballast water from their native range or from established populations elsewhere, and transport of larvae from Western Africa or the Caribbean via ocean currents. The lack of reports for nearly two decades means the aquaculture escapement in South Carolina in 1988 is likely not the source.

To help answer some of the questions regarding the establishment of tiger shrimp, the possibility of multiple introductions, and the present population structure, a team of state, federal, and independent researchers came together under the auspices of the Gulf and South Atlantic Regional Panel of the Aquatic Nuisance Species Task Force. In the fall of 2011, the team began gathering specimens and archiving tissue for genetic analyses at NOAA Fisheries' Center for Coastal Fisheries and Habitat Research in Beaufort, North Carolina. Geneticists at two USGS laboratories are analyzing DNA using microsatellites and single nucleotide polymorphisms (SNPs).

NOTES

Early Life Stage Biology of a New Population of Green Crab (*Carcinus maenas*) in Placentia Bay & Implications for Mussel Culture in Newfoundland

Kiley Best[1], *Cynthia McKenzie*[2], *Cyr Couturier*[1], [1]*Marine Institute of Memorial University of Newfoundland;* [2]*Fisheries and Oceans Canada*

Following the discovery of green crab *Carcinus maenas* in Placentia Bay Newfoundland in August 2007 there has been concern for the aquaculture industry. Blue mussels are not only a desired prey species for green crab; they also provide a very important protective habitat for early life stage *C. maenas* (Hedvall et al.1998). Thiel and Dernedde (1994) found juvenile *C. maenas* in high densities within mussel beds in the Wadden Sea immediately after larval settlement and they are small enough to hide effectively between mussels. If this is true for other green crab populations mussel seed transfers from Placentia Bay could provide a vector for post-larval juvenile transfer to the Green Bay area where provincial mussel aquaculture is concentrated.

Work was conducted to determine size at maturity by GSI and histology to further understand reproductive biology and timing for larval and juvenile green crabs under Newfoundland, subarctic conditions. Newly settled green crab juveniles were collected and used in a series of lab scale mitigation trials using exposures to thermal shocks applicable and feasible for mussel seed management in Placentia Bay. Mussel seed from Placentia Bay were also exposed to mitigation conditions and monitored for stress response, as this can negatively affect mussel growth rate and performance. Results show that this population sexually matures at a smaller carapace width than warmer populations and are active at much lower temperatures than previously observed for this species. Exposure to heated salt water was effective in culling juvenile green crab while causing minimal stress to mussel seed.

NOTES

Disruption of Essential Habitat by a Non-Indigenous Predator in Shoreline Habitats of the Southern Gulf of St. Lawrence

Pedro Quijon*, Paula Tummon Flynn, Cassandra Mellish, Tyler Pickering and Andrey Malyshev, University of Prince Edward Island*

Some of the most detrimental effects of invasive species are mediated by the alteration and potential loss of essential habitat. Given the importance of these habitats and their difficult recovery, their study in the light of the growth of many potentially harmful invasive species, should be considered a priority. This study focused on the direct effects of the European green crab (*Carcinus maenas*) on shoreline beds associated to sedimentary bottoms. In particular, we focused on feeding rates on American oysters (*Cassostrea virginica*), blue mussels (*Mytilus edulis*) and on the physical disruption of eelgrass shots (*Zostera marina*), all in a productive area of Atlantic Canada. A combination of laboratory and field experiments was implemented in order to assess the impact of the green crab in each of these species. The results of these experiments indicated that green crab feeding rates are higher than anticipated by the literature, and have a strong size component associated to it. Meanwhile, cage inclusions assessing eelgrass uprooting rates, did also indicate stronger than expected effects in both the field and the laboratory. Combined, these results call for more integrative studies assessing direct and indirect effects of green crab habitat disruption. Similarly, they encourage the study of species interactions between green crabs and two or more native components or species simultaneously.

NOTES

Managing Asian Carp at the Detectable Population Front in the Illinois Waterway through Standardized Monitoring and Removal by Contracted Commercial Fishers

Victor Santucci, *Kevin Irons and James Mick, Illinois Department of Natural Resources; David C. Glover, Southern Illinois University Carbondale, Center for Fisheries, Aquaculture and Aquatic Sciences*

The Illinois Department of Natural Resources is working with numerous federal, state, and local partners to prevent Asian Carp from establishing populations in the Chicago Area Waterway System (CAWS) and Lake Michigan. The Department has developed a three part approach to accomplish this goal. First, we have used intensive monitoring and rapid response removal actions to detect and remove any Asian carp from the system of canals and rivers nearest to the lake (upstream of river km 468) and in an area where bighead and silver carp have been encountered only rarely. Second, market development and licensed commercial fishing for population control has been supported in the river below Starved Rock Lock and Dam (river km 373) where silver carp abundance alone has been estimated to exceed 2,544 fish per river km. Finally, we have established monthly standardized sampling combined with closely monitored harvest by contracted commercial fishers in the middle river reach between Starved Rock and the Electric Dispersal Barrier near Romeoville, IL (river km 476). In this mid-river reach, we classify Asian carp abundance as low to moderate and have identified the detectable population front of the spreading invasion south of Joliet, IL (river km 450; about 26 km from the Dispersal Barrier). To date, contracted commercial fishing has removed 550 metric tons of bighead and silver carp at the population front. A concurrent mark-recapture study suggested exploitation rates approaching 50% in one targeted backwater area. Catch-per-effort of Asian carp in standardized electrofishing and trammel or gill net samples has indicated limited upstream movement of carp populations and a general decrease in relative abundance over the past 2 years. We were able to successfully remove substantial numbers and biomass of Asian carp at the advancing population front, thus lowering the risk of propagule pressure at the Dispersal Barrier.

NOTES

The Use of Chemical Stimuli in the Control of Asian Carp

Edward E. Little, Robin D. Calfee, H. Puglis and E. Beahan, U.S. Geological Survey, Columbia Environmental Research Center; ***Peter Sorensen***, *University of Minnesota*

We have found that invasive bighead and silver carp are responsive to conspecific pheromones both physiologically and behaviorally. Asian carp avoid alarm pheromones present in skin extracts as a means of avoiding predators, and are also attracted to chemical cues released by groups of conspecifics as a means of maintaining schooling behavior in turbid water conditions. Physiological screening assays (EOGs) indicate high sensitivity of the olfactory system for certain hormonal metabolites associated with the sex pheromones and lab behavioral assays verified attraction to them. In mesocosm tests free ranging silver and bighead carp appeared responsive to caged fish that had been hormonally implanted. An algal food stimulus was found to be highly stimulatory to bighead and silver carp in mesocosm tests and induced prolonged attraction in the area of release. Laboratory tests indicated several components of the algal stimulus were highly attractive. We initiated studies for conditioning wild fish response to feeding stations as a means of inducing aggregations of carp to facilitate harvest. We are using technologies such as side scan and dual frequency identification sonar and PIT-tag arrays to verify the behavioral effectiveness of chemical lures in the field.

NOTES

Asian Carp (*Hypophthalmichthys* spp.) and the Viability of a Vulnerable Native Fish: An Ecological Risk Analysis for Paddlefish (*Polyodon spathula*) in the Lower Mississippi River

*Jan J. Hoover[1], **Nicholas A. Friedenberg**[2], Adam J. Laybourn[2], Jonathan Borelli[2], [1]U.S. Army Corps of Engineers, Engineer Research and Development Center; [2]Applied Biomathematics*

Asian carp (*Hypophthalmichthys* spp.) are a threat to native fishes and ecosystems, though species-specific impacts are certain to vary broadly. Paddlefish, *Polyodon spathula*, a species of concern that is showing signs of recovery under recent protection efforts, uses backwaters as nursery and adult feeding habitat. Like paddlefish, Asian carp episodically invade backwaters during high water events. We examined the potential for resource competition with Asian carp to affect the growth and fecundity of paddlefish in backwaters of the Mississippi River. Using a two-habitat metapopulation model that mimicked the random reconnection of backwaters with the main stem of the river, we quantified the increased risk of paddlefish population decline in the presence of Asian carp. Uncertainty regarding population densities, prey abundance, and the degree of diet overlap led to a range of outcomes. Mean juvenile mass decreased by 270-1300 g. Mean adult mass decreased by 1,066-5,300 g. Population-level fecundity declined by 4.7-15%. The risk of a 25% decline in paddlefish abundance over 50 years was unaffected if Asian carp population density was low and competition affected only juvenile or adult growth. However, with higher carp density and effects on both life stages, the risk of decline increased by 14% relative to carp-free models. We conclude that population-level impacts are a possible result from the interaction of Asian carp with paddlefish in backwater habitats. The likelihood of such impacts is difficult to assess without a greater understanding of diet. However, the sensitivity of our results to carp population density indicates that a trend of increasing density brings with it a trend of increased risk to native fishes.

NOTES

Development of a Microparticle Delivery System for the Delivery of Control Agents to Bighead Carp and Silver Carp

*Jon J. Amberg, James A. Luoma, Terrance D. Hubert and **Mark P. Gaikowski**, U.S. Geological Survey, Upper Midwest Environmental Sciences Center*

As Asian carps, specifically silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*Hypophthalmichthys nobilis*), threaten the Great Lakes, resource managers consistently list the lack of chemical tools to control these aquatic invaders as a top resource concern. Currently available tools including non-specific piscicides affect both targeted and non-targeted species, thus the development of a management tool that is more "carp-specific" is highly desirable. Our research has focused on the possible exploitation of the planktivorous feeding habits of Asian carp. To evaluate whether this approach is feasible, manipulative and observational experiments were completed to assess differences in (1) digestive processes; (2) gill raker morphology; and (3) differential response of molecular detoxification processes of Asian carps versus native planktivores. Additionally, work was completed to assess the filtration specificity (particle size) and capacity (mass) of bighead carp and silver carp. The presentation will describe experimental results and describe the current status of on-going work with microparticles in which a control agent has been incorporated.

NOTES

Swimming Performance of Asian Carp

***Jan Jeffrey Hoover**, Alan Katzenmeyer, Larry Southern and Nicky Hahn, U.S. Army Corps of Engineers, Engineer Research and Development Center*

Managers require information on swimming capabilities of Asian carp (*Hypophthalmichthys* spp.) to determine water velocities capable of containing or displacing fish and to estimate exposure time for fish passing through electrical barriers. We have quantified positive rheotaxis (head-first orientation into flow) and endurance (time to fatigue) of bighead carp (*H. nobilis*) and silver carp (*H. molitrix*) in a 1200-liter Brett swim tunnel and a 100-L Blazka swim tunnel. Our data indicate that these fish, as a group, are strongly rheotactic and with moderate- to high endurance at a wide range of water velocities. Overall, > 90% of fish are rheotactic at onset of flow. Sustained swimming (> 200 min) of sub-adults (141-334 mm TL) occurs at maximum speeds of 50 and 80 cm/s, prolonged swimming (0.5-200 min) at 35-130 cm/s, burst swimming (< 0.5 min) at maximum speeds of 142 and 150 cm/s. Sustained swimming of juveniles (36-116 mm TL) occurs at maximum speeds of 20-60 cm/s, prolonged swimming at 25-70 cm/s, burst swimming at maximum speeds of 65-86 cm/s. Performance, however, differs substantially between species, among individuals within a species, among size classes, and between individuals swimming alone and in groups. Endurance of sub-adult bighead carp is approximately an order of magnitude greater than that of sub-adult silver carp at all water velocities tested. For sub-adult silver carp, water velocities capable of containing "best swimmers" are approximately 20-25 cm/s greater than those for "average swimmers." For juvenile bighead carp, maximum sustained swim speeds are three times higher and burst speeds > 30% higher for fish 72-106 mm TL than for fish 36-69 mm TL. For juvenile bighead carp < 73 mm TL, swim speeds corresponding to an endurance 1-min and 0.5 min are 65% higher for a group of 5 fish than for a single fish. These data demonstrate that differences in morphology and behavior, conspicuous (between species) or subtle (within size classes of a single species), can substantially affect swimming performance. Traditional models of swimming performance, based on a few fish (N < 50), swimming individually at representative water velocities, may underestimate swimming capabilities of the genus as a whole.

NOTES

Organism Patchiness in Ballast Water Tanks – Implications for Ballast Water Management Compliance Control Sampling

***Stephan Gollasch**, GoConsult; Matej David, David Consult*

Sample representativeness is one of the key points to proof (non-)compliance of ballast water management requirements. This was recognized at the International Maritime Organization (IMO) as one of the most critical outstanding issues hindering the ratification of the BWM Convention. Member States were asked to share their knowledge on this aspect with IMO so that the relevant IMO working groups can agree on ballast water sampling recommendations. The authors were involved in two studies addressing representative sampling, i.e. one funded by the Federal Maritime and Hydrographic Agency (BSH), Hamburg, Germany and the other by the European Maritime Safety Agency (EMSA), Lisbon, Portugal. Both studies were conducted on board commercial vessels to evaluate different sampling approaches with the aim to recommend compliance control sampling strategies. Results from both studies have shown that sampling and analyses results are biased by different sampling and analyses factors, hence confirming that there are issues with sample representativeness. One conclusion was that additional data are needed to support the findings. Consequently, the BSH funded another on board sampling study, which was undertaken in Fall/Winter 2012. The results from this study will be presented in combination with the data generated on the previously undertaken sampling voyages. Recommendations will be given how Port State Control officers may sample vessels for compliance control with ballast water management standards.

NOTES

'Fouling Begets Fouling': Can Species-Based Biofouling Biosecurity Management Work for Ships?

***John Polglaze**, PGM Environment*

The recognition of ship hull fouling ('biofouling') as a major risk vector for the transfer of aquatic invasive species is gaining traction globally, and failure to develop adequate ship biofouling controls will expose the world's coastal areas to greater risk from the threat of invasive species. This is particularly so when considered in the context of the expected waning of the threat presented by ballast water related introductions, and the changing hazard profile resulting from shifting world trade patterns. The imposition of overly-zealous controls, however, would present as an unjustifiable cost to industry and may unnecessarily impede trade freedom, with the possibility of sanction by world trade bodies.

National and international controls on ship biofouling are in their infancy and a clear dichotomy is emerging with regards to the best means of management - conceptually either 'no biofouling' or 'no specified species'. Neither approach is without flaws and compromise if adopted, but this is unavoidable. The corollary to rejection of imperfect management is no management, so jurisdictions, in collaboration with maritime industries, need to develop and implement effective yet workable control regimes. The key decision to be made is which underlying conceptual approach will work best.

This presentation examines the options and the experience to-date in developing ship biofouling biosecurity controls, and relates why management protocols based upon level of biofouling, rather than specific presence/absence of specified species, present the most viable means of effecting meaningful controls. It is advocated that in effect, a hybrid-based risk management approach is the only workable solution. This would be predicated upon coarse risk assessments underpinning evaluation of broad-scale ship movements with regard to marine biosecurity risks, with focused, individual ship risk evaluations and control measures based upon presence/absence of biofouling (but not directly related to presence/absence of specified species).

The presentation will draw upon the wide range of vessel biofouling and invasive marine species projects undertaken by the author. These include around 200 dive and drydock biofouling inspections of a diverse array of ships and specialist vessels, ranging from jack-up oil rigs to submarines, as well as participation in the development of national and international marine invasive species and biofouling risk evaluation and management measures for the IMO, GISP, Australian and other national authorities, ports and the shipping industry. A theme of this presentation will be upon how reliance upon biofouling risk assessments simply 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 efforts.

NOTES

Does Transport Pathway Influence the Relationship between Colonization Pressure and Propagule Pressure of Zooplankton in Ballast Water of Ships?

***Farrah Chan** and Hugh MacIsaac, University of Windsor, Great Lakes Institute for Environmental Research; Elizabeta Briski and Sarah Bailey, Fisheries and Oceans Canada*

The number of introduced species (i.e., colonization pressure) and the number of introduced individuals per species (i.e., propagule pressure) are key determinants of the number of species that successfully establish in new environments. While considerable research has been undertaken to examine the role of colonization pressure and propagule pressure in establishment success, much less is known about the relationship between the two variables and factors that may affect this relationship. We sampled 58 trans-Atlantic ships to investigate the relationship between colonization pressure and propagule pressure for zooplankton in ballast water. All sampled ships conducted mid-ocean exchange and were grouped into three categories based on transport pathway (the geographic route between source region and release site): Great Lakes, Atlantic, and Arctic. Correlation analyses were conducted to test if colonization pressure was related to propagule pressure. In addition, a series of regression analyses were performed to determine if colonization pressure and propagule pressure were related to change in ballast water temperature and/or voyage length. We found an inconsistent relationship between colonization pressure and propagule pressure for zooplankton among transport pathways. Our results suggest that the relationship was driven mostly by voyage length. While colonization pressure and propagule pressure were not initially related, due to non-random uptake of zooplankton into the transport vector (as observed in short voyages), differential mortality due to selective pressures during transportation on long voyages resulted in a strong positive relationship between these variables. Identifying factors that influence the relationship will improve our ability to assess invasion risk of transport vectors, especially the ones that translocate diverse assemblage of species in a single transport event.

NOTES

Hybrid Treatment to Control Plankton Densities in Ballast Water Tanks

Esteban M. Paolucci[1], *Marco C. Hernandez*[1], *Alexei Potapov*[2], *Hugh J. MacIsaac*[1], [1]*University of Windsor, Great Lakes Institute for Environmental Research;* [2]*University of Alberta, Center for Mathematical Biology, Department of Mathematical and Statistical Sciences*

In an effort to reduce the considerable magnitude of ballast water as a vector for the introduction of non-indigenous species, and align with increasingly strict shipping legislation, we evaluated the efficiency of mid-ocean Ballast Water Exchange (BWE), Chlorination (Cl), and the interaction effects of their combination (BWE+Cl) on microplankton and bacteria densities in ballast tanks. The four treatments were compared over four experimental trips conducted on the bulk carrier Federal Venture between Canada and Brazil from April-November 2012. A total of ten ballast tanks were used for each run (4) of the experiment. Initially, empty ballast tanks were filled with freshwater in Canadian ports, and initial samples collected before injection of a first dose of chlorine (~20ppm) in 5 port side tanks. Between four and five days after departing, BWE with seawater, or BWE plus a second dosing of chlorine, were carried out on applicable tanks. Final samples and measures of environmental conditions were obtained around two days after the BWE, pumping water from three different levels within each ballast tank. Samples for microplankton and bacteria analysis were collected and processed on board. A block design ANOVA was applied to analyze statistical differences for different plankton groups between treatments. In general, the chlorine and BWE+Cl treatments had the lowest final densities among all treatments for *Enterococcus*, coliforms and *E. coli* bacteria, and microplankton. For *Enterococcus* and *E. coli*, the BWE+Cl treatment exhibited a significant synergistic effect ($p < 0.04$ and 0.05, respectively). The control and BWE-only treatments typically had highest plankton abundances, and, in some cases, increasing densities of bacteria were observed in the BWE treatment. The lowest final values of microplankton density were observed in the BWE+Cl treatment, in which the combination of both treatments resulted in a significant interaction ($p = 0.04$), though with antagonistic effects. This trend was similar regardless of the wide range of initial concentrations of organisms among the four trips, and the hybrid (BWE+Cl) treatment displayed one of the best performances with final values lower than the proposed IMO D-2 standard.

NOTES

Taxonomic Relatedness and Functional Traits as Predictors of Establishment Success after a Massive Freshwater Fish Invasion in Neotropics

Felipe Skóra, Pós-graduação em Ecologia e Conservação, Setor de Ciências Biológicas Universidade Federal do Paraná; Jean Ricardo Simões Vitule, Laboratório de Ecologia e Conservação, Departamento de Engenharia Ambiental, Universidade Federal do Paraná; ***Vinícius Abilhoa****, Grupo de Pesquisas em Ictiofauna, Museu de História Natural Capão da Imbuia*

The Gulf of California is recognized as one of the most diverse and productive seas on Earth. Nevertheless, marine native fauna is threatened by the current introduction of invasive species. The aim of this study was to detect alien invertebrates in marinas, ports and aquaculture farms in this ecoregion. Intensives samplings were conducted in 11 localities from La Paz (Baja California Sur), Guaymas (Sonora), Topolobampo (Sinaloa) and surrounding areas. Seven shrimp farms and one oyster farms were inspected. The methodology used permits us to classify alien species into exotic (both established and occasional), versus "impacting" species (potentially invasive and invasive), also we indicate when the exotic species has several unresolved taxonomic problems. Twenty three alien species were detected: eight polychaetes: *Alitta succinea, Branchiomma bairdi, Ficopomatus miamiensis, Hydroides diramphus, H. elegans, H. sanctaecrucis, Myrianida cf. pachycera* and *Polydora websteri*, six sponges: *Gelliodes fibrosa, Halichondria* (*Halichondria*) *panicea*, *Haliclona* (*Haliclona*) *turquosia, Haliclona* (*Reniera*) *tubifera, Lissodendoryx* (*Waldoschmittia*) *schmidti* and *Suberites aurantiaca*, five ascidians: *Botrylloides violaceus, Botryllus schlosseri, Lissoclinum fragile,* Styela *plicata* and *Polyclinum constellatum*, two bryozoans: *Bugula cf. neritina* and *Zoobotryon verticillatum*, one mollusk: *Crassostrea gigas*, and one copepod: *Haplostomides hawaiiensis*. Merely five species were considered "impacting" species: the polychaete *B. bairdi* and the ascidian *P. constellatum* are invasive; and the bryozoan *Z. verticillatum* and the polychaetes *A. succinea* and *H. elegans* are potentially invasive. The remaining species are considered exotics in the Gulf of California and only two have taxonomic troubles. The introduction pathways of invasive species are the hull fouling and aquaculture activity; both species were recorded in shrimp and oyster farms, and marinas and ports. Consequently will be necessary to establish regulations and normative related to clean of fouling and aquaculture procedural with the objective to reduce the invasion risk in nearby ecoregions. However the implementation of these regulations will not possible without educational programs that involve all the people interconnected with these two introduction pathways (see poster by Tovar-Hernández et al. in this conference).

NOTES

Assessing Compliance with Ballast Water International Regulations in Argentina

*María Fernanda Ávila Velandia[1], Pablo Almada[2], **Francisco Sylvester**[1], Demetrio Boltovskoy[1], [1]Universidad de Buenos Aires; [2]Prefectura Naval Argentina*

Management of vessel ballast water is internationally regulated to prevent species introductions in marine and freshwater habitats, yet compliance with current normative varies geographically. In South America, in particular, there have been few attempts at evaluating observance of these guidelines. We collected and processed ballast-water reporting forms from all international vessels arriving in the port of Buenos Aires (the busiest container shipping hub in Argentina) between June 2010 and June 2011, Reported ballast water discharges were compared with the balance between downloaded and uploaded cargo by the same vessels obtained independently from the port authority. During the period covered, a total of 855 large commercial vessels called Buenos Aires moving a cargo volume of 4.7 (imports) and 4.3 (exports) million t. Only 404 of these vessels submitted a ballast-water reporting form. A large proportion of these forms were incomplete, had errors, and most (1355 out of 1592 tanks) declared no ballast water discharges in Buenos Aires. Considering that the average ballast-to-load-ratio is about 0.5, the analysis of cargo movements suggests that information contained in these ballast water reporting forms is highly biased: up to 23% of all vessels arriving in Buenos Aires left this port with 1000 t of cargo more than they brought in (for 6% of the vessels this difference was over 5000 t), strongly suggesting that ballast should had been released by these ships; yet only two reported ballast water discharges. Information on ballast water age is fragmentary, but many of the ballast water tanks had been loaded less than 2-3 weeks before arrival in Buenos Aires. While the introduction risk to this freshwater port from predominantly marine sources is probably low due to poor environmental match, the situation is different for the many marine ports along the Argentine Atlantic coast. In addition, some of these marine ports (e.g., Bahía Blanca, Quequén) are net exporters of commodities (grain, beef), which makes them particularly vulnerable to massive ballast water discharges. So far at least 100 aquatic nonindigenous species have been recorded in Argentina, many of which have shipping vectors as the most likely route of introduction. Our preliminary results indicate that control mechanisms aimed at enforcing current regulations must be tightened significantly in to ensure proper compliance and prevent further introductions.

NOTES

Ballast Tank Biofilms are Protected Reservoirs of Microspecies that Challenge Native Biodiversity

***Robert Baier**, Robert Forsberg, Anne Meyer and Joseph Zambon, SUNY at Buffalo*

The introduction of exotic microbial species into new ecosystems is a probable pathway for the establishment of non-native species that may have pathogenic effects or disturb a system's natural biodiversity. This research evaluated the natural biodiversity and possible threats of exotic species introductions, using ship ballast tank water, ballast tank biofilms and a subset of microorganisms associated with the biofilms. Previous studies documenting the routine survival of organisms in ballast tanks' water columns are extended here to the ballast tank wall and sediment surface-attached biofilms. This study detected, enumerated, and documented microstructural patterns of attachment of five "benchmark" species of marine bacteria associated with the biofilms of ballast tanks in ships traveling the world's oceans. *Rabbit antisera*, prepared for *Pseudomonas putrefaciens, Pseudomonas* sp., *Comamonas terrigena, Achromobacter* spp., and *Vibrio alginolyticus,* and converted to immunofluorescent reagents, were used to identify and quantify the five species of bacteria in biofilms from four ships, three on trans-oceanic routes and one entering the Great Lakes system. Non-toxic materials and coatings, with pre-characterized and different surface properties, were deployed in the ballast tanks of these ships as a means of acquiring biofilms. A "ballast organic biofilm" (BOB) sampler and a "portable biofouling unit" (PBU), harbored the test surfaces and coatings inside the actual ballast tanks or as sampled waters from ballast tanks, providing viable biofilms within which the immunofluorescence staining techniques identified specific bacteria species. Concurrent analysis of test coupons, using multiple attenuated internal reflection infrared spectroscopy and scanning electron microscopy, revealed that coatings with Critical Surface Tensions in the range from 20 to 30 milliNewtons/meter, typically methylsilicone polymers, changed the normally tightly bound, thin biofilms into looser biofilms (and associated particles), having clustered and more easily detachable patches. Nevertheless, all five "benchmark" bacteria species were present on all materials and coated materials installed aboard all vessels, indicating high species persistence with respect to these bacteria over time and geography. Ballast tank biofilms from different vessels revealed different associated small particle compositions, a result of sediment re-suspension during ballast exchange events and at-sea ship motions. Ballast tank biofilm-coated specimens taken from a cross-ocean BOB sampler did release bacteria and other biota into laboratory tanks of particle-free surrounding waters, seeding new biofilms on the tank walls and demonstrating a likely path for suppression of global biodiversity. Current studies seek to determine whether wall shear rates associated with ballasting/deballasting are sufficient to release these accumulating biofilms into the ballast water volume where mechanochemical control methods may be effective at much lower doses than required for disinfection of microorganisms in the biofilm state.

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NOTES

Mechanisms of Aquatic Species Invasions Across the South Atlantic States, USA

***Amy Benson**, Robert Dorazio, Fred Johnson, Michael Turtora and Pamela Fuller, U.S. Geological Survey*

The U.S. Geological Survey's Nonindigenous Aquatic Species (NAS) database provides records of sightings and capture data of non-native (introduced) aquatic species over the entire the United States. For states within the South Atlantic region, the NAS currently contains records dating back to 1885 for over 200 nonindigenous plant and animal species. This project seeks to utilize these data along with new GIS-based data on current and future landscape and climate parameters to develop models of invasive species introductions and dispersal across the South Atlantic states. Both multi- and single species models will be considered in these analyses. We will then utilize the results of NAS data analyses and modeling to help prioritize a set of monitoring, management and conservation strategies addressing potential future invasion pathways at the local and regional levels. This project will devote significant effort towards compiling GIS-based raster and vector data on land cover types, environmental parameters, and urban development throughout the South Atlantic states with the NAS records. We will leverage other on-going efforts focusing on the southeastern United States and led by the U.S. Geological Survey that will expand the number of environmental data types contained within the NAS. The compiled datasets at the completion of the project along with the modeling results and a structured, quantitative framework for utilizing these results in the optimization of invasive species control strategies will provide a valuable guide for future research foci and conservation actions across the South Atlantic states. The results of these efforts to date will be presented.

NOTES

Determinants of Rapid Response Success for Alien Invasive Species in Aquatic Ecosystems

***Boris Beric** and Hugh J. MacIsaac, University of Windsor, Great Lakes Institute for Environmental Research*

Human population growth and development have resulted in the spread of alien invasive species (AIS) in novel environments world-wide. AIS have received much attention for their harmful effects on health, ecology and the global economy. In response to this emerging threat, many countries, including Canada, adopted the *Convention on Biological Diversity* which requires the eradication of AIS. In 2004, Environment Canada unveiled its *An Invasive Alien Species Strategy for Canada* which emphasized the need for development of early detection and rapid response methods. We have compiled 453 different data sets involving management of aquatic AIS around the world. Factors which potentially determine AIS intervention success were catalogued, including habitat size, ecosystem type (marine vs. freshwater), management method (single vs. multiple methods) and project budget. Using chi-square analysis, we determined that there was a significant relationship between management success and budget availability, with lower budget projects reporting greater success than higher budget ones. In addition, there was a significant difference in management success between marine and freshwater ecosystems, with the former having greater success overall. There was no difference in success according to habitat size or management method. Future work will involve statistical quantification of these relationships (ie. effect size) and others influential to management outcome, including project duration, population abundance, and habitat type. This data will aid countries in managing AIS when prevention measures have failed. Most importantly, end users will be able to identify the suite of rapid response options most appropriate for management of AIS in their regions.

NOTES

Ponto-Caspian Predatory Cladocerans *Cercopagis pengoi* (Ostroumov 1891) and *Evadne anonyx* G.O. Sars 1897 in the Gulf of Gdańsk (Baltic Sea)

Luiza Bielecka, *Stella Mudrak-Cegiołka and Marcin Kalarus, University of Gdańsk, Institute of Oceanography, Department of Marine Plankton Research*

The hydrological and topographic specificity of the Baltic Sea makes it an excellent place for the settlement of non-indigenous species. As a consequence of their great plasticity, these can easily adapt to free ecological niches in which they establish productive and fertile populations. Until the beginning of the 21st century, about 100 allochthonous species had entered the Baltic Sea. Among them two Ponto-Caspian predatory species of Cladocera, *Cercopagis pengoi* and *Evadne anonyx*, had entered the Gulf of Gdańsk. Biological materials were collected in the Gulf of Gdańsk every month between February and December 2006, the samples being taken from the eastern (Krynica Morska and Świbno profiles) and western (Mechelinki and Sopot profiles) parts of the gulf. Zooplankton were collected to a maximum depth of 40 m with a Copenhagen vertical haul plankton net (mesh size 100 µm). Some data are available on the occurrence of *C. pengoi* and *E. anonyx* in the Gulf of Riga, in the Gulf of Finland and in lagoons, e.g. the Vistula Lagoon, but there is not much information regarding its presence in the more saline waters along the Polish Baltic coast. In the Gulf of Gdańsk, *C. pengoi* was reported for the first time in 1999. Then the species has been recorded only at irregular intervals and only at single sites. In 2006, the occurrence of *C. pengoi* in the Gulf of Gdańsk was the most abundant recorded up to that time. *C. pengoi* established a stable population (with the full population spectrum) and was observed continuously at all the stations and profiles throughout the recording period (July–August). In the same time, the first specimens of *Evadne anonyx* were detected in the Gulf of Gdańsk. *E. anonyx* was noted only several times at very low densities. This new cladoceran had never been observed in the Gulf of Gdańsk prior to 2006.

NOTES

Functional Responses as Predictors of Invasive Species Impacts: An Examination of Inter-population Variation in an Invasive Predator's Functional Response

Helene C. Bovy, *Jaimie T.A. Dick and Mark Emmerson, Queen's University Belfast*

Despite the consensus that predicting the ecological impacts of invasive species is essential for the advancement of fundamental and applied invasion biology, the development of appropriate methodologies remains elusive. The use of traits of species and individuals, such as body length, size and fecundity, to make predictions of invasion impacts, often fail. This occurs simply because of variation both across and within invaded ranges, and invasion history remains one of the few reliable predictors of ecological impact. However, this does not allow forecasting of the effects of emerging or potential invaders. Here, we examine inter-population variation in a new method in predictive invasion ecology: the comparison of the functional response of invaders. The functional response is the relationship between resource density (e.g. prey) and resource consumption rate (e.g. by predator). We have introduced this technique as a tool to rapidly assess the impacts of invasive species on native populations and communities. However, as individuals in such investigations are often sourced from a single location, it is unknown whether the measured functional response is consistent amongst populations. This study investigates the functional responses of an invasive species across its native and invasive ranges. *Gammarus pulex*, an invasive freshwater amphipod crustacean, with impacts on native invertebrate communities in Northern Ireland that are well documented, was used as the model species. Using standardized laboratory setups, populations from both native (England) and invasive (Northern Ireland) ranges were assessed on their predatory ability on a common prey item, *Asellus aquaticus*. This method has shown promise in terms of rapidly assessing predatory abilities of a species as it not only uncovers inter-species variation, but also highlights subtle differences in predation among populations of a single species.

NOTES

A Cellular Automata Model for the Spread of the Golden Mussel (*Limnoperna fortunei*)

*Vinícius Carvalho Resende[1], **Mônica de Cássia Souza Campos**[1,2], Fabiano Alcísio e Silva[1], Hellen Regina Mota[3], Marcela David de Carvalho[3], Antônio Valadão Cardoso[1,2], [1]Centro de Bioengenharia de Espécies Invasoras de Hidrelétricas (CBEIH); [2]Fundação Centro Tecnológico de Minas Gerais (CETEC); [3]Companhia Energética de Minas Gerais (CEMIG)*

The golden mussel (*Limnoperna fortunei* Dunker 1857) is a fouling bivalve native to Southeastern Asia. It arrived in South America around 1991, causing severe environmental and economic damage. In order to guide preventive and control actions different types of models may be developed. The most common models relate occurrence records to a set of relevant environmental variables, resulting in potential distribution maps. Spatially explicit dynamic models, in turn, take spatial and temporal scales into account, predicting *where* and *when* the species will invade. This work proposes a model of this kind, based on a Cellular Automata approach. The space is represented by a grid of cells, each containing one of three possible states: Mussel presence (1), Mussel absence (0), land areas or other barriers (2). Two Shapefiles are read and converted to appropriate formats (matrices and structs); one containing data from sampling points, another with the drainage surface area. The sampling points must contain the input parameters used by the model (initially Chlorophyll *a* and water velocity). Input data from sampling points are interpolated throughout the entire grid by an ordinary kriging algorithm, and used for evaluation of the *settlement factor (β)* of each cell, according to a set of fuzzy rules. This variable shows how suitable a cell is for the settlement of the species. Other data are inserted by the user, such as flow direction and invasion areas. The river flow may act as a dispersion agent downstream and halt the invasion upstream. However if the water speed is too high, the settlement is hindered both ways. Thus, the cell's neighborhood, originally Moore's, is divided into two parts; five downstream and five upstream neighbors. After the simulation begins, at each time iteration, the state of a cell with mussel absence may change (from 0 to 1) with probability P_i if it has a neighbor with presence. P_i is the product of the settling factor named β with a corrective factor *K*. This parameter is adjusted during the calibration process, in which the model is executed several times with different values for *K,* evaluating its performance according to the settlement data given by the user and sampling points. The use of Cellular Automata gives simplicity to the model, dispensing a thorough knowledge of the system. However, parameter estimation is highly dependent on accurate mussel progression data (temporal series). This is a problem when we are confronted with the available data, which is gathered through field sampling. So far scale tests in laboratories are unfeasible because the species does not reproduce readily in such environments. Future scale tests of environmental conditions and increasing shared databases may provide the model with enough data to evaluate its performance.

NOTES

Effects of the Presence of Saxitoxin and Microcystin in the Grazing Rate of *Limnoperna fortunei*

*Vinicius Sergio Rodrigues Diniz[1], Antônio Valadão Cardoso[1,2], **Mônica de Cássia Souza Campos**[1,2], Hellen Regina Mota[3], Marcela David de Carvalho[3], Patrícia Pimentel[2], [1]Centro de Bioengenharia de Espécies Invasoras de Hidrelétricas (CBEIH); [2]Fundação Centro Tecnológico de Minas Gerais (CETEC); [3]Companhia Energética de Minas Gerais (CEMIG)*

Limnoperna fortunei is a bivalve mollusk of the Mytilidae family, generally known as the "golden mussel". Its geographical native distribution was restricted to Southeast Asia, particularly China. However in 1966, this bivalve was described as an invasive species in Hong Kong and, in 1991, in Japan and South America. There is a strict relationship between *L. fortunei,* a filter-feeder, and Cyanobacteria, which is known to produce toxins that are released into the water, and which can be bioaccumulated in the food chain. *L. fortunei* is capable of filtering and ingesting solid particles in suspension, therefore, it can ingest toxic matter – such as cyanobacteria. This reveals *L. fortunei*'s ability to work as a bioaccumulator of cyanotoxins. Having realized studies "in vitro", this project intends to present the ecological relationship between the presence of cyanobacteria and the mussel's grazing rate.

The mussels were exposed for an hour to three strains of Cyanobacteria: a toxic, *Microcystis aeruginosa* (microcystin-producer); a non microcystin-producer *M. aeruginosa* and a saxitoxin producer, *Cylindrospermopsis raciborskii*. After this , the number of cyanobacteria from a portion of the medium was counted in a Neubauer chamber. The "t test" was used to detect significant differences between the parameters "grazing rate" and " species of cyanobacteria evaluated ". The null hypothesis was rejected with usual levels of probability (0.05).

The results for grazing rates differed. The mussels did not graze in the presence of toxic *M. aeruginosa*., None of them opened their shells for a period of at least two hours. This result agrees with Cataldo et al. (2012), who showed that, with high concentrations of mycrocistin, mussels did not graze. In contrast, Grazulha et al. (2012) and Ruckert et al. (2004), affirmed that the mussel's grazing rate was not influenced by the presence of toxic strains. The mussel's filtration rates were quite different from those wtih the non microcystin-producer *M. aeruginosa* and saxitoxin producer *Cylindrospermopsis* (163.00 and 17.51 $mL.mussel^{-1}.h^{-1}$, respectively) as has been found by t test ($p < 0.05$). It was observed that, in the presence of *Cylindrospermopsis* , the mussel kept its siphon opened during the period of the experiment, but its filtration rates were lower. This is probably due to the paralyzing effect that saxitoxin causes in some mollusks.

As a final inference, the results showed that the concentration and kind of cyanotoxins can be important in the selection of mussel feeding behaviour. The saxitoxin has a paralyzing effect on grazing, and mussels in mycrocistin concentrations greater than or equal to 2 ppb can inhibit filtration behavior . Therefore, in aquatic environments, cyanobacteria can affect *L. fortunei,* but further studies are necessary to elucidate the cyanotoxina concentrations which can generate negative effects on mussels.

NOTES

The Non-indigenous Aquatic Species Program: Past, Present, and Future

Matt Cannister, *Pamela Fuller, Amy Benson and Matthew Neilson, U.S. Geological Survey*

The United States Geological Survey's Nonindigenous Aquatic Species (NAS) Database has been established as a repository for geo-referenced introduced aquatic species observations. The NAS program provides various scientific resources including: online queries, spatial data sets, interactive species distribution maps, regional contact lists, species accounts, and an alert system designed to quickly spread information on new introductions.

The NAS Database maintains a high level of quality data that is frequently used by scientists, interagency groups, news outlets, and the general public. Since its inception, the NAS Database has been used in numerous products that include: peer reviewed journal articles, books and book chapters, press releases, agency reports, news articles, and other biodiversity databases.

The NAS Alert System has an automated process that generates alerts when species are introduced into new geographic regions such as states, counties, or hydrologic units, and has produced over 1200 alerts since it came online in 2004. This reporting system is an important component in building a rapid response system that can be used by invasive species biologists and resources managers alike.

Over the years, there has been an exponential increase in the amount of available high quality data on introduced species. The NAS Program is currently exploring strategies to take advantage of the increasing availability of online biodiversity information with tools such as a bulk data uploader, an environmental layers enhancement to current species distribution maps, as well as other potential future tools available through our website (www.nas.er.usgs.gov).

NOTES

Watchlist Species: Assessing Risk for Future Invaders of the Great Lakes

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A thorough understanding of potential aquatic nonindigenous species (ANS) is necessary to provide a complete assessment of risks, which then facilitates successful active monitoring and prevention activities. Identification of and subsequent risk assessment for these 'watchlist' species (i.e., ANS not established in the Great Lakes, but with a high likelihood for introduction and establishment) was initiated by the Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS), a Great Lakes-specific node of the U.S. Geological Survey Nonindigenous Aquatic Species national database. Species were identified as watchlist species if they met at least three of the following five criteria: existing transport vector, ability to survive transport, probability of high propagule pressure, potential for successful reproduction in the Great Lakes, and an invasion history. However, efforts were largely focused on species transferred via the shipping vector, and from the Ponto-Caspian region. Thus, all potential ANS may not have been identified, particularly organisms in live trade and connecting waterways.

This project seeks to complete risk assessments for all watchlist species, specifically: 1) complete assessments for the current list of 53 watchlist species identified by previous GLANSIS efforts; 2) identify and complete assessments for additional potential watchlist species from other important vectors and geographic regions; and 3) map the risk posed by these species, using Michigan as a pilot state. Here we present the first two of these three tasks. First, a summary of these watchlist species' taxonomy, native range, life history, habitat preferences and requirements, invasion history elsewhere, potential ecosystem and human interactions and effects, and management regulations and control methods. Second, a summary of the potential for introduction, establishment, and impact based on the information described above. Over the next year, we will use these assessments to map the risk from these watchlist species to assist in prioritizing areas for active monitoring and area- or vector-specific prevention activities. This will in turn help prevent primary introductions into the Great Lakes via ballast, biofouling, and live trade, as well as prevent the spread of ANS beyond their current range via recreational activities, canals, and waterways.

NOTES

Is a Recirculating Aquaculture System an Option for Non-native Species Management in the Polish Coastal Zone of the Baltic Sea?

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Invasions of aquatic non-native species are of global importance having significant ecological, economic and human health impacts. Yet, non-native species affecting Baltic marine environment are observed in a growing number. Today over 120 non-native aquatic species, originating from freshwater and brackish-water environments of North America, the Ponto-Caspian, and Asian region have been recorded in the Baltic Sea (around 80 of which have established reproducing populations). Most of the species have been introduced via man made channels and ballast waters, and only in some cases the species have been deliberately introduced for aquaculture or fishing. It is very likely that new species introduced to the Baltic Sea have an ecological impact on native biodiversity and ecosystem functioning. Still, the impacts caused by non-native species to the Baltic biodiversity, economy and well-being require an interdisciplinary research, the results of which could allow for integrated control and management. Apart from having potential negative effects, non-native species are an important food components of fish, for instance. Some of those species are caught and used as food for humans. Those species are also used as a live food in aquaculture. They could contribute to food production, biotechnology or other ecosystem goods and services. Since recently aquaculture is becoming increasingly dependent on non-native species, it seams that there is an option to combine the experience of non-native species management together with the latest environmentally-friendly technology of breeding aquatic species, that is to develop scientific, technical and business conceptual models for aquacultures, based on brackish-water Recirculating Aquaculture Systems (RAS) in Polish coastal zone of the Baltic Sea.

NOTES

Developing a Risk Assessment Model for Identifying Potential Invasive Aquatic Weeds in Texas

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Determining which non-native aquatic plants have the greatest potential to invade a new area, and prohibiting those species prior to their introduction, is the key to preventing future serious infestations. This study intends to develop a tool that will as accurately as possible predict potential aquatic invasive plants for the state of Texas. The vast majority of exotic plants, either aquatic or terrestrial, are intentionally introduced to an area for purposes such as food crops, ornamental gardening, or as novelties. Once established in "captivity", many plants are accidentally or intentionally released into the environment. The majority do not pose a serious threat of infestation, however a select number can quickly become well established and cause severe damage to both the ecosystem and the economy. Each year, millions of dollars are spent in an attempt to control these invaders in the United States. Weed Risk Assessments, tools for determining the invasive potential of a plant species, have been developed and are currently being used around the world to screen non-native plant species and identify those which should be excluded. Most notably, a risk assessment was developed for Australia in 1999 as a biosecurity tool. The Australian system is regarded as a highly accurate tool for screening exotic terrestrial plants prior to their introduction. This model has been widely adapted to screen for terrestrial and aquatic plants in a number of other countries including New Zealand, Chile, and the United States, as well as individual states in the U.S. such as California and Hawaii. A tool specifically tailored to the unique ecosystems of Texas has not yet been developed, however. Texas is a major hub in the aquatic plants trade and likewise is very susceptible to new invasion, so developing and implementing an effective risk assessment tool is imperative to reducing future invasions. This study will review the models that are currently available, the Australian and United States models in particular, and adapt them to develop a tool that will accurately identify those aquatic species which should be prohibited from entering the state of Texas, while recognizing those which should be safe to import.

NOTES

Parasite Effects on the Feeding Behaviour and Functional Response of the Invasive Amphipod *Gammarus pulex*. (Crustacea; Amphipoda)

***Marilyn Ennis**, Mhairi Alexander, Jaimie T.A. Dick, Rachel Paterson and Sheena Cotter, Queen's University Belfast*

Invasive species can alter macro invertebrate community structure, and parasite mediated competition is now thought to play a significant role in the success or failure of these invasions. Parasitically induced phenotypic behavioural changes may potentially alter the feeding strategy of the host, with subsequent impacts on the functioning of the broader ecological community. The amphipod *Gammarus pulex*, invasive in Ireland with a significant impact on community structure in fresh water ecosystems, is an intermediate host to the brown trout acathocephalan parasite, *Echinorynchus truttae*. Here, I used the 'functional response' (the relationship between prey consumption and prey density) to examine parasite effects on amphipod impact on prey. Infected *G. pulex* killed significantly greater numbers of mayfly (*Baetis rhodani*) than uninfected individuals with significantly more mayfly killed at higher densities. Parasitised individuals consumed a significantly greater mass of mayfly material and consumed a significantly higher percentage of mayfly partially than uninfected *G. pulex*, with a non-significant trend for preferential consumption of thorax tissue. Infected and uninfected *G. pulex* displayed type II functional responses, with the response curve of parasitised individuals rising more steeply and with a higher asymptote than uninfected individuals. At high prey densities, selective partial consumption of prey may satisfy parasite-induced increased energy, protein or nutrient demands, by reducing handling and digestion time, resulting in a heightened functional response with a potentially greater community impact.

NOTES

Program to Control Exotic Species in the Area of Usina Hidrelétrica Serra do Facão

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The introduction of exotic species, flora and fauna, has negative effect on most ecosystems and is causing a serious environmental impact in Brazilian rivers and reservoirs. Exotic species are the second greatest cause of biodiversity loss worldwide. To prevent, control and, if possible, eradicate exotic species is an important task aimed at maintaining environmental quality and ensuring the conservation of native species. There is a great debate in Brazil on the most environmentally friendly controls of invasive species, particularly in the electricity generation industry.

A comprehensive project was initiated to prevent and control the introduction of exotic species in the reservoir of Usina Hidrelétrica (UHE) Serra do Facão (SEFAC), located in São Marcos river, Paraná basin in the Goiás state, center of Brazil. The aim of the program was to inform and educate the employees of SEFAC as well as the urban and rural populations on the problems and impacts caused by the introduction of exotic species. Species such as non-native fishes in the river, golden mussel and aquatic plants. Included in the project was the assessment of impacts in infested regions; establishment of a network of basic monitoring to identify and assess the presence or absence of exotic species and eventually, when necessary, establish population densities.

The first step in the project's plan of action was a series of lectures on the risks associated with exotic species and the importance of prevention of introductions. These lectures were given by specialists in golden mussel (*Limnoperna fortunei*) biology and impacts, ichthyology and macrophytes. These three groups represent the main threat of exotic introductions to the basin of the São Marcos river and prevention of introduction is of utmost importance. In addition to the lecture series, folders on exotic species were developed as well as a booklet on the golden mussel. These materials were widely distributed during all public events.

The environmental education focused on training individuals, which would further disseminate the information in the community. Lectures were therefore given in schools and community centres located in the vicinity of the reservoir. In order to promote the program and involve the population in the area of the reservoir, we carried out numerous field trips to the area. During these field trip we distributed flyers on the program, explained our goals and outlined the actions the local population could take to prevent or control introduction of exotic species. Visits were made to the neighbouring properties of the reservoir with a questionnaire on the presence and movements of boats and the presence of ponds devoted to fish farming. Following the questionnaires we visited the area offering clarification on the risks of spread of exotic species such as golden mussel and some species of fish and carried out demonstrations on cleaning the boats in order to avoid contamination of the hull with aquatic plants and invasive golden mussels.

Printed materials were delivered to agricultural and fishing establishments. Follow-up visits with fishermen and other people involved in aquatic trades were also made to increase awareness of the risks and consequences of the invasion by exotic species. Traps were installed downstream and upstream of the central area in order to monitor the presence of the golden mussel. These traps were checked every month for the presence of adult golden mussels. We also monitored, identified and marked islands of macrophytes located in the area of the reservoir. This monitoring tracks the growth of macrophytes in the reservoir and their movement. In addition, we carried out research on the identification and distribution of the malacofauna in the basin.

We continue to distribute published material in the area detailing the damage and problems that the exotic species can cause. We identify residents who have acquired vessels and alert them to the appropriate disinfection methods prior to visiting other water sources. We continue to maintain the traps for golden mussel in selected areas which are as yet not contaminated, but are considered at risk of infestation. We also continue our macrophyte monitoring effort. Up to now we have not identified any exotic species that could impair the water quality in the reservoir or impact the operation of the electrical generating plant. Efforts to educate the local population will continue in order to prevent unwanted introductions of exotic species. If such an introduction should occur appropriate control measures will be developed and implemented.

Zebra Mussel Habitat Preference, Growth, and Mortality within and among Lakes in Northeast Wisconsin and Upper Michigan

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Zebra mussels (*Dreissena polymorpha*) are being transported by anthropogenic mechanisms and through natural corridors from the Great Lakes to inland lakes in northern Wisconsin and Upper Michigan. With limited zebra mussel management options, there is a need to contain the spread through early detection monitoring. Suitability models based on water calcium concentrations currently assist managers by identifying which lakes to focus pre-invasion monitoring efforts. Knowledge of lake-specific habitat limitations will help refine monitoring efforts by identifying locations within lakes that have high invasion potential. Additionally, quantitative comparisons of population dynamics among lakes across a range of colonization periods will provide information to managers and landowners on anticipated population trajectories following establishment. The objective of this study was to determine zebra mussel habitat preferences and population dynamics within and among lakes in northern Wisconsin and upper Michigan. SCUBA diving was used to sample quadrats at regular intervals along transects representing a variety of substrate types and water depths. Within quadrats, water depth and substrates were recorded to quantify habitat availability. Presence and density of zebra mussels, substrates zebra mussels were attached to, as well as zebra mussel age and length were examined to assess habitat preference and population dynamics. Results indicate that some substrate selection is occurring within lakes. Among lakes, there is a difference in zebra mussel growth, but no difference in mortality.

NOTES

Phylogeography of the Invasive Ctenophore *Mnemiopsis leidyi* in Eurasia

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

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Are there Benthic Non-indigenous Species in the Canadian Arctic?

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Increased shipping activity in the Canadian Arctic combined with global warming and resource exploitation may result in an increased risk of aquatic invasive species (AIS) in the near future. The Canadian Arctic coastline is one of the longest in the world, however, the distribution of the native taxa and the extent of AIS incursions are unknown. The objective of this work is to develop an inventory of existing benthic biota in areas of the Canadian Arctic with high risk for introduction of AIS and compare with historical and recent biodiversity distribution information to test for temporal changes. Focal high risk ports were identified based on a recent risk assessment of current shipping activity along with information on probability of future increases in shipping activity. Here we present results from three of these ports: Churchill (MB), Tuktoyaktuk (NT) and Iqaluit (NU). Baseline surveys of benthic invertebrates from different depths (subtidal and intertidal) and habitat types (brackish and marine) were conducted in Churchill (2007), Tuktoyaktuk (2008) and Iqaluit (2011). A total of 6 transects were sampled at each port using a combination of SCUBA diving and intertidal based standard methods including: quadrat clearings, cores, and where possible, high resolution photographs and videos. All samples were sieved at 500um and preserved in 5% buffered formalin. Geographic coordinates as well as environmental/habitat information was collected for each transect-depth location. Following lab identification, species lists for each port were compared with historical and recent distribution lists from databases and several biodiversity information systems on the web to a) identify any new species records for the port/local region, and b) determine probable source of new species. Preliminary results show that in Churchill new taxa were predominantly in the Polychaete group, followed by Amphipods, Molluscs, Copepods and Echinoderms, mostly from the North American Atlantic coast, while in Tuktoyaktuk, new taxa were mainly Polychaetes and Amphipods from other regions of the Arctic. Identifications of specimens from Iqaluit are still underway; results will be presented for comparison with the other two sites. Of the new species identified to date, *Littorina littorea* (common periwinkle), found in Churchill 2007, is the only one known to have invasive characteristics. This species competes with native gastropods and can change the substrate of the intertidal ecosystem. Our findings suggest it is likely established in the area. More recent collections made in the Churchill area in 2011 together with data collected in Deception Bay (QC) in 2012, where it was also identified, will provide more information on the level of establishment and potential origins of this species. The results from these surveys will help establish a solid baseline for further monitoring and early detection of AIS, and at the same time, add to our knowledge on the diversity contained in the Canadian Arctic coastal regions.

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Moving Faster than a Snail's Pace: Trends and Consequences of Invasive Freshwater Snails

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As the world becomes more connected as a result of the movement of people and goods, an increasing number of species are introduced into new ecosystems. While not all introductions result in established populations, some non-indigenous species thrive in their new environment and harm or alter native biota and ecosystem processes. Many invasive species gain public and scientific interest due to their immediate impact on ecosystem services; other species do not have obvious immediate consequences and go unnoticed until populations are established past the point of easy eradication. Freshwater snail species are reported as invasive worldwide, with a range of economic and ecological consequences. We synthesized information on freshwater snail invasions with the aim of improving management options, including prevention efforts as well as post-invasion control. We identified 33 species from 12 families of freshwater gastropods found worldwide, and compared and contrasted both species and family characteristics as well as consequences of successful invasions. Movement of individuals most commonly takes place between North America and Europe, Asia, and South America. The most common traits shared among families include a high tolerance to abiotic variability and pollution, the presence of an operculum, hosting parasites known to harm other animals and humans, an average fecundity greater than 50 individuals per reproductive event, and the capability of multiple foraging strategies that vary based on current environmental conditions. Invasions are typically passive, spreading due to human activities. Shipping and the dumping of ballast water, the food trade, and the aquaria and aquatic plant trades are the most common means of dispersal. Invasive snails may clog industrial water pipes, cause a decrease in crop production, and dominate secondary production by displacing native snails, grazers, and other benthic macroinvertebrates. Additionally, efficient filter feeding reduces the amount of food available to native planktivores. Predicting potential distributions and consequences of various invasive snails requires knowledge on the similarities and differences among these species, and this review begins to assemble this valuable information for freshwater gastropods.

NOTES

Effects of Thermal Effluent on Exotic Benthic Invertebrates in the St. Lawrence River

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Temperature is a primary physical constraint on the distribution and abundance of organisms within an aquatic system, owing to its critical role in metabolism, growth, and reproduction. Temperature regimes vary naturally on spatiotemporal scales, but increasingly they are altered by anthropogenic sources such as thermal effluent from power-generating stations. In the St. Lawrence River, the Gentilly-2 Nuclear Power Plant (CNG-2) has been in operation since 1983, creating a thermal 4-km thermal plume with temperatures as much as 12ºC higher than ambient. Reproducing populations of the subtropical Asian clam Corbicula fluminea and other exotic species have been discovered in the thermal plume in recent years. The present study evaluated how the diversity and abundance of benthic macroinvertebrates (and of exotic species in particular) downstream of CNG-2 have been altered by thermal discharge relative to natural areas of the river. In spring and summer 2012, we conducted a field survey using benthic grabs to sample macroinvertebrates in mixed sediments at 40 sites along a 6-km transect from the outflow of the power plant to natural sites downstream. The abundances of native and exotic species were related to environmental data (temperature, dissolved oxygen, flow, sediment composition) collected at each site. Artificially heated sites had higher abundances, but lower diversity, of native species. The most abundant exotic species were restricted to the warmest areas of the thermal plume.

NOTES

Are Non-native species More Likely to Become Pests?

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Some ecologists have recently argued that native species are just as likely to be invasive pests as non-native species and so the biogeographic origin of a species should not be considered in management decisions. Using published data on freshwater plants and animals established in North America and Europe, we tested whether the pest status of a species is independent of its biogeographic (native/non-native) origin. Pests were defined as those whose presence has resulted in demonstrable socio-economic damage. All species were classified on the basis of whether they are native to the continent, transplanted beyond their native range within the continent, or non-native to the continent.

The results of this study show that non-native species comprise the majority (58%) of aquatic pests in North America and Europe, and they are 10 times more likely than native species to become a pest. Proportionally, the majority of pests are comprised by species non-native to the continent, followed by transplants, and then natives. Our results refute claims that the biogeographic origin has no bearing on a species' propensity to cause undesirable impacts.

NOTES

Protecting the Great Lakes from Internet Trade of Aquatic Invasive Species

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The sale of live organisms over the Internet can lead to the movement of invasive species to areas where they are a threat to the ecosystem. For example, several studies have documented the availability of invasive aquatic plants via the internet, including federally regulated noxious weeds. Although often cited as a problem, limited work is being done in the Great Lakes region to assess and manage this mechanism for aquatic invasive species (AIS) introduction and spread. In response, the Great Lakes Commission received funding through the U.S. EPA Great Lakes Restoration Initiative to conduct a project that will advance AIS management efforts for this pathway by assessing the availability of AIS of concern on the Internet and developing management options to reduce the risk that these species will be released in the Great Lakes region. A key component of this project is to develop and demonstrate new software-based technology to search the Internet and detect the availability and sources of invasive species. Once proven, this technology will be made available to agencies and other interested parties to conduct their own assessments once the project is completed. Further, using the information gathered by implementing this new technology, the Great Lakes Commission will work with managers to develop recommendations for future management of the Internet pathway. The project will also promote the use of best practices, such as those developed by the Habitattitude™ campaign, by sharing this information with sellers of live organisms that are identified during the project. Overall, this project will provide management tools to decision-makers and regulators, present information on the Internet marketplace, better quantify the overall risks associated with this pathway, and present options for additional action to effectively prevent further releases via this pathway.

NOTES

The Experimental Evaluation of Habitat Preferences of the Ponto-Caspian Gammarid *Pontogammarus robustoides*

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Learning the preferences of alien species for various environmental conditions makes it possible to estimate the susceptibility of novel areas to their invasions and may help predict their spread rate and directions. Ponto-Caspian gammarids are among the most successful invertebrate invaders in European waters. One of several species spreading in Europe is *Pontogammarus robustoides*, a relatively large, predatory and resistant gammarid, capable of generating considerable changes in local environment. So far, it has invaded Eastern and Central Europe, but its further spread is likely. On the basis of field observations, *P. robustoides* is often regarded as a psammophilous and/or phytophilous species, but experimental evaluation of its exact habitat preferences has not been carried out yet. This seems necessary as animal distribution in the field may be affected by numerous contradictory factors, their effects being difficult to separate from one another. To address this question, we conducted a series of laboratory experiments in controlled conditions to examine the selectiveness of this gammarid for different types of substratum. We collected gammarids from the Włocławek Reservoir (the lower Vistula River, central Poland), where they occur on the shallow sandy bottom near the shore. We studied their preferences for five mineral substrata of different grain sizes, from sand to stones (mean±SD: 0.3±0.08, 2.0±0.60, 15±3.2, 27±4.8, 59±7.4 mm), as well as four plant species: *Potamogeton pectinatus, Potamogeton fluitans, Potamogeton perfoliatus* and *Myriophyllum spicatum* (common in the reservoir and differing in the complexity level). The substrata were divided into two groups: mineral materials and plants. Within each group, we conducted pairwise tests (N=15) with two substratum types presented simultaneously to 10 gammarid individuals in a test tank (24 x 12 cm, depth: 15 cm). The tests were carried out in darkness. After 24 h, we separated both substrata with a glass barrier and counted the gammarids. Furthermore, to determine the most preferred habitat, we tested gammarids in the presence of the most preferred substrata from each group. Our results show that *Pontogammarus robustoides* offered two mineral substrata differing in grain size selected that of larger diameter up to 27 mm. This fraction was also selected in the presence of the largest stones (diameter: 59 mm), thus being most preferred by gammarids. Probably, stones of that size provide the highest level of safety and freedom of movement due to optimum dimensions of free spaces among them. *Potamogeton fluitans* was the most preferred plant substratum in our study, followed by *Myriophyllum spicatum*, *Potamogeton pectinatus*a and *Potamogeton perfoliatus*. When the most preferred stone fraction and macrophyte were presented to gammarids, they selected the former. The preferences of *P. robustoides* observed in our study do not reflect their occurrences in shallow sandy areas or among submerged macrophytes, reported by field studies. Thus, the distribution of this species in the field is likely to be affected by some other factors, such as predator pressure and/or interspecific competition (e.g. by another invasive, rock-dwelling gammarid, *Dikerogammarus villosus*), displacing gammarids to locations that are safer, though devoid of the most suitable substratum.

NOTES

Underwater Evaluation of Habitat Partitioning between Non-native Invader (Racer Goby) and a Threatened Native Fish (European Bullhead) in a European River

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The invasion of Continental European inland waters by Ponto-Caspian gobiids has coincided with the decline of some native fishes, in particular the increasingly vulnerable European bullhead *Cottus gobio*. The racer goby *Babka gymnotrachelus* has invaded the lower stretches of the River Brda (River Vistula catchment, central Poland) where the bullhead is native. As both species are small, stream-dwelling benthivores that use crevice refuges for reproduction and anti-predator protection, there is considerable potential for niche overlap and thus adverse impacts by the alien on the resident native species. As a complement to experimental studies of interactions between these two species (see oral communication by Kakareko et al.), underwater surveys were conducted in the lower River Brda using SCUBA gear to record, within a defined area, the occurrence of European bullhead and racer goby by total length (TL) size class (small, <6 cm TL; large >6 cm TL), and local environmental conditions (depth, water velocity, substratum type, plant coverage, shelter type). In total, 89 separate observations were made, revealing a limited level of niche overlap between the two species. A clear size-related segregation was observed in both species, with small fish preferring smaller grain sizes (small stones, gravel) and larger fish preferring large stones and boulders. Racer gobies were found more often in lentic areas over sand or mud, which contrasted a higher occurrence of bullheads in lotic areas with stony bottoms. Additionally, bullheads usually took refuge under stones in contrast to a wider range of shelters used by racer goby, including tree roots and rubbish. Water depth and submerged plants were less important habitat use variables. However, general linear modelling of the data revealed a probable ongoing displacement of European bullhead by the invader, as significant inverse relationships were found within particular habitats between small bullheads and large gobies (in all habitats) as well as between small bullheads and small gobies (on stones and boulders, not on sand). This suggests the invading gobies may be adversely affecting the recruitment of small bullheads, particularly at moderate flow rates and over small stones and gravel, where small fish of both species can co-occur. The implications of these results for European bullhead conservation management are summarized.

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NOTES

The Regional Euro-Asian Biological Invasions Centre (REABIC) Information System

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The Regional Euro-Asian Biological Invasions Centre (REABIC, http://www.reabic.net) information system is a web-portal providing on-line information services in the area of biological invasions research and management, with the current focus on aquatic invasive species (AIS). Facilitation of international cooperation on AIS related information management, and the provision of links among the international research community and general public, managers and decision-makers as well as other interested stakeholders are among the main REABIC objectives. REABIC also serves as an independent regional data centre and an international repository of checklists of non-native species and geo-referenced record data on AIS. Currently REABIC is focusing on the elaboration of effective mechanisms to support online information systems on AIS, primarily via the three REABIC-based international open access thematic journals Aquatic Invasions, BioInvasions Records, and Management of Biological Invasions. These journals include a peer-reviewing system as the mechanism of quality control of AIS information, are available after their publication in the online information system of REABIC and other online information systems, and provide services for data holders in the protection of their author rights on information. Aquatic Invasions (http://www.aquaticinvasions.net) is an academic international open access journal focused on advances in species identification, patterns of species dispersal, population dynamics, ecological and evolutionary impacts of AIS, and prediction of new invasions. Timely publications on the most recent geo-referenced records of AIS in BioInvasions Records (http://www.reabic.net/journals/bir/) provide a unique opportunity to develop early warning systems. Management of Biological Invasions (http://www.reabic.net/journals/mbi/) involves publications in the applied research of AIS, including advances in management of invasive species and risk assessments, while also serving as an instrument to support online Decision Support Systems (e.g. REABIC-based Decision Support System for management of introductions of invasive alien species for the Black Sea basin at http://www.reabic.net/DSS_BlackSeaBasin/Default.aspx). The incorporation of thematic open access journals into the REABIC information system represents an innovative approach to AIS-related information management and ensures sustainability of REABIC-based information management tools. In combination with other REABIC-based online services for information management, REABIC also provides a virtual platform for linking the international research community and general public, managers and decision-makers. The REABIC web portal is hosting web sites of the International Society of Limnology Working Group on Aquatic Invasive Species (SIL WGAIS), and the European Information and Research Network on Aquatic Invasive Species (ERNAIS). Also, REABIC is a partner organisation and data provider for the Global Biodiversity Information Facility (GBIF), the Global Invasive Alien Species Information Partnership (currently developing under CBD) and for the European Alien Species Information Network (EASIN).

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Out with the Old, in with the New: Dealing with Aquatic Weed Succession in South Africa

Julie Coetzee, Martin Hill and ***Grant Martin****, Rhodes University*

Historically, control efforts against aquatic macrophytes in South Africa have focused on the floating weeds, water hyacinth, *Eichhornia crassipes* (C. Mart.) Solms (Pontederiacaeae), salvinia, *Salvinia molesta* D.S.Mitch. (Salviniaceae), water lettuce, *Pistia stratiotes* L. (Araceae), parrot's feather, *Myriophyllum aquaticum* (Vell.) Verdc. (Haloragaceae), and red water fern, *Azolla filiculoides* Lam. (Azollaceae). Post-release evaluations over the last five years have shown that, with the exception of water hyacinth, all of these problematic aquatic plants have been suppressed effectively using classical biological control. However, in eutrophic water bodies at high elevations that experience cold winters, an integrated approach, that includes herbicide application and augmentive biological control, is required against water hyacinth. In contrast, there is a dearth of research into the invasion and control of submerged, aquatic macrophytes. With numerous submerged invasive species already established in South Africa, thriving horticultural and aquarium industries, nutrient-rich water systems, and a limited knowledge of the drivers of invasions of submerged macrophytes, South Africa is highly vulnerable to a second phase of aquatic plant problems. Experiences gained in the U.S.A. on biological control against submerged weeds, such as hydrilla, *Hydrilla verticillata* (L.f.) Royle (Hydrocharitaceae) and spiked/Eurasian watermilfoil, *Myriophyllum spicatum* L. (Haloragaceae), have provided South African researchers with the necessary foundation to initiate programmes against these weeds. Feasibility studies into biological control of some incipient weeds are also being conducted, including Brazilian water weed, *Egeria densa* Planch. (Hydrocharitaceae), Canadian water weed, *Elodea canadensis* Mitch. (Hydrocharitaceae) cabomba, *Cabomba caroliniana* A. Gray (Cabombaceae) and S*agittaria platyphylla* (Engelm.) J.G. Sm. (Alismataceae). Progress with, and potential constraints that may limit these programmes are discussed.

NOTES

The Successful Biological Control of Parrot's Feather, *Myriophyllum aquaticum* (Vell.) Verdc. (Haloragaceae) in South Africa by the Flea Beetle, *Lysathia* sp. (Chrysomelidae)

Julie Coetzee, Martin Hill and ***Grant Martin****, Rhodes University*

Myriophyllum aquaticum (Vell.) Verdc. (Haloragaceae), parrot's feather is an aquatic plant indigenous to South America, but regarded as invasive in southern Africa, Australia and North America. It was first recorded in South Africa in 1918 in the Western Cape Province but spread to many rivers, dams and impoundments throughout the country where it impacted water resource utilization and aquatic biodiversity. A biological control programme was implementd with the release of the flea beetle, *Lysathia* sp. against this weed in 1994. To date South Africa is the only country to have initiated a biological control programme against this weed. Post release evaluations over the past five years at 32 parrot's feather sites across South Africa revealed that the beetle had resulted in the disappearance of the weed at 14 of the previously recorded sites while the weed had been significantly reduced at the other sites. The beetle was recorded at all of the sites where the weed was still present, and at these sites, 100% of the stems of the weed were damaged and percentage cover of the weed was less than 10%. Parrot's feather can now be considered to be under complete biological control in South Africa, and release of *Lysathia* could be implemented elsewhere in the world where parrot's feather is problematic.

NOTES

Exploring Management Alternatives for an Invasive Species in Atlantic Canada: Chemical Analysis and the Basis for a Fishery of the European Green Crab

***Cassandra Mellish**, Paula Tummon Flynn, Mary McNiven, Sophie St. Hilaire and Pedro Quijon, University of Prince Edward Island*

European green crabs (*Carcinus maenas*) have successfully colonized coastlines worldwide, prey heavily on numerous shellfish species and alter a variety of habitats. Where populations are found in high abundances, trapping aiming to control their numbers would be ecologically beneficial. However, long-term trapping would be unfeasible without identifying potential uses for this species, and the development of a market for this species would not work without a sustainable fishery for the green crabs. This study addressed these issues by comparing the dynamics of two green crab populations in Prince Edward Island, as a way to establish the basis for a potential fishery for the species. This study also conducted chemical analyses (protein, lipids, dry matter and ash content) to explore the possibility of using green crabs as a low-cost additive in animal feed. Comparisons of green crab populations focused on abundance, size, sex ratios and physical condition, and identified differences among locations and between samples collected early and late in the summer season. Results show Souris River crabs were on average larger than North River crabs, and male crabs were larger than females at both locations. North River female crabs carried eggs during the first two weeks of June only, while Souris River crabs were found with eggs later in the summer. North River crabs appear to have higher lipid and protein content but lower ash content than Souris River crabs. Percent protein decreased in the late season results at both locations. Based on the data collected to date, the Souris population seems more suitable for a directed and sustainable fishery, a result that is likely related to its longer time of invasion and it closeness to other areas with well established populations.

NOTES

Third Prototype Shipboard Filter Skid (p3SFS): An Automated, Flow-Through Ballast Water Sampling Device

***Cameron Moser** and Lisa Drake, U.S. Naval Research Laboratory; Jonathan Grant, Battenkill Technologies, Inc.; Timothy Wier, U.S. Naval Research Laboratory-Excet Incorporated*

The current practice for sampling living organisms ≥ 50 µm (nominally zooplankton) in ballast water is to concentrate organisms from the discharge stream using plankton nets, with the wastewater typically discarded into the bilge. For shipboard applications, this method can be impractical since it can require a large operating space, and the net setup is susceptible to overflows. At the U.S. Naval Research Laboratory in Key West, Florida, a new approach was used: an array (i.e., a filter skid) of closed, pressurized filter housings, each fitted with a net constructed of 35-µm mesh, was designed and constructed to concentrate organisms from relatively large volumes (i.e., cubic meters) of ballast water. The goal was to design a straightforward system capable of sampling water with a biological capture efficacy equal to or greater than that of a plankton net but while accommodating the restrictions specific to shipboard installation and operation.

This presentation will describe the third prototype shipboard filter skid (p3SFS), developed specifically for a bulk carrier owned and operated by the American Steamship Company, the M/V Indiana Harbor. The skid was designed to continuously draw sample flow from a port in the ship's ballast header, concentrate organisms in the water through a pair of filter housings arranged in parallel, and then return the effluent into the same ballast header. The p3SFS provides a touch-screen control interface whereby a user enters the desired operational flow, sample volume, and sampling duration. The user is then guided through steps to ready the system for sampling. The filter skid's controller initiates flow by activating a centrifugal pump and outputs position commands to a control valve to maintain the user-specified flow rate. The user can monitor the operation status using the real-time display of key sampling parameters from sensor outputs, which are logged every second and can be extracted for analysis after the operation is completed. Once a condition specified by the user (i.e., sample volume or duration of sampling) is achieved or a critical alarm is triggered (e.g., a high pressure drop across the filter housings, due to clogged filter bags), the controller closes all valves to isolate the sample in the filter housings and then deactivates the pump. An unfiltered (whole water) sample can also be obtained from the p3SFS using the skid's 'drip sampler', which is collected from a sample port situated immediately upstream of the filter housings. All of the components are contained within a rigid steel frame designed to provide mobility and structural integrity.

NOTES

Containment of Knifefish (*Chitala ornata*) Infestation in Laguna De Bay, Philippines

***Adelaida Palma**, Bureau of Fisheries and Aquatic Resources*

Laguna de Bay is the largest lake in the Philippines covering a total surface area of 900 km^2. A total of 33 species of fish have been reported to have thrived in the lake which included nine indigenous, five migratory and nineteen introduced. Species introduction has been a major driver in the changes in species diversity. While deliberate introductions of aquaculture species like *Oreochromis sp., Cyprinus carpio* and *Aristichthys nobilis* had significantly increased fisheries production; accidental stocking through escapement from aquaculture has lead to infestation by introgression (Thai catfish, *Clarias batrachus*), habitat destruction and benthic foraging (Janitor fish, *Pterygoplichthys disjunctivus*), and loss of indigenous species by predation (Knife fish, *Chitala sp.*). The knife fish was introduced in the Philippines as an ornamental fish. Severe flooding of the coastal municipalities has resulted to its escapement from the land-based hatchery and its proliferation in Laguna de Bay. Baseline fisheries and socio-economic survey conducted by the Bureau of Fisheries and Aquatic Resources showed Knifefish comprised 40.34% the major catch in the open water at an average combined catch of 3,151.45 kg/day of 8 major fishing gears. The fish is caught mainly by gill net, drift long line and motorized drive-in net. Analysis of the gut content showed remnants of small fishes (32.29%); scales and eyes of indigenous fishes (29.41%); shrimps (17.65%) and shells 17.65.%. The proliferation of knife fish has affected the livelihood of some 5,768 fisherfolks in 16 coastal municipalities and 3 cities; and the production from 11,429 has of fishpens and 1,781 has of fish cages. Economic valuation showed 32.25% reduction in the value of capture fisheries. Initial measure to control knifefish population through environmental manipulation to harness the natural salt intrusion on the lake was ineffective. Salinity tolerance showed lethal concentration at 12 ppt. Interference in the reproductive cycle; fisherfolks participation in the massive retrieval under the Cash for Work Program and increased economic utilization of the fish; and tri-media information campaign were implemented through convergent efforts between the Bureau of Fisheries and Aquatic Resources, the Laguna Lake Development Authority, the Department of Social Work and Community Development, the Local government units and the Fisheries and Aquatic Resources Management Council.

NOTES

Evaluating Incentive Programs as an Effective Tool to Control Invasive Species

***Susan Pasko**, National Oceanic and Atmospheric Administration – ERT; Jason Goldberg, U.S. Fish and Wildlife Service*

Commercial markets, bounties, and other incentive programs have recently received significant public interest and media attention as a means to manage invasive species by encouraging the harvest of these species for various purposes including food, clothing, and biofuel. The potential for such programs remains uncertain; some acclaim incentivized harvest as a simple solution to manage invasive species populations while others condemn the idea, declaring incentive programs to be ineffective, costly, and producing a poor return on investment compared to other available control measures. Success of commercialized markets or harvest programs for invasive species may be dependent on biological, ecological, human health, and socioeconomic considerations. Programs that encourage harvest may be an effective management tool in targeting small, distinct populations or they may play a supplementary role within larger control or eradication programs. Their use requires careful review, planning, and monitoring to ensure success and that they do not unintentionally cause the further spread of invasive species or additional harm to native species. Recommendations are offered to assist resource managers and private entrepreneurs to establish feasibility when developing, implementing, or encouraging incentive programs or harvesting efforts that target invasive species.

NOTES

Ecological Determinants of Parasite Acquisition by Exotic Fish Species

***Rachel Paterson**, Queen's University Belfast; Colin Townsend and Robert Poulin, University of Otago; Daniel Tompkins, Landcare Research*

Disease-mediated threats posed by exotic species to native counterparts are not limited to introduced parasites alone, since exotic hosts frequently acquire native parasites with possible consequences for infection patterns in native hosts. Several biological and geographical factors are thought to explain both the richness of parasites in native hosts, and the invasion success of free-living exotic species. However, the determinants of native parasite acquisition by exotic hosts remain unknown. Here, we investigated native parasite communities of exotic freshwater fish to determine which traits influence acquisition of native parasites by exotic hosts. Model selection suggested that five factors (total body length, time since introduction, phylogenetic relatedness to the native fish fauna, trophic level and native fish species richness) may be linked to native parasite acquisition by exotic fish, but 95% confidence intervals of coefficient estimates indicated these explained little of the variance in parasite richness. Based on R-squared values, weak positive relationships may exist only between the number of parasites acquired and either host size or time since introduction. Whilst our results suggest that factors influencing parasite richness in native host communities may be less important for exotic species, it seems that analyses of general ecological factors currently fail to adequately incorporate the physiological and immunological complexity of whether a given animal species will become a host for a new parasite.

NOTES

Developing and Refining a Rapid DNA Test for Invasive Fish Species

***Carson Prichard**, Carol Stepien and Von Sigler, University of Toledo*

The diagnosis and effects of invasive species are of primary Great Lakes fishery management concern. This new project aims to identify the presence and abundance of non-native species, at all life history stages, by developing and testing a rapid, inexpensive, easy-to-use test for environmental DNA samples (eDNA) collected from water. We are developing a diagnostic test to identify all high-risk invasive fish species, including snakehead, Asian carp taxa, and Ponto-Caspian gobies, using DNA barcode sequences. In partnership with Ohio EPA, water samples were collected from sites around Lake Erie and its tributaries for use in ground-truthing the test results in comparison with traditional qualitative sampling. Project outcomes are to: (1) improve ability to detect invasive species at low population levels to facilitate rapid response actions, (2) help stop the introduction of new invasive species through enhanced surveillance (e.g., ballast water), and (3) control and reduce the spread of invasive species already present in the ecosystem through the up-to-date provision of critical information needed by managers.

NOTES

An Unexpected Role for an Invasive Seaweed: Uprooted Rockweeds Act as Key Subsidies of Food and Habitat for Sandy Beach Invertebrates

***Pedro Quijon**, Mitchell MacMillan, Tyler Wheeler and Terrie Hardwick, University of Prince Edward Island*

Some species may play dual roles in distinctive, even contrasting coastal habitats. *Fucus serratus*, a non-indigenous species and one of the most common seaweeds in Atlantic Canada rocky shores, is also a common species among the wrack or stranded seaweeds of sandy beach habitats. In this study we surveyed stranded seaweeds from several sandy beaches along Prince Edward Island north shore, and established two colonization experiments aiming to assess the influence of rockweed on local upper-shore populations of beach invertebrates. The surveys were conducted during the summer season and at the upper intertidal fringe. They confirmed that *Fucus serratus* was one of the two most common stranded seaweeds in the area and the one that contributed the most to the wrack biomass. The first experiment consisted of manually-made *Fucus serratus* patches originally collected at nearby by rocky shores that were anchored to the upper shore levels of two sandy beaches to monitor invertebrate colonization rates over the course of a month. The second used similar manually-made patches to study colonizations of bare sediments associated to two distinctive patch spatial arrangements. The relatively high number of invertebrates associated to rockweeds, as compared to bare sediments, suggests that this invasive seaweed represents a key subsidy of both food and habitat for upper-shore invertebrates. The abundance of invertebrates in bare sediments surrounded by two spatial arrangements of patches suggests that the rockweed influence goes beyond the edges of the patches and is heavily dependent on distance. Further studies should integrate these results into a landscape scale involving satranded rockweed temporal dynamics and its distribution along distincitve sandy beach habitats.

NOTES

RAMP: A Tool for Quickly Determining a Species Current and Potential Climate Envelope

***Scott Sanders** and Michael H. Hoff, U.S. Fish & Wildlife Service*

Predicting a species climate envelope can be important to both native species conservation and estimating risk of invasive species. RAMP provides a simple tool to map the climate envelope for any species in both current and potential future conditions. Species location information is acquired from the Global Biodiversity Information Facility (GBIF). This location information is used to pre-select climate stations which would be used for the match. The user can then add and remove stations at will. Once a suitable set of climate stations are selected a match can be performed. RAMP produces maps and scores of the climate match. That information is useful for projecting whether, and where, an invasive species is at risk of establishing self-sustaining populations or a threatened species climate envelope will shift under future climate conditions. Future climate conditions are modeled for the U.S., Canada, and Mexico using two IPCC scenarios (A1b and B2a) over three periods (2020, 2050, and 2080). RAMP products are intended to help support decisions for regulatory and non-regulatory approaches to enhancing protection of the biosecurity of the U.S. with respect to invasive species. For threatened and endangered native species, climate envelope mapping could be used for improved decision making for recovery.

NOTES

Modeling the Population Dynamics of the Species *Limnoperna Fortunei* in Reservoirs as Influenced by the Presence of Predatory Fish

Fabiano Alcísioe Silva[1], *Roberto Lopes*[1], *Newton Gontijo*[1], *Mônica de Cássia Souza Campos*[1,2], *Hellen Regina Mota*[3], *Marcela David de Carvalho*[3], *Antônio Valadão Cardoso*[1,2], [1]*Centro de Bioengenharia de Espécies Invasoras de Hidrelétricas (CBEIH);* [2]*Fundação Centro Tecnológico de Minas Gerais (CETEC);* [3]*Companhia Energética de Minas Gerais (CEMIG)*

The golden mussel, *Limnoperna fortunei* (Dunker, 1857), is a freshwater bivalve native to China and Southeast Asia that was introduced into, and established itself effectively in South America due to its high adaptive potential (Darrigran & Pastorino, 2004) causing economic and environmental impacts (Darrigran, 2002). The successful establishment of an invasive species in a given environment depends on, among other factors, the low efficiency or lack of predators in the invaded area (Williamson & Fitter, 1996). However, several fish species have been reported in South America as being predators of the golden mussel (e.g., Penchaszadeh *et al*. 2000). The development of models that predict how a golden mussel population is affected by the presence of predators in a given location can be useful as providing tools for monitoring and controlling the invasive process of this species. This study aimed to develop a mathematical model based on differential equations to predict the population dynamics of *L. fortunei* taking into account their predation by fish in dam reservoirs. The model was based on and adapted from another developed by Hannon & Huth (2009), built to predict the population dynamics of the zebra mussel, *Dreissena polymorpha* (Pallas, 1769), using the graphical programming language STELLA (Structured Thinking Experimental Learning Laboratory with Animation) and a review was made to characterize the biology and ecology of the species as well as its main fish predators registered in South America. The model was divided into three interconnected modules. Module 1: the mussel's growth. In it are located the three state variables of the model and each one of them corresponds to a mussel age class that were chosen due to the fact that *L. fortunei* can reach an age of up to three years in South America (Boltovskoy & Cataldo, 1999). It was considered that each year a new generation of mussels would be formed, so all individuals born that year would be part of the same age class. The first corresponds to the mussel's initial juvenile stage and the second and third ones are represented by adults of two and three years old, respectively. The population growth is affected by several factors, such as the adult mussel's fertility, and the sustainable population of the area and its mortality is influenced by both natural death and that caused by predators. Module 2: sustainable population. This corresponds to the maximum mussel density that could inhabit a given reservoir in the long term taking into account some variables of the area such as the amount of hard substrate available for mussel establishment. Module 3: predation rate. This indicates the estimated amount of mussels consumed per year by the predatory fish communities that inhabit the environment. The model developed is a simple tool that can be adjusted to many environments, yet it still needs calibration and validation through field monitoring.

NOTES

Development of the Computational Tool TerraME for Modeling the Process of Invasion by the Species *Limnoperna fortunei*

Fabiano Alcísioe Silva[1], *Thalisson Correia*[1], *Newton Gontijo*[1], *Roberto Lopes*[1], *Mônica de Cássia Souza Campos*[1,2], *Hellen Regina Mota*[3], *Marcela David de Carvalho*[3], *Antônio Valadão Cardoso*[1,2], [1]*Centro de Bioengenharia de Espécies Invasoras de Hidrelétricas (CBEIH);* [2]*Fundação Centro Tecnológico de Minas Gerais (CETEC);* [3]*Companhia Energética de Minas Gerais (CEMIG)*

The creation of geographic distribution models is a tool used to estimate the potential distribution of species, and is currently used for a wide variety of objectives (Guisan & Thiller, 2005). These models have been developed to evaluate the progress of various invasive species. This study aimed to create a computer model for simulation of invasion and spreading of *Limnoperna fortunei* using the software TerraME. The suggested modeling rules were based on species ecology and river dynamics. A modeling procedure based on the concept of Cellular Automata was established, which is characterized by discrete simulations in time, space and state through simple rules that aim to mimic the laws of nature (biological, physical, etc.) that rule the real process (Ermentrout et al., 1993). The Moore Neighborhood was also chosen as the type of relationship between neighboring cells, where there are cells in the vertical, horizontal and even the diagonal of a cell in evidence (Gremonini et al., 2008). The rules established for iteration of the program considered a faster contamination of cells located downstream of the river, as species spreading occurs faster in the upstream – downstream direction, due to the greater dispersion of larvae by the water entrainment . Thus, the model is able to predict a more efficient spreading by the species from contamination points in the upstream portions of the basin. In Google Earth, it was possible to download the information present in the Digital Elevation Data 90m (SRTM - Shuttle Radar Topography Mission) for the geographic region of interest. The digital elevation information was opened in ArcGIS 10 software to be merged with a hydrologic shape containing selected rivers. The output was a shape containing elevation data from CGIAR-CIS. In a TerraView 4.1.0 environment, a database from the new shape was created. In addition to the existing attribute columns in cellular space, six new columns were added: "rivers", created with the objective of detecting cells that pass through rivers; "state", to be the output of the program and the placement of initial points of infestation; "altitude" to contain elevation data from the shape created in ArcGIS; "direction" for the most likely flow direction; the other two were created to contain approximate values of latitude and longitude of each cell of the cellular space. Three possible states for automata were established: "INACTIVE" (cells not yet infested), "INFESTED" (cells already infested) and "BARRIER" (terrestrial cells). The model has proven effective, and as it considers the general rules of the rivers and biology of the organism, can be reproduced in different areas with minor specific adjustments corresponding to the locations to be modeled. Although the results obtained suggest a very functional tool, calibration and validation of the model depend on the monitoring of the invasion by the species at a certain location.

NOTES

Autonomy Mediates the Impact of an Invasive Predator: Injury Patterns and Feeding Rates in Prince Edward Island Green Crab (*Carcinus maenas*) Populations

***Paula Tummon Flynn**, Cassandra Mellish, Tyler Pickering and Pedro Quijon, University of Prince Edward Island*

The potential impact of an invasive species may depend not only on the establishment and growth of populations but also on the condition of the populations. Among crustacean decapods, the loss or damage of a claw is a common injury that can have severe effects on their ability to forage efficiently. The nonindigenous European green crab (*Carcinus maenas*) is heterochelous, i.e., has claws differentiated morphologically and functionally into a major crusher and a minor cutter. Because of their differences, the effect of injury may not only depend on missing claws but also on which claw is lost. The invasion of the green crab in Prince Edward Island (PEI)'s coastal waters has been recognized as a threat to the province's commercial shellfish industry as well as to native decapods. This study examined the influence of claw loss on the feeding rate of the green crab and whether it changed depending on which claw was lost. Injury surveys of green crab populations were also carried out at two coastal sites in PEI during the summer and autumn of 2012. Laboratory and field experiments were performed to measure the feeding rates of healthy and injured crabs on juvenile stages of soft-shell clams (*Mya arenaria*), oysters (*Crassostrea virginica*), rock crabs (*Cancer irroratus*) and green crabs. The results of our study showed that approximately 22% of the all the green crabs collected in the injury survey were missing at least one limb. The most common type of injury was the loss of at least one walking leg and to a lesser extent the loss of a cutter or crusher claw. The rate of injury was also found to vary considerably between locations. Injury generally reduced the feeding rate of green crabs on shellfish and juvenile decapods. The loss of the crusher claw had a greater effect than the loss of the cutter claw, particularly on the feeding rate on oysters. These differences suggest that the frequency and nature of injury should be considered when forecasting the impact of this species.

NOTES

Utilizing Different Eradication Methods to Manage Alien Fish Populations in the Cape Floristic Region Biodiversity Hotspot: South Africa

***Megan van der Bank** and Johannes Adriaan van der Walt, CapeNature*

The Cape Floristic Region (CFR), located in the south western cape of South Africa is a well renowned biodiversity hotspot. The freshwater fish species endemic to the rivers of the region however are under serious threat from invasive alien fish, with most of the 24 endemic and near endemic species threatened. The region is home to endangered species such as spotted rock catfish (*Austroglanis barnardi*) and fiery redfin (*Pseudobarbus phlegethon*) as well as other threatened species such as Clanwilliam yellowfish (*Labeobarbus capensis*), Clanwilliam rock catfish (*Austroglanis gilli*) and Clanwilliam redfin (*Barbus calidus*). Alien spotted bass (*Micropterus punctulatus*) was eradicated from the Thee River using a combination of manual techniques while smallmouth bass (*Micropterus dolomeiu*) was chemically removed from the Rondegat River using CFT legumine (rotenone). Both these rivers are tributaries of the Olifants River in the CFR but differ in their suitability for chemical and mechanical alien fish eradication techniques. The clear, relatively shallow waters of the Thee River with its low riparian vegetation cover and temporary weir barrier was cleared of spotted bass using gill nets, hand nets, fyke nets and electrofishing. These methods were used because of the relative low numbers of spotted bass while all six indigenous fish species were still present in the invaded area. Smallmouth bass has eliminated all but one indigenous fish species in the lower Rondegat River over a period of 50 years and dense riparian vegetation made rotenone the obvious option for eradication of the smallmouth bass. These projects demonstrated that both manual and chemical eradication could be a viable option for smaller tributaries in the CFR depending on the level of alien fish invasion and structure of the river.

NOTES

Practical Management of Aquatic Invasive Species in Ireland

Joseph M. Caffrey, *Senior Researcher, Inland Fisheries Ireland*

Aquatic invasive species represent a growing threat to the island of Ireland, as elsewhere worldwide, and their prevalence and impact is becoming increasingly apparent. These non-native species can cause appreciable damage to natural aquatic and riparian environments, indigenous biota as well as to the local and national economy. As a small country on the western edge of Europe, Ireland has experienced fewer invasions than many countries on the mainland. However, those aquatic invaders that have established have managed to wreak serious environmental, social and economic damage. Additionally, the rate at which new high priority aquatic invasive species are accessing Ireland has increased in recent years, necessitating urgent and robust intervention.

Inland Fisheries Ireland (IFI) has assumed responsibility for tackling the threat posed by aquatic and riparian invasive species in Ireland and has applied considerable resource to this task. A twin-track approach has been adopted where efforts are divided between a) education and awareness-raising, and b) research that is focused on achieving practical control of the target species. The latter is the focus of this presentation.

Surveillance and monitoring by stakeholders and IFI staff has, on occasions, provided valuable information of the early introduction of invasive species. This permitted planned and coordinated mitigation measures to be implemented, with positive results. Examples for an introduced fish species (*Leuciscus cephalus*) and an ornamental aquatic plant (*Ludwigia grandiflora*) will be described.

Where invasive species have become established before their presence or significance was noted, the primary objective must be management to achieve long-term control or at least containment, although the ultimate goal of eradication is always to the fore. In tackling adversaries such as *Corbicula fluminea, Lagarosiphon major, Crassula helmsii* and other high impact invasive species it is important at the outset to research their basic biology and ecology in their 'adopted' habitat so as to identify weak links in their life cycle that may be targeted for selective control. Results from this research can direct the focus of practical control and has proved critical in the success achieved in managing the spread of *L. major* in the second largest lake in Ireland. Details relating to this control programme will be presented.

In addition to life cycle research, considerable effort has focused on developing, upgrading and refining tradition methods that have been used in Ireland and elsewhere to control invasive species. Where these methods have proved to be relatively ineffective in controlling the abundance or spread, or mitigating the adverse impact of the target species, focus has been directed at developing new and innovative control techniques. Towards this end, considerable success has been achieved in Ireland and these methods, and their application, will be described during the presentation.

NOTES

Invasive Fishes: What's Next?

Nicholas Mandrak, *Executive Director, Centre of Expertise for Aquatic Risk Assessment, Fisheries and Oceans Canada*

Much attention has been placed on relatively few invasive species such as Asian carps, Common Carp, and Northern Snakehead. However, they may be just the tip of the dorsal fin. Thousands of fish species are annually transported across the planet through a variety of vectors including the ornamental and live food trades. The challenge is to identify which of these species will become invasive if released into the wild. The establishment and spread of potentially invasive species can be minimized if they are identified and regulated before they are released into the wild. Canada is developing risk screening tools to identify freshwater fish species, currently in trade, that may be harmful to aquatic ecosystems if released into the wild. These tools include global freshwater fish family climate match layers and rapid, screening-level, and detailed-level risk assessment protocols. The climate matching layers and screening-level risk assessment protocol allow the large numbers of fish species in trade to be screened for invasiveness in an efficient manner. This screening will be used to inform potential Canadian regulations to minimize the introduction, spread, and impact of aquatic invasive species.

NOTES

Influence of Phylogenetic Community Structure on Fish Introductions in the Southeast United States

Matthew Neilson *and Pamela Fuller, U.S. Geological Survey*

A central goal of invasion ecology and management efforts for introduced species is to identify both the communities that are susceptible to introduction and the likelihood of success of a species' introduction within a given community. Ecological theory suggests several potential roles for the influence of phylogenetic relatedness and community structure on a community's potential for invasion as well as the success of introduced species. For example, species in diverse communities (measured through species richness or phylogenetic diversity) likely occupy a larger portion of available niche space, thereby limiting the success of potential invaders through competition. Similarly, Darwin's naturalization hypothesis suggests that successful invaders are more distantly related to a community, potentially occupying unique niches and facing less competition from native species. Although the interplay between phylogenetic community structure/diversity and invasion success has been well studied in plant communities, few studies have examined its role in vertebrate communities, especially fishes. We examined the influence of phylogenetic community structure on invasions in fish communities in the South-Atlantic Gulf region (HUC 03). At the sub-basin (HUC8) scale, there was no relationship between number of introduced species and native species richness or phylogenetic diversity. At the basin (HUC6) scale, there was a significant negative relationship between community phylogenetic diversity and number of introduced fishes, echoing a similar (but non-significant) trend for species richness where more diverse communities had fewer numbers of introduced species. Future analyses will investigate the influence of relatedness of successful and unsuccessful invaders to native fish communities.

NOTES

Biological and Ecological Features, Enough to Predict Invasion – The Round Goby Case

Mariusz Sapota*, University of Gdańsk*

Biological invasions are one of the most important treats for stability of ecosystems. For many years, biological invasions have been investigated and general rules concerning this process are well described. In many cases, knowing the main invasion vectors, we can predict which species could be the next invader. Many non-indigenous species present in the Baltic Sea are of Ponto-Caspian origin. Both regions have similar geological history and partially similar environmental conditions. They are connected by rivers and canals systems. Round goby is common Ponto-Caspian species with wide environmental conditions tolerance. In 1990, first round gobies were fished in the Gulf of Gdańsk. It was unexpected as each invasion but not curious. Many aspects of the Gulf of Gdańsk environmental conditions were favorable or at least acceptable for round goby. Unexpected was the scale of invasion, we observed, in subsequent years. Round goby spawns in waters of temperature over 10°C, embryo development is most effective in temperatures from 15 to 20°C. Such temperatures are typical for shallow, inshore waters of the Gulf of Gdańsk, in summer. Round goby is classic euryhalinic species. Salinity of 7 PSU does not influence fish importantly on any stage of its ontogenesis. Round goby is typical bivalvevorous fish. Zoobenthos of the Gulf of Gdańsk is dominated by bivalves, especially blue mussel, forming very good food base for round goby. So, environmental conditions seem to be favorable for round goby. Why do we describe the invasion of round goby, in the Gulf of Gdańsk, as at least to some extent, unexpected? Round goby builds nests under hard substrate, on bottom. Nest and territory around it are guarded effectively by male. The Gulf of Gdańsk is typical soft bottom area. Stones are present on very limited regions. Ports, concrete piers and other hydrotechnical constructions may be use for round goby nests placement, also. Taking into account the area of hard substrates on the bottom and the average distance from one nest to another (about 2 meters); reported from fish native regions, it was possible to predict the effectiveness of spawning. This calculation did not give round goby chance for serious invasion, in the Gulf of Gdańsk. Surprisingly, round goby nest distance in the Gulf of Gdańsk is much smaller than in fish native region. Nests are situated very close. Often, they attach one to another. As the result we observe much more effective reproduction that could be predicted. Invasion of round goby in the Baltic Sea could be expected but the place of its start and the invasion extent in southern, sandy bottom areas are definitely unexpected. In contrary, almost all north shores of Baltic Sea are rocky with hard bottom but round gobies are still not so frequent in those areas. In described case, fate and lack of predators in shallow water zone were the main factors promoting invasion despite deficiency of spawning areas. This case shows, that prediction of invasion place and size is very difficult and many invasions could be still unexpected.

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In the Driver's Seat? Disentangling the Influence of Habitat Degradation and Round Goby Invasion on the Structure and Function of Benthic Communities in the St. Lawrence River

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Invasions by non-native species often occur concomitantly with anthropogenic disturbance, confounding cause and effect interpretations of apparent impacts. While some authors argue that non-native species are a major driver of native species declines, others view invasions and biodiversity loss as coincident consequences of changing abiotic conditions caused by human activities. The goal of this study was to determine the relative importance of abiotic factors and an invasive freshwater fish, the Eurasian round goby (*Neogobius melanostomus*), in the alteration of macroinvertebrate communities and subsequent benthic algal production. To this end, we measured goby density, macroinvertebrate abundance and diversity, and algal abundance at 25 sites along the St. Lawrence River. We also measured 15 environmental variables at each site to characterize local abiotic conditions. A Principal Components Analysis was conducted to reduce the set of environmental variables to abiotic gradients, which were then used in structural equation modeling to evaluate the strength of interaction pathways between biotic and abiotic factors.

Contrary to previous experimental work, we found a negative relationship between goby density and algal abundance. On small spatial and temporal scales, gobies may have an indirect positive effect on algal abundance through their consumption of macroinvertebrates. However, as goby density increases, the positive effects of reduced grazers may be exceeded by the negative effects of the reduction of non-native dreissenid mussels (zebra mussels, *Dreissena polymorpha*, and quagga mussels, *D. bugensis*), which provide microhabitat for benthic algae.

Turbidity had a strong negative effect on goby density and algal abundance. Nevertheless, goby density was the best single predictor of macroinvertebrate diversity loss and had the highest Akaike weight among the set of predictor variables examined. Moreover, abiotic factors did not significantly influence the impacts of round gobies on macroinvertebrates. These results suggest that round goby invasion is the principal driver of changing macroinvertebrate diversity in the St. Lawrence River.

NOTES

Rapid Recent Expansion of the Round Goby (*Neogobius melanostomus*) and the Western Tubenose Goby (*Proterorhinus semilunaris*) in Flanders (Belgium)

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Since their initial discovery in Flanders in 2010, the round goby (*Neogobius melanostomus*) and the western tubenose goby (*Proterorhinus semilunaris*), both originating from the Ponto-Caspian area, have spread rapidly over canals and large rivers. Currently, round goby is recorded in 23 sites in Flanders while western tubenose goby is present in already 63 sites in ever increasing densities.

As in The Netherlands, it is likely that round gobies were released in the lower part of the River Scheldt (within the proximity of the international harbour of Antwerp) with ballast water disposal. It cannot be ruled out, however, that also active migration of specimens from the dense populations in the Dutch Rhine delta through the Rhine–Scheldt Canal has taken place. Recently (Oct. 2012) very small (young) specimens of the round goby were discovered in the Albertcanal near Hasselt, strongly suggesting natural reproduction in Belgian waters. Also mature males and females were sampled from the same canal.

Western tubenose goby almost certainly actively migrated upstream from the downstream parts of the Meuse in the Netherlands to the Border Meuse in Belgium and spread from there to neighbouring canals and rivers.

Finclips of specimens of both species have been sampled for genetic analysis to clarify their origin. Also, preliminary research on the life-history traits has been started and the results will be compared with studies from native and non-native areas.

There are no data on possible negative impacts of the presence of these species in Flanders yet but literature from neighbouring countries suggests a decline in small, benthic fish species may be expected.

NOTES

Spread, Population Dynamics and Ecosystem Impacts of Zebra Versus Quagga Mussels: What Do We Know and What Do We Not?

Alexander Y. Karatayev, *Director and Lyubov E. Burlakova, Research Scientists, Great Lakes Center, Buffalo State College; Diana K. Padilla, Stony Brook University, Department of Ecology and Evolution*

Zebra (*Dreissena polymorpha*) and quagga (*Dreissena rostriformis bugensis*) mussels continue to spread, both in Europe and North America, at virtually all spatial scales, altering the aquatic communities and ecosystems they invade. Both species have similar life history characteristics, but differ in their timing and rates of spread, habitat requirements, growth, and population dynamics. Although both *Dreissena* species were introduced into North America at about the same time, zebra mussels have colonized twice as many states as quagga mussels, almost eight times more counties, and over 15 times more waterbodies. The ecological impacts of both species are associated with their role as ecosystem engineers, and the magnitude of their effects is determined by the population density in a given waterbody. However, all populations of *Dreissena* do not stabilize, and can vary widely over time. When both species colonize the same waterbody, quagga mussels usually establish high densities and outcompete zebra mussels in deep lakes with large profundal zones. However, zebra mussels may be abundant and coexist with quagga mussels in shallower lakes and rivers. While the zebra mussel is among the best studied freshwater invertebrates, we do not always have comparable information for quagga mussels, which limits our ability to predict the spread and ecological impacts of this important freshwater invader. We do not have reliable information on the longevity and fecundity of the quagga mussel, which are critical for predicting potential population sizes in newly invaded waterbodies as well as long term population dynamics, and for determining the mechanisms that underlie differences in population dynamics between these two invaders. Finally, we do not have enough data on the ecological effects of quagga mussel invasions. They may be similar to those of the zebra mussel, or they may be greater given that quagga mussels live in more habitats within lakes than do zebra mussels, and are therefore capable of attaining much larger overall population sizes, particularly in lakes with large profundal zones. Because the vast majority of the observations of quagga mussel impacts on aquatic communities and environments have been conducted in waterbodies previously colonized by zebra mussels, it is very difficult to distinguish between the effects of quagga mussels and zebra mussels. We need more data on the impacts of quagga mussels alone to be able to determine their ecological effects.

NOTES

Behavioural Responses of the Zebra Mussel (*Dreissena polymorpha*) to the Presence of Various Gammarid Species Inhabiting its Colonies

Jarosław Kobak[1]*, Małgorzata Poznańska*[1] *and Tomasz Kakareko*[2]*,* [1]*Nicolaus Copernicus University, Faculty of Biology and Environmental Protection, Department of Invertebrate Zoology;* [2]*Nicolaus Copernicus University, Faculty of Biology and Environmental Protection, Department of Hydrobiology*

Colonies of the invasive Ponto-Caspian zebra mussel constitute suitable habitats for many invertebrate organisms, providing them with valueable food sources and shelters among shells. That is why many species, both native and alien, increase their densities within mussel beds. These include several Ponto-Caspian gammarids, currently spreading throughout Europe. There is, however, little known of the opposite interaction: the potential impact of gammarids occupying a mussel bed on their bivalve hosts.

To check if gammarids can have any influence on zebra mussel behaviour, we studied mussel responses (attachment to substratum, vertical movement, aggregation forming) in the presence of 3 gammarid species differing in their origin and degree of association with *Dreissena* habitats: (1) Ponto-Caspian *Dikerogammarus villosus*, commonly observed in mussel beds and preferring this habitat type, (2) Ponto-Caspian *Pontogammarus robustoides*, showing no specific preferences for mussel habitats and (3) native European *Gammarus fossarum*. We tested mussels in 3 treatments: (1) gammarids moving freely among them (mechanical and chemical stimuli for mussels), (2) gammarids separated from mussels by a mesh barrier (chemical stimuli only) and (3) no gammarids (control).

Mussels responded most strongly to the presence of *D. villosus* by increasing their attachment strength and reducing upward movement. Mussel responses to *P. robustoides* were limited to a moderate increase of attachment strength, significant but lower than that induced by *D. villosus*. Mussels exposed to *G. fossarum* did not change their behaviour. Mussels did not change their aggregation level in the presence of any gammarids. They only responded to gammarids moving freely among their shells and not to those kept behind a mesh barrier. Thus, the most likely factor inducing the observed behavioural changes was mechanical irritation of mussel soft parts by amphipod appendages. That is why the strongest response was observed in the presence of *D. villosus*, a species preferring shell habitats and therefore likely to spend more time among mussels.

This hypothesis was confirmed in an additional experiment with a catfish *Corydoras paleatus* used as another potential source of mechanical irritation. This small, bottom-dwelling South American fish is obviously allopatric with dreissenids, without any common evolutionary history. Thus, we assumed that any changes of mussel behaviour in their presence could be interpreted as responses to mechanical irritation by fish exploring the substratum. However, our results did not fully confirm this assumption. Apart from increasing attachment strength and reducing upward migration of mussels, fish stimulated their aggregation and, more importantly, affected mussel behaviour also without a direct contact with them, being separated by a mesh barrier. Nevertheless, mussel responses to fish moving freely among their shells were significantly stronger, confirming our hypothesis on the impact of mechanical irritation on mussels.

The responses of zebra mussels to gammarids were to some extent similar to their anti-predator defences shown earlier in the presence of molluscivores. Thus, it appears likely that Ponto-Caspian gammarids living withing mussel colonies have the capacity to compromise the normal functioning of bivalves through inducing their defensive responses.

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NOTES

Dreissena Impacts on Unionidae: General Trends in North America and Europe and Recent Findings from the Lower Great Lakes

***Lyubov Burlakova**, Alexander Karatayev, Brianne Tulumello, Buffalo State College; David Zanatta, Central Michigan University; Frances Lucy, Institute of Technology Sligo; Sergey Mastitsky, RNT Consulting Inc.*

The continued invasion of zebra mussels (*Dreissena polymorpha*) and quagga mussels (*Dreissena rostriformis bugensis*) in North America and Europe has threatened the survival of native unionid mussels. We used data from multiple waterbodies in Europe and North America to test if the impact of *Dreissena* on unionids depends on densities of dreissenids in a waterbody, time since invasion, and *Dreissena* species. We found an overall trend for increase of attached dreissenid weight with unionid host's size during the first 10 years after *Dreissena* invasion, however, this adverse impact reduces beyond 10 years after the recorded invasion. We also learned that while impacts of zebra mussels on unionids are well described, there is little comparable data for quagga mussels. Considering that zebra mussels have been almost completely replaced by quagga mussels in most of the Great Lakes, and the fact that quagga mussels have weaker attachment strength, we hypothesized that the adverse impact of dreissenids on unionids is now less than in the early stages of the invasion. We conducted extensive surveys of unionids in lakes Erie, St. Clair and Ontario in 2011-2012, and recorded the number, weight, and species of dreissenids attached to unionids shells. Confirming our hypothesis, most of the unionids found were free of dreissenids, and infested unionids had fewer attached dreissenid mussels than in the early 1990s. Despite the quagga mussels' lake-wide dominance, zebra mussels were more often found on unionids, and their number and weight per host unionid were higher than those of quagga mussels.

NOTES

Could Zebra Mussels Help Unravel the Mysterious Life Cycle of an Introduced and Virulent Parasite of Oysters?

***Daniel Molloy**[1], Laure Giamberini[2], Nancy Stokes[3], Bénédicte Sohm-Rederstorff[2], [1]SUNY at Albany; [2]University of Lorraine; [3]Virginia Institute of Marine Science*

Who said zebra mussels were all bad? Although oysters are marine and zebra mussels are freshwater organisms, studying the latter, much-maligned, striped bivalves may well provide critical new insight into a disease that causes serious economic losses to oyster populations. There are about 40 species in the *Haplosporidia* – a phylum of aquatic, spore-forming parasites of invertebrates. One of the most studied haplosporidians, *Haplosporidium nelsoni*, is a species likely introduced from the Pacific that has devastated "naïve" eastern oyster populations along the Atlantic coast of the United States for over 50 years. But the life cycle of *H. nelsoni*, as well as all other haplosporidian species, remains shrouded in mystery. In short, no one understands how hosts become infected with haplosporidians. As a result of decades of failed attempts to infect oysters with spores liberated from dead/dying conspecifics, there is now general scientific agreement that haplosporidian species, including *H. nelsoni*, probably have complex life cycles involving one or more alternate, obligate hosts. Research efforts to prove this hypothesis and demonstrate the existence of such alternate animal hosts in oyster habitats, e.g., typically large estuaries and bays, have been hampered both by the expensive effort required to sample such large aquatic habitats and also the very high biodiversity, i.e., thousands of species of possible alternate hosts needing to be screened. But what if a haplosporidian disease existed in a water body that was relatively small – a water body that was easier to sample and one with a much lower biodiversity of candidate alternate hosts to screen – possibly just hundreds, not thousands, of species? Such a rare research opportunity now exists in the Meuse River in France. A new species of haplosporidian, *Haplosporidium raabei*, has recently been described from the Meuse's zebra mussel population, and a hot spot of infection has been determined to exist in zebra mussels at a small lock on this river. Specific *in-situ* hybridization and PCR assays have been developed and are now being refined for use in this upcoming study to define the alternate host(s) and elucidate the complete life cycle of a haplosporidian species for the very first time. These latter molecular tools will be particularly valuable in detecting non-patent infections. With success, this zebra mussel project should help marine scientists narrow their search for the alternate host(s) of the introduced species *H. nelsoni*, as well as other economically important haplosporidian parasites of bivalves.

NOTES

Evolutionary and Biogeographic Relationships of Dreissenid Mussels, with Revision of Component Taxa

***Carol Stepien**, University of Toledo*

The identification of taxa and discernment of evolutionary relationships within the family Dreissenidae have been confounded by morphological plasticity as well as prior lack of a comprehensive DNA sequence data analysis. We thus analyzed the phylogenetic relationships of putative taxa (species and subspecies) in the genus *Dreissena* in relation to its nearest living relatives (*Mytilopsis leucophaeata* and *Congeria kusceri*) using DNA sequence data from the nuclear 28S RNA gene and three mitochondrial genes: cytochrome *c oxidase* subunit I (COI), 16S RNA, and cytochrome *(cyt) b oxidase*. Relationships resolved by maximum-likelihood and Bayesian phylogenetic trees were robust and congruent and support division of *Dreissena* into three subgenera: *Dreissena*, *Pontodreissena*, and *Carinodreissena*. The subgenus *Pontodreissena* contains two species: *Dreissena caputlacus* and *D. rostriformis*. Putative subspecies proposed for *D. rostriformis* lack genetic divergence and likely should no longer be recognized; these include *D. r.* "*bugensis*" (the quagga mussel), *D. r.* "*grimmi*", *D. r.* "*distincta*", and *D. r.* "*compressa*". The *Pontodreissena* then comprises the sister group (nearest relative) to a clade comprising the other two subgenera (*Dreissena* and *Carinodreissena*). The subgenus *Carinodreissena* contains the valid taxa *D. carinata* and *D. blanci*; both inhabit ancient lakes in the Balkan Peninsula. DNA and morphological evidence support the synonymy of the formerly recognized *D.* "*stankovici*" and *D.* "*presbensis*" into *D. carinata*. The subgenus *Dreissena* includes two species, *D. polymorpha* and *D. anatolica*. *Dreissena anatolica* is endemic to Turkey in the southern Black Sea region and *D. polymorpha* (the zebra mussel) has been widely introduced throughout much of Eurasia and North America, spreading from its native distribution in the Ponto-Caspian region.

NOTES

Emerging Integration of Risk Assessments in an Aquatic Invasive Species Program

***Becky Cudmore**, Fisheries and Oceans Canada, Centre of Expertise for Aquatic Risk Assessment*

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 a key component of any aquatic invasive species program where the focus is prevention. The general framework on which biological risk assessments are based explores 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. These risk assessments can be conducted at various levels of detail and certainty depending on the need for the advice. Fisheries and Oceans Canada's internationally recognized Centre of Expertise for Aquatic Risk Assessment (CEARA) has developed a national standard for conducting risk assessments and provided the Government of Canada with several risk assessment tools and advice. The success of this program and the valuable information found in risk assessments has led to the emerging use of risk assessments for aquatic invasive species program elements beyond simply identification of risk and prevention. Risk assessments can provide advice for the science, policy, and management aspects of an aquatic invasive species program. Specific examples from risk assessments conducted by CEARA will be used to highlight the practical applications of risk assessment results.

NOTES

Managing an Establishment Pathway Using Import Records and Biological Data

Johanna Bradie *and Brian Leung, McGill University*

To prevent non-indigenous species (NIS) establishments, much work has focused on predicting which species are likely to establish. Successful establishment requires that species be introduced to a new location and survive the biotic and abiotic conditions to which they are exposed. As such, habitat suitability, species' traits, and propagule pressure data are at the foundation of most prediction efforts. The majority of studies to date have focused on one of these predictors and, for those using propagule pressure data, analyzed for a limited number of species. Since NIS are often introduced by a pathway that transports a suite of species, it would be beneficial to develop tools that can predict establishment risk at the pathway-level. Such pathway-level curves would utilize species-specific propagule pressure data to create an establishment curve that predicts the establishment risk associated with species transported by a given pathway. However, species also likely differ in exactly how many propagules are needed for establishment to occur, and these differences may be identifiable based on species traits. Thus, we integrate propagule pressure analyses with trait-based analyses to estimate risk across an entire pathway of introduction. We use aquarium trade introductions as a case study, and parameterize our model using Canadian aquarium fish import data (Cudmore and Mandrak, unpubl. data) for propagule pressure combined with species-specific information from FishBase (Froese and Pauly, 2012). We quantify the reduction in uncertainty that can be anticipated by incorporating species-specific information into pathway-level establishment models. Further, we inform on the methodology of building a joint pathway-level model for other pathways where data permits. Despite the relatively coarse data available for many establishment pathways, there is a need to generate models which can inform establishment risk for use in management. The methodology presented here will enable informed decisions even when data is limited.

NOTES

Anticipating Bioinvasion Risks in a Coastal Context

Daniel Kluza*, New Zealand Ministry for Primary Industries*

The ability to manage marine bioinvasion risks can be bolstered by proactive assessment of potential likelihoods and consequences of a species' introduction, establishment, and spread. To this end, the New Zealand Ministry for Primary Industries (MPI) is developing risk profiles for New Zealand's major commercial, recreational, and passenger vessel ports. The risk profiling effort is a systematic assessment of port-specific pathway characteristics from which potential risk organisms (or organism types) can be identified and establishment likelihoods can be estimated based on species distribution models and measures of propagule pressure. For a given port and its surrounding region, an organism's establishment likelihood and life-history characteristics are assessed within a spatially-explicit context to determine the potential risks (likelihood × consequence) to coastal marine environmental, economic, and social values. Here, I demonstrate the assessment process and show how these outputs can be applied towards managing and mitigating biosecurity risks.

NOTES

Global Changes and Biological Invasion of Aquatic Alien Species: The Case in Russia

***Yury Yu. Dgebuadze**, A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences*

In the XXI century, the earth is facing great challenges of global changes such as global climate change, environmental degradation, global transportation, etc. Globalization of world economy has greatly increase risk of biological invasion and destruction of native ecosystem functions.

Existing cases in Russia as well as other countries show that alien species invasions can nullify attempts to use ecosystems or to keep them from destruction. Mollusks veined rapa welk (*Rapana venosa*), zebra and quagga mussels (*Dreissena polymorpha* and *D. bugensis*); comb jelly (*Mnemiopsis leidyi*); fishes: Amur sleeper (*Perccottus glenii*) and topmouth gudgeon (*Pseudorasbora parva*); beavers (*Castor* sps.) have already done severe damage to both artificial and natural water ecosystems of Russia.

The studies revealed that vulnerability of ecosystems to alien species introduction is one of the least studied and the most difficult questions. However, from the data obtained it is possible to assume that an ecosystem primary production growth and pressure of predators make the system more vulnerable when aboriginal competitors and parasites block invasions.

Biological invasion process supposes that introduced species on the one hand have to adapt to new climate of the region of introduction and on the other hand discomfort aboriginal species. This allows presuming corresponding alterations in the regulation of the vulnerability of ecosystems to invasions. Under climate warming ecosystems are more vulnerable because of the primary production growth when the role of aboriginal species in the regulation process lowers as many of them are discomforted. It is obvious that introduced species from the warmer climatic zones receive a competitive advantage.

Data obtained during the last two decades in Russia confirm the correctness of these assumptions. Long-term observations of the development of the invasive process of aquatic organisms in the Volga River as a Northern Invasion Corridor revealed that the main cause of the community composition alterations was the appearance of new ecological factors the most important of which are new water current regime and eutrophication of constructed reservoirs. The analysis of the introduced species composition showed that southern species predominate in the Volga fauna now.

Several species of fish spreading to the North and East of Russia in basins of big Siberian Rivers Ob, Yenisei and Amur have occupied mainly man-maid reservoirs. Thus case of Russia demonstrates that global change as sum of climate change and human impact promotes the invasion process through the growth of primary production of ecosystems and ecological regulation of their vulnerability to alien species invasions.

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A Risk Analysis of Australia's Marine Ornamental Value Chain Focusing on Biosecurity (Diseases and Pathogens) Concerns

***Kevin Erickson**, Marnie Campbell, Chad Hewitt and Nicole Flint, Central Queensland University*

This presentation shows the progress of ongoing Ph.D. research focusing on the management and risk prevention efforts that Australia is implementing to ensure imported marine ornamental animals, algae and seagrasses do not establish a permanent wild foothold within Australia. Additionally, consideration and monitoring of these imported organisms as pathways of foreign disease transmission is being carried out. Supply/value chain analysis is being used to establish an Australian current practices baseline for the aquarium trade. This occurs via a survey of marine ornamental organisms that are available in Australia to identify the species that are non-native. Determination of a marine species status (native, introduced or cryptogenic) occurs using an established protocol. From there, the methods of how these imported species enter the country are investigated and the importer's current biosecurity measures are recorded. These imported organisms are then followed to the distributer who sends them to various stores around Australia who then passes them on to the individual aquarium hobbyists. While the organisms are being followed, they are monitored for potential diseases and parasites that may have been imported with them, or that they may have been exposed to when they were in quarantine facilities.

NOTES

Is AIS Spread Inevitable: Fact or Fiction?

***Douglas A. Jensen**, Aquatic Invasive Species Program Coordinator, University of Minnesota Sea Grant Program*

Effective management of aquatic invasive species (AIS) is influenced by practical experiences and "lessons learned" stemming from natural resource and human dimensions research. While various management approaches are used, preventing the spread of AIS through effective communication and education is key. Evidence shows that public campaigns like *Stop Aquatic Hitchhikers!*™ can be very effective in changing behavior among water recreationists.

Unfortunately, a lack of research-based information about AIS has led to public outcry, political debate, hindered management objectives, and created outreach conflicts. First, there is an underlying lack of public knowledge and understanding of life histories of AIS and associated risks for spread. Second, there is lack of research describing the *potential* versus *actual* AIS spread. Last, many believe that the spread of AIS will be frequent and widespread. It is these issues that have led to perpetuation of some myths and fallacies about AIS. Johnson and Carlton (1993) first refer to these in their paper, *Counter-Productive Public Information: The Noah Fallacy and Mussel Myths*. These include:

- it only takes just a pair (or single mistake) to cause an infestation (aka Noah Fallacy)
- ducks will spread AIS anyway
- the spread of AIS is inevitable
- it's only a matter of time

Prevalence of these myths and fallacies can feed misperceptions that support negative attitudes:

- AIS are everywhere anyway, so why take action?
- my actions won't help
- AIS are not a problem, spread is a natural thing
- don't worry, they're not in my backyard
- AIS won't affect me. Perpetuating distorted perceptions can validate and promote public apathy and complacency.

Negative perceptions undermine emancipatory behavioral change desired in targeted audiences, thus rendering people powerless in controlling their future. Such attitudes allow individuals an excuse to brush off their personal and social moral obligation to deal with reality. Reality is that if society does nothing, AIS *will* spread.

Every public communication opportunity is critical. Choosing the right words is equally critical (e.g., *preventing* spread instead of *slowing* spread). Social science research shows that misinformation can cause cascading negative attitude and beliefs on positive behaviors. It can influence perception of reality which can lead to false premises and faults in logical thinking. It is well understood that misinformation can affect recall—influenced by suggestibility tests—demonstrating that social influence can strongly affect contagion of memory. Impacts of mixed messages can have long reaching impacts concerning support for AIS research, funding and public policy.

Evidence taken from various authors will be used to dispel these myths and fallacies. This presentation will discuss the importance of more careful and thoughtful promotion of messages to the public and how human dimensions research can help inform and improve campaigns and programs so that we get it right.

NOTES

Curbing Invasion Pathways: A Sea Grant-U.S. Coast Guard Auxiliary Pilot Partnership to Assess and Enhance Aquatic Invasive Species Awareness among Coastal Anglers and Boaters

*William Nelson, U.S. Coast Guard Auxiliary; **Nancy Balcom**, Connecticut Sea Grant/University of Connecticut; Eric C. Dyson, Community College of Rhode Island*

This outreach project built upon a unique partnership of Sea Grant, the U.S. Coast Guard, and the U.S. Coast Guard Auxiliary, along with bait retailers, marinas, and state agencies, working together to share messages with coastal boaters and anglers about steps they can take to minimize the spread of aquatic invasive species (AIS). Certain behaviors of marine recreational boaters and anglers can inadvertently cause the introduction or transfer of non-native marine species, including those with the potential to become established and invasive. These behaviors include the improper disposal of unused live marine bait and its associated natural packing material, and poor hull maintenance and upkeep. Over a two year period, a social marketing campaign was undertaken to address coastal boaters and anglers utilizing the Long Island Sound estuary, located between Connecticut and the northern shore of Long Island, New York.

The results of a 2009 study by researchers from the University of Connecticut and State University of New York - Purchase reinforced concerns that live marine bait, such as bait worms, and more particularly, the seaweed or other material they are packed in, can serve as a vector or pathway by which organisms from one region can be introduced into another. An outreach campaign was initiated to address these findings as well as prevention priorities identified in both the State of Connecticut Aquatic Nuisance Species Management Plan: (3 B 3) Minimize bait industry introductions and (3 C 1) Minimize recreational boating and fishing introductions; and the draft Long Island Sound Interstate Aquatic Invasive Species Management Plan: (3 C 1) Minimize introductions from fouled recreational boat hulls and (3 C 2) Minimize introductions from angling activities. A variety of outreach materials (stickers, key floats, magnets, posters, signs, and neck wallets) with three consistent simple messages, were either distributed to boaters and anglers at boating and fishing shows, public events, during courtesy U.S. Coast Guard Auxiliary vessel safety inspections, and at points-of-sale for live marine bait, or posted at public launch sites, bait shops and marinas. Over two summers, coastal boaters and anglers were interviewed by student research assistants to 1) assess general awareness of aquatic invasive species relative to Long Island Sound, 2) document behaviors reported in response to open-ended questions that either increase or minimize the risk of introduction and spread of AIS, and 3) determine familiarity with, and response to, the products and messages of this particular outreach campaign. The results of this effort, funded by the National Fish & Wildlife Foundation, the EPA Long Island Sound Study, and Connecticut Sea Grant, will be shared and discussed.

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Education and Outreach: Changing Angler and Boater Behavior Over Time

***Matt Smith**, Ontario Federation of Anglers and Hunters*

Second only to habitat loss, invasive species are one of the greatest threats to Ontario's biodiversity. Targeted education and awareness on the pathways that facilitate the spread of invasive species, such as recreational angling and boating, can reduce the impacts that invasive species have on Ontario's biodiversity by preventing their introduction and/or spread to new ecosystems. Preventive actions to avoid spreading organisms, such as washing a boat between movement to new waterbodies and discarding unwanted bait on land or in the trash, significantly lowers the risk of spreading organisms. Since 1992, the Ontario Federation of Anglers and Hunters in partnership with the Ontario Ministry of Natural Resources have been educating anglers and boaters about the risks of spreading invasive species, and how they can prevent their introduction and/or spread. To qualify the effectiveness of the education and understand the gaps in the outreach, two surveys were conducted over 11 years; the first survey in 1998, and the second in 2009. Over the surveys, between 3000 and 5000 surveys were mailed to anglers holding a recreation angling licence with an average response rate of 35%. The survey consists of 33 questions covering five main categories including: boating habits, recreational fishing habits, sources of information on invasive species, social impacts of invasive species, and demographics of survey respondent. Although a formal comparative analysis between the results of the surveys has not be completed, preliminary results show a growing trend in awareness of invasive species among anglers, as well as an increasing number of anglers and boaters taking preventive action to avoid spreading invasive species. The survey results also identify key barriers to anglers for not taking preventive steps to avoid spreading invasive species. From the results of the surveys, we can conclude that, targeted education and outreach for this pathway of spread have been effective; however, although there is an increasing effort among anglers to take action to avoid spreading invasive species, continued education and outreach targeted to angling and boater movement is required to mitigate the risk of invasive species introduction and/or spread through this pathway.

NOTES

Understanding Motivations Behind the Live Release of Organisms

***Debrupa Pathak**, Ontario Ministry of Natural Resources*

Understanding the motivations behind the live release of organisms into natural ecosystems is essential for the effective design of education & outreach programs, as well as policy and regulation focused on preventing new introductions of invasive species.

Cultural ceremonies – known as "merit releases" – are acts which involve the release of live organisms from captivity in order to demonstrate compassion and accumulate merit for the individual and their family. Merit releases are often performed by members of the Buddhist faith – and can be conducted by individuals or groups of people.

The objective of this project was to get a better understanding of these ceremonies, including times of year these ceremonies occur, which species are utilized and the motivations for performing the ceremony. The project had three deliverables: 1) A literature review of current research on live release 2) interviews with community leaders in the Greater Toronto Area to learn more about practices and motivations in Ontario and 3) A workshop with interested agencies and experts to confirm findings and to initiate discussion on the key principles and approaches to communicate concerns regarding the release of live organisms as a pathway for invasive species.

As Ontario's multi-cultural society continues to evolve and grow in the future, understanding cultural practices and motivations behind live releases will help us effectively direct our communication methods to work with community groups and leaders in advocating the importance of preventing the introduction of invasive species to new environments. This presentation will share the key findings and outcomes of this project.

NOTES

Lake Simcoe Aquatic Invasive Species Community-Based Social Marketing Project

***Sophie Monfette**, Ontario Federation of Anglers and Hunters; Erika Weisz, Ontario Ministry of Natural Resources; David Dilks and Jeff Garkowski, LURA Consulting*

The Lake Simcoe Aquatic Invasive Species Community-Based Social Marketing (CBSM) Project was a joint initiative of the Ontario Ministry of Natural Resources and the Ontario Federation of Anglers and Hunters as part of the Invading Species Awareness Program. The purpose of the CBSM project was to develop and test strategies to change boater and angler behaviours that may be contributing to the spread of aquatic invasive species in Lake Simcoe. CBSM is a methodology rooted in the social sciences that aims to foster long term behavioural change through a demonstrated approach and effective behaviour change "tools".

Specifically, the two behaviours that were selected to be the focus of this CBSM initiative were: 1) Changing boater behaviour – After leaving a water body and before entering another water body, boaters are to clean their boats/equipment/gear, drain their outboard motor, and empty their bilge. 2) Changing angler behaviour – Anglers are to dispose of unused baitfish – whether in bait buckets or boat live well – properly.

Two CBSM strategies were developed to target these behaviours following extensive research which included a literature review of best practices, focus groups with boaters and anglers, and a survey. Strategies were designed to reduce the barriers, maximize the benefits, and reinforce the behaviours using CBSM tools. These behaviour change strategies were pilot tested at six boat launch sites on Lake Simcoe over a four week period in the spring of 2011. Three conditions of varying intensity in personal communications and equipment availability were tested at the pilot sites. Core components of the first two conditions were mobile boat wash stations and baitfish disposal units. Condition #1, the most intensive condition, had a large focus on personalized communication through the presence of personnel, approaching and speaking with boaters and anglers, providing a high level of personal interaction and using a number of CBSM tools, such as seeking commitments and providing prompts as reminders. Condition #2 included the same boat wash station and baitfish disposal units but provided a reduced level of personal assistance. This included many of the same CBSM tools, but was applied without having personnel approach boaters and anglers, with participants relying on the visual cues only. The third condition was a control condition, where no interventions were deployed. Results of the pilot were very promising in affecting boater behaviours. Incremental increases in participation levels in the desired boating practices were evident as the condition intensity increased. Sustained behavioural change was also measured beyond the end of the pilot project during post-pilot evaluation, which also showed increased levels of awareness among boaters about the issues of aquatic invasive species. As a result of the pilot, the high intensity condition targeting boater behaviours has been demonstrated as an effective approach to form the basis for developing a broader scale behaviour change initiative on Lake Simcoe. Additionally, using the high intensity approach at Lake Simcoe boat launches in a short-term "blitz" format has the potential to raise awareness of the desired boating practices and to change boater behaviours. The angler strategy could not be effectively evaluated because the number of anglers who used live baitfish at the time the pilot was conducted was very small. It is suggested that in the future, angler behaviours involving the proper disposal of unused baitfish are best addressed during the winter angling ice fishing season, when the use of live baitfish is more widespread.

NOTES

Does the Racer Goby, a Ponto-Caspian Invader of Continental European Waters, Pose a Threat to the Endangered Native European Bullhead? – An Experimental Approach

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Racer goby *Babka gymnotrachelus* is one of several Ponto-Caspian gobiids invading European canals and river systems, coinciding with declines in some native fish species of similar, benthic life style, in particular the threatened European bullhead *Cottus gobio*. Evidence of competitive interactions remains scarce, so the behaviour of racer goby and European bullhead was examined under experimental conditions to determine whether or not the invader displaces the native species. Two separate experiments were conducted to determine whether or not the two species compete for refuge (i.e. a PVC shelter) and for limited food recourses (i.e. living Chironomidae larvae distributed from a single feeder at rates below satiation levels). In the foraging experiments, fish were tested in pairs (single specimens of each species together, also pairs of each species) in shared space (40-L aquaria) under two light conditions (light vs. total darkness) during repeated trials, which each lasted 24 h or 48 h. In the refuge use experiments, a similar set-up was used, but with the non-native fish being into an aquarium with an extant resident native fish. Behavioural activities (aggressive events, time spent in refugee, feeding time) were recorded using digital video cameras and infrared illumination. Hypothesis that racer goby influence on behavior of bullhead was confirmed. Racer goby was observed to exhibit aggressive behaviour towards bullhead, resulting in significantly less time spent by European bullhead foraging and making use of the refuge. In both species, significantly more time was spent outside shelter and foraging during darkness than during daylight. The results suggest that racer goby do constitute a threat to bullhead, with potential adverse consequences for foraging efficiency (i.e. acquisition of energetic resources) and increased risk of predation where refuges are limited. This provides direct experimental evidence in support of the assumption that the decline of bullhead in European waters could be associated with the recent invasions of the invasive Ponto-Caspian gobiids due to direct competitive and aggressive interactions for space and food resources. However, this may be only partly true for the racer goby, as field evidence (see poster by Kakareko et al.) suggests that the invader may use less optimal types of habitat (sand and mud bottoms) in areas occupied by resident European bullhead.

NOTES

Identifying Drivers of Pumpkinseed Sunfish Invasiveness Using Population Models

Eelke Jongejans, Radboud University Nijmegen; ***Hein van Kleef****, Bargerveen Foundation*

Knowledge of the factors that determine the ability of non-native species to dominate ecosystems is essential for effective management. Pumpkinseed sunfish (*Lepomis gibbosus*) is globally one of the most invasive fish species and a major threat to local biodiversity. The species appears to be facilitated by intensive habitat management, such as dredging and digging of pools. The mechanisms behind this facilitation can be many, such as improved water quality, increased availability of nesting substrate and altered biotic interactions. The relative importance of these mechanisms, however, is unknown. Information of which demographic parameters determine a species' abundance may shed light on these drivers of invasiveness. With this in mind, we studied the demography, i.e. growth, maturation, reproduction and survival, of Pumpkinseed sunfish. Pumpkinseed were sampled in 19 isolated standing waters varying in pumpkinseed abundance. Pumpkinseed sunfish were collected in early summer in order to determine their abundance, condition, sex, age, growth and reproductive effort and in late summer to determine reproductive success. Additional information was collected on pumpkinseed nesting preferences, availability of nesting substrate, water quality (acidity and nutrients), vegetation cover, temperature and the fish community. Assuming a stable population structure, we constructed population projection models to assess the relative importance of each demographic rate for the growth of the populations. Regional pumpkinseed dominance was not induced by growth, reproduction or maturation of the fish. On the contrary, juvenile growth and reproductive effort were negatively correlated with pumpkinseed densities indicating a strong density dependant feedback. This finding has important repercussions for management of pumpkinseed invasions. A one time removal of part of invasive populations will lift the density dependant regulation. This will result in a strong increase in growth and reproduction, leading to a rapid recovery to high population densities. Crucial in determining pumpkinseed densities appears to be survival of juvenile fish. This observation rules out availability of nesting substrate, water quality, vegetation cover and temperature as determinants of pumpkinseed abundance. This corresponds to our data: none of these environmental parameters correlated with observed pumpkinseed densities. Abundance of native piscivores and European pike (*Esox lucius*) especially, correlated negatively with pumpkinseed abundance, and is a plausible determinant of juvenile survival. There are many management options available for eradicating or controlling pumpkinseed sunfish. Of these, introducing or enlarging populations of European pike appears to be most natural and durable.

NOTES

Community Dynamics of an Invaded Ecosystem: Investigation of a *Pterygoplichthys disjunctivus* Invasion in the Nseleni River System, KwaZulu Natal, South Africa

Ray Jones[1], ***Jaclyn M. Hill****[2], Olaf Weyl[3], Martin P. Hill[4]; [1]Ezemvelo KZN Wildlife; [2] Rhodes University, Department of Zoology & Entomology; [3]Centre for Invasion Biology, South African Institute for Aquatic Biodiversity; [4]Rhodes University, Department of Zoology & Entomology*

Increases in urbanization and anthropogenic activity within watersheds is globally recognized as one of the main drivers of eutrophication to date, and excessive nitrogen loads in aquatic systems can result in widespread ecosystem degradation including: hypoxia, toxic algal blooms, increased turbidity, disruption of ecosystem functioning and the loss of biodiversity. Aquatic ecosystems compromised by increased N-loading have a lower capacity for system resilience and often face further threats to ecological integrity by the establishment of invasive species. Despite existing legislation regarding the import and sale of exotic species worldwide, the establishment of invasive species in many aquatic ecosystems has been the result of accidental or deliberate introduction via the aquarium trade.

The South American loricariid catfish *Pterygoplichthys disjunctivus* for example, is popular with home aquarists and has been an ornamental fish export worldwide since the mid-20th century. This highly fecund, fast growing fish is extremely invasive and to date congeners have been confirmed throughout central and southern Florida, Hawaii, Puerto Rico, Asia and South Africa. In some habitats they have become the dominant fish taxa, outcompeting their endemic counterparts. This study aimed to examine determine the dietary and niche width variation amongst the fish community in the highly invaded Nseleni River system, Kwazulu Natal, South Africa. Stable isotope analysis provided clearer insights into community dietary and niche width variation, confirming a trophic position for *P. disjunctivus* consistent with a detritivorous diet. A similar diet was observed for the invasive snail *Tarebia granifera,* suggesting potential resource competition. Isotopic niche width comparisons using SIBER suggested slight overlaps in occupied niches between four fish species; *P. disjunctivus, Barbus paludinosus*, *Marcusenius macrolepidotus* and *Oreochromis mossambicus*, indicating a strong potential for the disturbance of native species, with important implications for ecosystem functioning.

NOTES

Reconciling Large-scale Model Predictions with Small-scale – Impacts and Interactions of the Invasive Smallmouth Bass (*Micropterus dolomieu*) with Native Species in British Columbian Lakes

Martina Beck *and John Volpe, University of Victoria; Leif-Matthias Herborg, BC Ministry of Environment*

Impacts of introduced non-native smallmouth bass (*Micropterus dolomieu*) in British Columbian (BC) lakes remain undefined however the species life history and ecological profile suggest potential for serious vertical and horizontal disturbance. Characterization of smallmouth bass interaction with native species assemblages, especially salmonids, in lakes throughout BC is prerequisite to identification of high-risk habitats warranting active control. Therefore this project addresses the following issues: How does trophic overlap with native species vary across time and space? Do rainbow trout fry (*Oncorhynchus mykiss*) constitute a significant prey base for smallmouth bass? Does the presence of a preferred smallmouth bass prey, signal crayfish (*Pacifastacus leniusculus*), alter trophic mediated impacts of bass on other species? Baseline data were collected from three reference lakes for comparison to paired lakes containing naturalized smallmouth bass. Gut-contents were employed to quantify dietary overlap between smallmouth bass and other fish species. Rainbow trout fry stocking events were used to characterize magnitude of smallmouth bass predation on juvenile trout. The potential for biogeographic variability of smallmouth bass interactions was tested by repeating paired lake surveys in south central BC (Okanagan region) and at the species global northernmost range in the Cariboo region.

NOTES

Evolutionary and Biogeographic Patterns of an Emerging Quasispecies: The Fish Viral Hemorrhagic Septicemia Virus (VHSv)

Carol Stepien*, Lindsey Pierce and Jacob Blandford, University of Toledo*

Viral Hemorrhagic Septicemia virus (VHSv) is an RNA rhabdovirus that causes one of the world's most important finfish diseases, killing over 70 marine and freshwater species. It was discovered in European cultured fish in 1938 and since has been described across the Northern Hemisphere. Four strains and several substrains have been designated, whose evolutionary relationships and genetic radiation are evaluated here. We focus on in-depth analysis of the IVb substrain that first appeared in the North American Laurentian Great Lakes in 2003. We analyze all known and new RNA sequences from the glycoprotein (G), nucleoprotein (N), nonvirion (Nv), matrix protein (M), and phosphoprotein (P) genes, employing Maximum Likelihood and Bayesian models. Phylogenetic trees largely are congruent, distinguishing strains I–IV as reciprocally monophyletic with high bootstrap and posterior probability support. VHSv originated from a marine ancestor in the North Atlantic Ocean, diverging into two primary clades: strain IV in North America, and strains I–III in Europe. Strain II appears to comprise the basal group of the European clade, diverging in Baltic Sea estuarine waters; strains I and III appear to be sister groups, with the former mostly in European freshwaters and the latter in North Sea marine/estuarine waters. Strain IV is differentiated into three monophyletic substrains, with IVa in the Northeast Pacific Ocean, IVb endemic to the freshwater Great Lakes, and IVc in the North Atlantic Ocean. Two separate substrains independently appeared in the Northwestern Pacific region (Asia) in 1996, with Ib originating from the west and IVa from the east. Our results depict an evolutionary history of relatively rapid population diversification in star-like patterns, following a quasispecies model, with IVb in the Great Lakes appearing to be evolving especially quickly. This study provides a baseline for future tracking VHSv spread and interpreting its evolutionary diversification pathways.

NOTES

Predicting the Zebra Mussel Spread: What Can We Learn From 200 Years of Continuous Invasion?

Alexander Karatayev *and Lyubov Burlakova, Buffalo State College; Sergey Mastitsky, RNT Consulting Inc.; Dianna Padilla, Stony Brook University*

Zebra mussels colonized Belarus in the early 1800s, when three canals connecting the rivers Dnieper and Zapadnyi Bug, Dnieper and Neman, and Dnieper and Zapadnaya Dvina were constructed to provide shipping routes between the Black Sea and the Baltic Sea basins. Of the 1,040 glacial lakes in the Republic of Belarus (Europe), 553 have been examined for the presence of zebra mussels during 1971-2008. In spite of 200 years of continuous invasion, by 1996 zebra mussels were found in only 16.8% of all lakes studied. The initial rate of spread of zebra mussels was very slow and did not exceed 4 lakes per 50 years during the first 150 years of invasion, but then increased to 23 lakes per every 10 years. This rapid increase was associated with the removal of political borders (Belarus was divided between the USSR and Poland) after World War II, and with increased commercial fisheries, the main vector of spread for D. polymorpha in the former Soviet Union. At least 70% of all lakes have been predicted to be colonized with zebra mussels in the future based on the threshold value of pH > 7.47, calcium concentration > 24.7 Mg L^{-1}, and TDS > 163.5 Mg L^{-1}. The prediction was checked in 1997-2008 years when 80 lakes free of zebra mussels during the initial survey were re-examined. Zebra mussels were found for the first time in 34 lakes, all of which were classified initially as suitable for zebra mussels. Using data on 15 environmental variables, Random Forests classification algorithm was employed to develop a model predicting potential occurrence of zebra mussel.

NOTES

Invasion of Western Europe by *Dreissena rostriformis bugensis*

Jonathan Marescaux *and Karine Van Doninck, University of Namur*

River basins are conducive to invasions because they form corridors that facilitate rapid spread of introduced species. The reinforced river bank and the whole river bed are disturbed habitats considered as most favorable to the invasion. Western European Rivers are particularly vulnerable to invasive species because they have been highly altered by anthropogenic pressures (e.g. artificial banks, construction of weirs, dense navigation).

Biofouling invaders constitute one of the major threats to freshwater biodiversity not only because they have an impact on both aquatic ecosystems and biodiversity but also because they negatively influence industrial activities. The best-known example is the invasion of Western Europe and North America by the zebra mussel (*Dreissena polymorpha*, Pallas 1771). In the meantime, a second dreissenid species, the quagga mussel (*Dreissena rostriformis bugensis*, Andrusov 1897) recently became invasive in both the Old and New World. Both species are native to the Ponto-Caspian area.

The quagga mussel is native to the Dnieper delta in Ukraine. Since 1930, the species extended its distribution range, first into the Ponto-Azov basin and Volga River and then into Eastern European Rivers. The species apparently reached the Danube River in 2004, the Rhine River in 2006 and was found in its tributaries, the Main River in 2007 and the Moselle River in 2010. Furthermore, the quagga mussel was found in Lake Erie in the U.S. in 1989 and rapidly spread across all the Great Lakes, the Finger Lakes and the rivers St. Lawrence, Ohio and Mississippi. Then the species reached the Western United States in 2007. The first observation of the quagga mussel in Western Europe was made in 2006 in the Hollansch Diep. Outside the Rhine basin, the quagga mussel was recently found in the Meuse River (2012) and the Albert Canal (2010).

Here, we propose to take stock of the invasion of the quagga mussel in the Meuse River in Western Europe. Using both mitochondrial and microsatellite molecular markers, we establish a phylogeography investigation of the quagga mussel to elucidate its colonization routes. Finally, we assess the impacts in the Meuse River of both invasive dreissenid species on native mollusc species and on plankton community.

NOTES

Rapid Range Expansion of the Invasive Quagga Mussel in Relation to Zebra Mussel Presence in Western Europe

***Rob Leuven**, Jon Matthews, Frank P.L. Collas, Remon (K.R.) Koopman and Gerard Van der Velde, Radboud University Nijmegen; Abraham bij de Vaate, Waterfauna Hydrobiologisch Adviesbureau*

Since its appearance in 2006 in a freshwater section of the Rhine-Meuse estuary (Hollandsch Diep, The Netherlands), the non-indigenous quagga mussel has displayed a rapid range expansion in Western Europe. However, an overview characterising the spread and impacts of the quagga mussel in that area is currently lacking. A literature study, supplemented with field data, was performed to gather all available data and information related to quagga mussel dispersal. Dispersal characteristics were analysed for rate and direction and in relation to hydrological connectivity and dispersal vectors. To determine ranges of conditions suitable for quagga mussel colonisation, physico-chemical characteristics of their habitats were analysed. Evidence for potential replacement of the zebra mussel by the quagga mussel was examined. The quagga mussel demonstrated a rapid and continued range expansion in Western Europe, after its initial arrival in the freshwater section of the Rhine-Meuse estuary and River Danube. Quagga mussels extended to the network of major waterways in The Netherlands and in upstream direction in the River Rhine (Germany), its tributaries (rivers Main and Moselle) and the River Meuse (Belgium and France). The calculated average quagga mussel dispersal rate in Europe was 143 km yr^{-1} (range 23-383 km yr^{-1}). Hydrological connectivity is important in determining the speed with which colonisation occurs. Dispersal to disconnected water bodies requires the presence of a suitable vector e.g. pleasure boats transferred overland. Upstream dispersal is primarily human mediated through the attachment of mussels to watercraft. The relative abundance of quagga mussel to zebra mussel has greatly increased in a number of areas sampled in the major Dutch rivers and lakes and the rivers Main and Rhine and the Rhine-Danube Canal. However, evidence for displacement of the zebra mussel is lacking due to the limited availability of temporal trends related to the overall density of dreissenids.

NOTES

Exotic Species Replacement in Relation to Small-scale Environmental Heterogeneity

***Lisa A. Jones** and Anthony Ricciardi, Redpath Museum, McGill University and Groupe de recherche interuniversitaire en limnologie et en environnement aquatique (GRIL)*

Few studies have examined mechanisms causing the replacement of one dominant exotic species by another, even though such events can generate a new suite of impacts on the recipient community. One example involves the zebra mussel (*Dreissena polymorpha*) and the quagga mussel (*D. bugensis*), which both colonized the upper St. Lawrence River during the early 1990s. Following nearly a decade of zebra mussel dominance, quagga mussels have increased in abundance to the point of replacing the zebra mussel as the dominant dreissenid 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 quagga mussels have been dominant in the canal for several years and are larger and more abundant in the deeper areas than zebra mussels ever were. Yet, zebra mussels remain the most abundant dreissenid at shallow depths on the canal wall. We hypothesize that these patterns result from differences in species traits and life history strategy. Compared to zebra mussels, quagga mussels invest proportionately more energy to individual growth than to reproduction. Furthermore, their lower respiration rates may provide a further competitive advantage to quagga mussels, particularly under the turbid conditions found in the deeper waters of the canal.

To test the hypothesis of a physiological advantage, we measured the growth rate, body condition, and mortality of dreissenid mussels in 2008 and 2009 at each of two depths in the canal: 'shallow', where zebra mussels remain abundant; and 'deep', where quagga mussels are dominant. Quagga mussels were predicted to have a higher growth rate, higher body condition, and lower mortality than zebra mussels, regardless of depth. These predictions were supported. Moreover, such differences were more pronounced in the 'deep' zone of the canal, where environmental conditions were less favorable to mussels. Similar patterns of dreissenid replacement have been documented in the Great Lakes, but our study demonstrates that it may occur over a very small depth range (<6m), owing to environmental gradients.

NOTES

Comparative Variation in Growth of Two Invasive Mussels in the St. Lawrence River: Do Differences in Filtering Apparatus Matter?

Jordan Ouellette-Plante, *Groupe de recherche interuniversitaire en limnologie et en environnement aquatique (GRIL) and Redpath Museum, McGill University; Anthony Ricciardi, Redpath Museum, McGill University; Ladd E. Johnson, Université Laval*

The quagga mussel (*Dreissena bugensis*) has replaced the zebra mussel (*D. polymorpha*) as the dominant bivalve throughout much of the St. Lawrence River, even at downstream sites where phytoplankton biomass is progressively reduced. More efficient feeding adaptations might be responsible for the quagga mussel's recent expansion in waters whose phytoplankton standing stock has diminished as a result of both intense zebra mussel feeding activities and nutrient abatement. As an adaptation to fluctuating seston quality and concentration, bivalves are equipped with different feeding organs (i.e. gills, labial palps, and the gut) whose relative size can be optimally adjusted through differential growth. In river systems where suspended particle concentrations vary greatly over space and time, the capacity for this optimal adjustment may determine the overall efficiency of resource acquisition by mussels. Therefore, we explored the hypothesis that the replacement of the zebra mussel by the quagga mussel could be attributable to more efficient and plastic filter-feeding organs.

In field experiments, we tested if quagga and zebra mussels grow at different rates, and if these differences are attributable to their filtering apparatus (specifically, the palp-to-gill area ratio, PGR). Preliminary results suggest that their growth rates do not vary early in the season, but quagga mussels continued to grow in the warmest months of the summer, while zebra mussels suffered lower growth rates and heavy mortality. Sites with high suspended particle concentrations contained mussels with higher palp-to-gill area ratios; however, surprisingly, zebra mussels always exhibited the highest PGR. It appears that quagga mussels can dominate sites of high-turbidity and lower food quality, despite having a smaller PGR than its congener.

NOTES

The Utility of Hub and Spoke Network Models to Analyse Pre-border and Post-border Dispersal of Introduced Marine Species

Marnie L. Campbell *and Chad L. Hewitt, Central Queensland University, School of Medical and Applied Sciences; Fauziah Azmi, University of Tasmania, National Centre for Marine Conservation and Resource Sustainability*

Hub and spoke network models are a proven method of analysing transport pathways/corridors and strengths. The vectoring of introduced aquatic species has been conceptualised in a hub and spoke network context previously, yet few have created or used hub and spoke network models to examine realised vector connectivity. In this presentation, we present three hub and spoke network models that have been developed to examine maritime connections:

1. The international and domestic pathway connections to the Galapagos Islands, Ecuador, focussing on international tourist and domestic supply vessels and using Santa Cruz as the gateway;
2. The domestic pathways between the 33 provinces of Indonesia, using Jakarta Bay as the gateway port and focussing on all vessel types, and
3. Domestic connections between the eight states and territories of Australia, focussing on commercial vessels and using Gladstone as the gateway.

Each of the models assesses the strength of transport pressure (frequency of maritime vessel transfers as a surrogate of propagule pressure) between hubs (or gateway ports) and the outports (or spokes). This assessment uses shipping datasets (vessel next port of call records for maritime vessels) to derive a province or port ranking of vulnerability. When species data is available for ports the models are strengthened by including a species weighting function. However, we note that often marine species data at the level of the port or province is often missing. Based on the model outcomes vulnerable provinces or regions can be identified, which can better inform management actions.

NOTES

Incorporating Biotic Interactions in Species Distributions: Community Distribution Modeling of the Invasive Species *Bythotrephes longimanus*

Kristina Enciso *and Brian Leung, McGill University*

Species distribution models (SDM) have seen widespread use to gain a better understanding of ecological processes and steer policy, especially in invasion ecology. SDM use statistical methods to predict species presence using known environmental data. Unfortunately, rarely do SDM incorporate biotic interactions; instead the environmental data used to build models is constrained to abiotic conditions. Data on biotic interactions and more broadly community dynamics are quite often difficult to obtain and to quantify. Ecological theory states that species distributions are determined by both biotic and abiotic factors. Despite the increasing usage of current SDM in ecological studies and management policies, without including biotic functions model accuracy will likely suffer.

Species distribution models of aquatic native species and the invasive species, spiny waterflea (*Bythotrephes longimanus*), were created using database records and survey data collected from lakes in Ontario. These SDM were then integrated to create an interactive community distribution model (iCDM) to capture the full range of community interactions. iCDMs were then used to analyze the abiotic and biotic processes that effect the distribution of spiny waterflea.

iCDMs provide a more complete picture of ecological and environmental factors that contribute to invasive species growth and spread, increases the current body of knowledge, guide management efforts, and can pinpoint areas of future research.

NOTES

Improving Model Transferability and Generality for Predictive Modeling on Invasive Species: A Case Study on *Bythotrephes longimanus*

Lifei Wang *and Donald A. Jackson, University of Toronto*

When we use species distribution models to infer environmental suitability or predict current and potential distributions for invasive species, we are faced with the trade-off among model generality, precision and realism. Models are often more applicable to specific conditions on which they are developed, but typically not readily transferred to other situations. In order to better assist management programs on invasive species, it is critical to know how to validate and improve model generality while maintaining good precision and realism of the model. We used a case study on the aquatic invasive species *Bythotrephes longimanus* to determine the importance of these procedures for providing insight into understanding and predicting biological invasions. In this study, we developed four commonly used modeling approaches (linear discriminant analysis, multiple logistic regression, random forests, and artificial neural networks) on three datasets with different sample size (315 or 179 lakes) and predictor information (environmental with or without fish data), and evaluated them by five-fold cross-validation and several independent datasets. Our results indicated that, in five-fold cross-validation, models developed on 315-lake environmental dataset performed better than those developed on 179-lake environmental and fish dataset. The advantage of a larger dataset disappeared when models were tested on independent datasets. Prediction performance of the four models appeared to be more diverse when developed on environmental conditions alone, whereas they lead to more similar results when including fish data (especially fish diversity). Random forests had relatively good and more stable performance than the other approaches when tested on different independent datasets. Our study demonstrates the importance of relating the potential distribution of *Bythotrephes* to not only environmental conditions but also fish community, and how biotic interactions may be as important as, or even more important than, abiotic conditions alone for validating and improving model generality. Given the improvement of model transferability in this study by including even presence-absence summary fish data, incorporating biotic information in addition to climate or environmental predictors may help develop more reliable models with better precision, realism and generality, and more effectively assist design and implementation of management programs regarding biological invasions.

NOTES

Implications of Uncertainty: Bayesian Modelling of Aquatic Invasive Species Spread

Corey Chivers *and Brian Leung, McGill University*

The amount of uncertainty inherent in predictive models of biological invasions is often considerable. When model predictions are used to inform management strategies, failure to accurately account for uncertainty can potentially lead to sub-optimal allocation of limited resources. In invasion biology, we wish to predict how a non-native species will spread once introduced to a novel environment. Our uncertainty about such predictions arises in three forms: 1) our sampling data is often limited such that we do not know the extent to which the invader has already spread, and hence where propagules may be originating from; 2) the suitability of a novel habitat is an unknown function of its environmental characteristics, and 3) given some level of propagule pressure and habitat suitability, the establishment success of the invader is a chance event, subject to stochastic variation. In such spatially explicit, stochastic systems, confidence in our predictions of the state (invaded/uninvaded) of the unknown locations in the system will be non-uniform. If we do not properly account for this, the precision of predictions may be overstated at some sites, and conversely, understated at others. The implications can affect the robustness of both preventative and responsive policy and management decisions. A full accounting of both aleatory and epistemic uncertainty has, until recently, been very difficult for high dimensional problems such as those encountered in invasion ecology. We present a Bayesian model of the human-mediated spread of Bythotrephes longimanus in the 2EB watershed in Ontario, Canada. By integrating across the posterior distribution, our model provides estimates of risk which incorporate several aspects of uncertainty and thereby providing quantitative decision support to resource managers and policy makers.

NOTES

Response to Biofouled Marine Debris Generated by the 2011 Japan Tsunami

Margaret M. (Peg) Brady *and Susan Pasko, U.S. National Oceanic & Atmospheric Administration*

On March 11, 2011 (JST), a magnitude 9.0 (Mw) earthquake struck off the coast of the Oshika Peninsula (Honshu, Japan), creating a devastating tsunami that reached heights of up to 133 feet and inundated 217 square miles. The tsunami sent millions of tons of Japan Tsunami Marine Debris (JTMD) into the ocean, originating both from terrestrial and coastal environments. Then over a year later on June 5, 2012, a 188 metric ton (207-ton) floating dock, confirmed to have been lost from Misawa on Honshu Island during the 2011 tsunami, washed ashore on Agate Beach in Newport, Oregon. Scientists confirmed that a number of the marine organisms attached to the dock were not native to the Northwest Pacific coasts of North America. These incidents raised awareness of the potential introduction of non-native, and possible invasive species, to the West Coast of the United States, Hawaii and British Columbia, Canada from JTMD. A Regional Preparedness and Response Workshop to Address Biofouling and Aquatic Invasive Species on JTMD was held July 31 – Aug 1, 2012 at Portland State University, Portland, Oregon. This presentation will provide an overview of that workshop, the steps taken to develop the response protocol and on-going efforts to understand as well as minimize the impacts of non-native species to West Coast marine ecosystems.

NOTES

Go Giddy Over Guidelines for Recreational Activities

***Douglas A. Jensen**, University of Minnesota Sea Grant Program; Laura Norcutt, U.S. Fish & Wildlife Service*

Invasive species damage the environmental, recreational and economic value of forests, rangelands, farms, urban and managed parks, wildlands, lakes and rivers across in the U.S. Nationally, it is estimated at more than $120 billion in economic damages annually. Preventing and controlling invasive species requires targeted efforts that interrupt the pathways for spread. Aquatic invasive species (AIS) can spread unintentionally to lakes, rivers, and wetlands by "hitching" rides with anglers, boaters, and other recreationists. To most effectively prevent the spread of AIS, water recreationists need to recognize the threats and impacts of AIS, know what to look for, where to look, and how to take action at water accesses. The question becomes: what do we want them to do? Unless a uniform set of actions is promoted, it is likely that guidelines developed independently, while well-intentioned, may vary considerably or even conflict with one another. If recreationists are confused or do not know what to do, it is likely that they will not take appropriate actions.

In 2011, the Aquatic Nuisance Species Task Force (ANSTF) re-established the Recreational Activities Committee composed of 55 federal, state, tribal, non-profit and industry representatives. The Committee's charge was to update the 2000 ANSTF Recommended Voluntary Guidelines for Preventing the Spread of Aquatic Nuisance Species Associated with Recreational Activities. (Development of those guidelines was based on efforts by the Great Lakes Panel on ANS in 1997.) The goal was to develop standard and effective guidelines that are easy for recreationists to understand and implement. These guidelines take into account new aquatic invasive species (AIS), and new recreational activities and equipment. Guidelines focus on six recreational activities including those for: anglers, motor boaters, non-motorized boaters, scuba divers and snorkelers, sea plane pilots, and waterfowl hunters (approval pending by the ANSTF).

The guidelines are intended to: 1) provide consistent, practical, and effective actions that recreationists can take to help prevent the spread of AIS, 2) take into account the specific pathways, vectors, and life histories of all AIS, including fish, aquatic plants, invertebrates and pathogens, 3) support local, state, or tribal laws concerning possession or transport of AIS, and 4) be a cornerstone for the national Stop Aquatic Hitchhikers!TM campaign, which helps recreationists be a part of the solution to prevent the spread of AIS. Organizations conducting AIS outreach are strongly encouraged to join the campaign and promote and use the guidelines in their communication and outreach efforts. Rationale on how and why the guidelines were revised will be discussed.

NOTES

An Ounce of Prevention: AIS Education, Evaluation, and Communication in Illinois and Indiana

***Sarah Zack**[1,2], Patrice Charlebois[1,2], Lainey Pasternak[1], Erin Seekamp[3], [1]Illinois-Indiana Sea Grant; [2]Illinois Natural History Survey; [3]North Carolina State University*

Overland transport of aquatic invasive species (AIS) by recreational water users, a diverse group including boaters and anglers, is one of the primary methods of AIS spread among water bodies. Illinois-Indiana Sea Grant (IISG) has attempted to increase public awareness of Stop Aquatic Hitchhikers!™, a national AIS prevention campaign, in an effort to educate recreational water users and slow the transport of AIS by this user group. Increased regional exposure to Stop Aquatic Hitchhikers!™ in recent years has been achieved through the use of various outreach efforts, including staffed booths at trade shows, in-person events, talks to local user groups, articles in local media outlets, and increased visibility on social media platforms. Most notably, the summer of 2012 marked the beginning of the revamped Clean Boats Crew volunteer education program. The expansion of the Clean Boats Crew program along the southern Lake Michigan shore provided a new opportunity to interact directly with the fishing and boating public. Data from IISG's 2012 outreach program as well as recommendations for the continued success of the Clean Boats Crew program will be will be discussed.

In 2012, Illinois-Indiana Sea Grant also initiated a series of evaluation efforts. Focus groups and in-person surveys were conducted in order to: 1) evaluate public response to IISG's current outreach efforts, 2) assess the level of local recreational water user participation in the Stop Aquatic Hitchhikers!™ campaign, and 3) better inform future outreach efforts. Focus group and in-person survey results will be presented. The results of the evaluations performed in 2012, as well as anecdotal feedback from recreational water users at in-person events, have guided the creation of Illinois' new statewide invasive species prevention brand. This new brand focuses on terrestrial and aquatic invasives, and will be broadcast throughout Illinois using both traditional and social media outlets and well as in-person events. With the implementation of the AIS-prevention brand in Spring 2013, IISG hopes to address local concerns with AIS prevention and thereby reduce the risk that recreational water user activities will facilitate the continued introduction and spread of AIS.

NOTES

Working With Fishing Tournaments to Prevent the Spread of Aquatic Invasive Species

Philip B. Moy, *Wisconsin Sea Grant*

Since 2010, the Great Lakes Sea Grant Network has been working with fishing tournament organizers including the Bass Federation, Cabela's Master Walleye Circuit and the Forest L. Wood Tournament series. Our focus is to help professional and tournament anglers understand the importance of aquatic invasive species (AIS) prevention and their role in prevention and as role models for other anglers. A second focus was to work with tournament organizers to assist them in developing AIS prevention plans or tournament best management practices to prevent the movement of AIS between tournaments via anglers or tournament-related equipment. By expanding our partner base to include the National Professional Angers Association and Wildlife for Tomorrow, we were able to more effectively reach young anglers through tournament anglers and develop angler-targeted AIS prevention outreach materials. The Network partners worked with tournaments from the Vermont to Colorado and from Minnesota to Georgia. In this presentation I will discuss what we learned about tournament activities, angler movements and possible ways to address AIS spread through tournament related activities and the efforts of tournament organizers to educate their participants and members as well as their AIS prevention efforts adopted as a consequence of the project.

NOTES

Mitigating the Threats Posed by Freshwater Invasive Species in Ireland

Joseph M. Caffrey, *Inland Fisheries Ireland*

Aquatic invasive species represent a serious problem in most countries worldwide, and Ireland is no exception. Being a small island on the edge of Europe, Ireland has experienced fewer invasions by non-native species than countries on mainland Europe. However, increasing globalisation is accelerating the rate of non-native species introductions to Ireland, as evidenced by the fact that most of the problematic aquatic invasive species present here today were introduced in the last 20 years. Indeed, some of our most problematic invaders were first recorded here as recently as 2010. Inland Fisheries Ireland (IFI) is the lead agency responsible for the control and management of invasive riparian and aquatic species in the Republic of Ireland. In recent years IFI has commenced wide ranging biosecurity initiatives that are aimed at preventing the introduction and spread of invasive species and fish pathogens in our watercourses. Foremost among these has been the creation of awareness among key stakeholders and the public at large regarding the serious threats posed by invasive species and what measures can be taken to halt the advance of these harmful organisms. Most recently a free app for use on smart 'phones has been put on general release. Education relating to invasive species is crucial and IFI has produced a diversity of materials and initiatives to promote this. These will be described in the paper. Additionally, a suite of biosecurity protocols has been produced by IFI that detail the correct procedures that should be taken to clean and disinfect field sampling equipment, angling tackle, boats or SCUBA diving gear.

A major biosecurity initiative undertaken by IFI in the recent paste has been the roll-out of a coordinated disinfection procedure for use at freshwater angling competitions, whether salmonid, coarse or pike. The exact procedures will be outlined in the paper. The feedback from anglers and angling federations towards this initiative has been extremely positive and it is anticipated that disinfection will become an integral part of most angling competitions in the near future. IFI is currently exploring the possibility of having permanent disinfection facilities positioned at key angling centres.

NOTES

Nab the Aquatic Invader! – Young Stewards Prevent the Spread of AIS

Marte Thabes Kitson[1], *Robin Goettel*[2], *Douglas A. Jensen*[1], [1]*University of Minnesota Sea Grant Program;* [2]*Illinois-Indiana Sea Grant*

Aquatic invasive species (AIS) can "hitchhike" on water-related equipment and recreational water users can contribute to the spread of AIS if they do not take appropriate action. Education and outreach campaigns such as *Nab the Aquatic Invader!* and *Stop Aquatic Hitchhikers!*™ teach people about AIS and the appropriate actions to take. *Nab the Aquatic Invader!* featuring *Stop Aquatic Hitchhikers!*™ is geared towards K-12 education to help raise awareness about the harmful impacts of AIS. Although *Nab the Aquatic Invader!* and many other AIS classroom resources such as traveling trunks, curricula, and lesson plans exist, ways to turn new-found knowledge into action are lacking.

Conducting a community stewardship project turns knowledge into action. Enlisting the help of teachers in AIS spread prevention efforts not only provides content for the classroom but can also serve as a platform for community stewardship projects. Through a grant from the Great Lakes Restoration Initiative, the Great Lakes Sea Grant Network and state geography alliances are leading the *Nab the Aquatic Invader!* campaign featuring *Stop Aquatic Hitchhikers!*™. *Nab the Aquatic Invader* is a web-based AIS resource (www.iisgcp.org/NabInvader) for teachers and students, while *Stop Aquatic Hitchhikers!*™ (www.protectyourwaters.net) is a national campaign that helps boaters and anglers be part of the solution to prevent the spread of AIS. Based in social marketing, the *Stop Aquatic Hitchhikers!*™ campaign uses both natural resource science and social science to reduce the barriers that prevent recreational water users from taking the necessary steps to stop the spread of AIS. Grounded in previous research, targeted outreach and *Stop Aquatic Hitchhikers!*™ product development capitalize on the campaign brand's visibility, memorability and marketing power. Teacher training workshops encourage teachers to "think product" and "think outreach" while guiding their students in development of stewardship projects. Teachers learn about which *Stop Aquatic Hitchhikers!*™ media boaters and anglers report are most effective in reaching them. Capitalizing on the power of *Stop Aquatic Hitchhikers!*™ brand recognition further strengthens the visibility and impacts of students' stewardship projects in their communities.

Teachers applied their training in the classroom and in their communities. Stewardship projects and products included outreach at community events, You Tube videos, board games, brochures, and posters. Completed stewardship projects are featured on the *Nab the Aquatic Invader!* website and serve as examples for other teachers and students. Since August 2010, Great Lakes Sea Grant Network partners hosted, presented, or exhibited at 83 community events and educated an estimated 246 teachers and 23,870 students. Twelve stewardship projects are completed. Teachers submitting qualified stewardship projects presented at national conferences where projects serve as models for use in other classrooms throughout the United States.

NOTES

Dispersion, Impact and Abundance Mitigation Study of Round Goby (*Neogobius melanostomus*) and Chinese Sleeper (*Perccottus glenii*) in Lithuania

Saulius Stakėnas*, Tomas Virbickas, Vytautas Rakauskas and Andrius Steponėnas, Nature Research Centre, Institute of Ecology, Department of Freshwater Biology*

Findings of preliminary studies of Chinese sleeper (thereafter CS) in water bodies of Lithuania indicate serious threat for native fish communities. CS invasion drastically altered typical native fish communities in Lithuania, as absolute majority water bodies with established CS population were depleted to fish communities of only 2-3 native fish species. In all water bodies with abundant CS population, extremely low abundance of younger age class native fishes were detected. However recent finding revealed, that in 7 water bodies CS population disappeared likely due to rapid increase in northern pike (*Esox lucius*) abundance or/and due to substantial water physicochemical quality changes. High abundance of other predatory fishes (e.g. Eurasian perch (*Perca fluviatilis*) seems to have only limited effect on CS abundance. In year 2012 data collected from 37 different water bodies with established CS populations reveals voracious predatory nature of CS, as cannibalism were recorded in all samples and tadpoles were virtually absent in all sites with CS. Therefore expansion of this invasive fish species in eastern (Poland, Latvia, Ukraine, Belarus), central Europe (Poland, Slovakia, Czech Republic, Hungary, Austria) and recent concurrencies in south Europe (Croatia, Romania) indicates serious threats for native fish communities, especially in lentic waters, lakes, ponds, backwaters and marshes with dense underwater vegetation, poorly oxygenated water and low abundance of predatory fishes.

Round goby (thereafter RG) after invasion since 2003 became very important food source for predatory fishes zander (*Sander lucioperca)*, Eurasian perch, burbot (*Lota lota*), turbot (*Scophthalmus maximus*) and Atlantic cod (*Gadus morhua*) in Baltic Sea and Curonian lagoon. Till 2008 bay mussel (*Mytilus trossulus*) abundance and distribution in shore zone of Baltic Sea were almost the same as before RG invasion, however initial underwater studies revealed that bay mussel abundance in 2012 drastically decreased as RG abundance drastically increased. RG in Baltic Sea prefers relatively shallow habitats – being most abundant in 3-5 meters depths and their abundance gradually decreases till 15 meters depth; there RG can be caught only occasionally. RG was recorded in almost all study sites in Curonian lagoon, suggesting its successful establishment in the entire Lithuanian part of the Curonian Lagoon, therefore further expansion of the RG into the freshwater systems seems unavoidable. In Curonian lagoon RG should be considered as generalist feeders with the increasing proportion of zebra mussel (*Dreissena polymorpha*) in the diet as they mature. However, the δ15 N values of the RG changed little during its growth, suggesting that RG does not shift to more predatory diet. Isotopic niche revealed that RG strongest dietary and/or habitat overlap with the ruffe (*Gymnocephalus cernuus*).

NOTES

Detecting the Invasive Snakehead: DNA Barcoding as a First Step in Developing Species Specific Primers and Probes for Environmental DNA Detection

Natasha Serrao[1,2], *Dirk Steinke*[2], *Robert Hanner*[2], [1]*Trent University, Department of Environmental and Life Sciences;* [2]*University of Guelph, Biodiversity Institute of Ontario*

Snakeheads represent a diverse group of opportunistic predators endemic to Asia and Africa that have entered North America through the ornamental fish trade. They have been released into Florida, Hawaii, Maryland, Virginia, New York, Arkansas, Philadelphia waters establishing invasive populations that pose a threat to indigenous freshwater biodiversity. Understanding pathways of invasion requires access to accurate species identification, which can be challenging because snakehead taxonomy is not well understood. DNA barcoding has gained attention as a powerful tool for identifying diverse fishes and has the benefit of being suitable for the identification of all life stages. The aims of this study are to 1) build a library of mitochondrial 5′ COI DNA barcodes derived from expert identified reference specimens in order to 2) determine the identity of invasive species found in North America using barcoding, and 3) exploit species-specific patterns of sequence variation in the barcode library to develop Taqman assays needed to 4) detect invasive *Channa* species from the environmental DNA (eDNA) they shed into water using real-time PCR. One hundred and eighteen tissue samples representing twenty-four Channidae species were sourced, including the invasive species from the United States as well as market specimens and the Burnaby specimen from British Columbia. Total genomic DNA was extracted, PCR amplified and bi-directionally sequenced according to standard Fish Barcode of Life protocols. Sequence and specimen meta-data was archived and aligned with other published data using the Barcode of Life Data Systems (www.BOLDSystems.org), yielding a combined data set of 228 specimens representing 26 species. Results from genetic distance-based analyses demonstrate that DNA barcodes can be used to diagnose snakehead species. High intra-specific variation was observed among *C. gachua, C. striata and C. marulius* suggesting the presence of cryptic diversity. Invasive snakeheads in Lake Wylie, North Carolina, reported as *C. argus* were actually identified as *C. maculata* using barcodes. Probe design for remote detection of varied snakehead species from eDNA using qPCR will be discussed.

NOTES

Morphological Responses to Competition in Native and Non-Native Fish

Stan Yavno *and A. Rooke, Trent University, Environmental and Life Sciences Graduate Program; M.G. Fox, Trent University, Environmental and Resource Studies Program and Department of Biology*

Phenotypic plasticity can significantly influence the establishment and spread of invasive species. If an organism exhibits morphological changes that are well matched to a novel environment (i.e. adaptive plasticity), the introduced population is more likely to survive and spread through the invaded ecosystems. Unfortunately, there are limited empirical data available as to why some introduced species fail to establish, while others are particularly invasive. One possibility is that dispersal is constrained by an ecological process. Competition, for example, can limit the availability of food, and lead to a decrease in fitness. Native species possess behavioural and morphological characteristics that are well matched for the environment, and thus the acquisition of food; introduced species can be naïve to, and/or incapable of, capturing prey. However, an introduced species that exhibits a high degree of adaptive plasticity could respond by developing characteristics that help to overcome native competitive pressures.

The pumpkinseed (*Lepomis gibbosus*) is a North American sunfish that was introduced to Europe over a century ago. In its native range, the species is often found in sympatry with a common congeneric competitor, the bluegill (*Lepomis macrochirus*). There are, however, several areas where pumpkinseeds also occur in allopatry, and the bluegill has not been introduced into Europe. In its non–native range, the pumpkinseed is present in over 28 countries and it continues to spread through the Iberian Peninsula; the species has become widespread in several waterbodies, suggesting that it is able to overcome the novel competitive pressures of native European fishes. We hypothesized that, in response to a novel competitive pressure, internal and external morphological traits of native allopatric pumpkinseed populations would differ from those of Europe. European populations were also hypothesized to exhibit a level of phenotypic plasticity that was greater than that of native allopatric fish, and insinuate a greater ability to overcome novel competitive pressures. Using artificial enclosures placed in a common pond, juvenile pumpkinseed from two non–native Iberian and two native Ontario populations were reared in either the presence or absence of bluegill. After 75 days, all fish were photographed and morphological changes were quantified using ImageJ. Data were analysed using ANCOVA and discriminate function analysis, and stomach contents were examined to identify possible shifts in diet. Previous experiments using native and non–native pumpkinseed have tested for plasticity differences in response to changes in water velocity and trophic levels (factors that can influence the establishment of a non–indigenous species during a biological invasion). The present study provides a natural extension by testing for differences in response to a third ecological factor, competition. Together, these results may help us to understand how phenotypic plasticity influences biological invasions, and why some species pose a higher invasion risk than others.

NOTES

Thermal and Biotic Influences on Life-History Traits of Pumpkinseed Introduced in Europe

Michael G. Fox[1], *E. Valente*[2], *G. Masson*[2], *Gordon H. Copp*[3], [1]*Trent University, Department of Biology and Environmental and Resource Studies Program;* [2]*Université de Lorraine, Laboratoire Interactions Ecotoxicologie Biodiversité Écosystèmes ;* [3]*Cefas, Salmon & Freshwater Team and Environmental and Trent University, Life Sciences Graduate Program*

The pumpkinseed (*Lepomis gibbosus*) is a North American sunfish that was introduced to Europe in the 1890's and has spread rapidly across the Iberian Peninsula, France and other parts of western Europe. It is now established in 28 European countries. Previous research on pumpkinseed have shown that populations exhibit more 'opportunistic' life history traits (earlier maturity, smaller size at maturity, higher reproductive allocation) in their introduced European range than in their native North American range, and while the reasons for this are not known, it is a pattern that has been observed in other invasive species. The warmer climate in Europe is one possible explanation, but biotic factors may be involved as well. To evaluate the influence of thermal regime on these life history differences, we used a two-tier approach involving thermal and life history comparisons: (1) between 90 North American and European populations, and (2) among 11 populations in the Moselle River Basin (northeastern France) from waterbodies with different thermal regimes. Within continents, mean age at maturity of a population was negatively related to the juvenile growth rate as well as air temperature degree-days, whereas mean length at maturity and gonadosomatic index of a population was not significantly correlated with either juvenile growth rate or temperature degree-days on either continent. European pumpkinseed populations mature earlier than North American populations even when juvenile growth and temperature are accounted for. Native pumpkinseed populations in waterbodies containing piscivores mature later and at a larger size, and have lower gonadosomatic indices than those in water bodies lacking piscivores, whereas there is no significant difference in the three life history traits of European pumpkinseed populations between water bodies containing or lacking piscivores. Because congeneric competitors of the pumpkinseed are absent from Europe, the apparent absence of a predator life history effect there could also be due to the absence of the major sunfish competitors in their native range, and in North America, later maturity at a larger size is most evident when both piscivores and sunfish competitors are present. The intercontinental findings suggest that the more opportunistic life history traits of non-native pumpkinseed are mainly the result of biotic differences between North American and European continents.

In the Moselle River Basin, populations in warmer waters were characterised by faster juvenile growth, precocial maturity and elevated reproductive effort, with thermal effects mainly restricted to age 1 juveniles. The thermal effects on life history traits in the Moselle Basin suggest that future global warming will accelerate the expression of opportunistic traits and result in increased range expansion of the Pumpkinseed in Europe.

NOTES

Modelling the Occurrence of Zebra Mussel Parasites According to Contamination in France and the USA

Laure Giamberini *and Laëtitia Minguez, University of Lorraine; Simon Devin, Pascal Poupin and Francois Guerold, University of Metz; Daniel Molloy, SUNY at Albany*

Parasites can be a reliable tool in assessing the effects of ecosystem disturbances. However, they can respond in different ways and any changes in population or community assemblages are not easily predictable due to a lac University of Leeds of knowledge of their biology and ecology. Descriptive modelling could be a precise first step to acquire new data about the relationship between environmental contamination and parasitism since it provides information on the relative importance of a pollutant on parasite occurrence. In the present investigation, we chose the zebra mussel *Dreissena polymorpha*, a bivalve commonly used in ecotoxicological studies, as the test organism and twelve sites in France and the USA. *Dreissena polymorpha* fulfills all the criteria of a good host in such studies. Microparasite inventories (i.e., ciliates and bacteria) were performed by classic histology and microscopic observation, and then related to sediment qualities by descriptive modelling. The contamination by polycyclic aromatic hydrocarbons (PAHs) seemed to have less impact on parasite occurrence compared with metals. Metallic pollution enhanced the infection, except zinc which displayed a positive relationship only with the commensal ciliate *Conchophthirus acuminatus*. We should note that nickel and chromium promote Rickettsiales-like organism infections. Therefore, the continuous contamination of freshwater ecosystems implies a significant risk for organisms, promoting the development of parasites often associated with pathologies that may affect bivalve populations and other species belonging to their life cycles. Moreover, another danger is that associated with the status of invasive species, like the zebra mussel. The "Enemy Release Hypothesis" assumes that in the process of invasion organisms lose most of their parasites, but environmental contamination could facilitate the installation of new species with their parasites involving a certain risk to indigenous populations. In our study, the fact that the three stations in the USA (i.e., a quarter of the data set) fit well to the models and that the observed parasite species in France and USA are the same confirm this risk. Modelling appears here to be a valuable method to examine the influence of pollutants on microparasite communities

NOTES

A Non-Destructive Method for Monitoring Dreissenid Settlement and Evaluating Treatment Efficacy

***Carolyn Link**, Marrone Bio Innovations*

During the summer of 2011 and 2012 new methods were developed for monitoring dreissenid mussel settlement and rapidly evaluating the efficacy of control treatments on newly settled mussel growth. These methods provide a means for not only identifying indications of treatment efficacy within a few weeks, but the methods also offer evaluation where minor differences in densities need to be distinguished quickly, and where repeat analysis of the same samples over time is desired.

Since the beginning of research on invasive dreissenid mussels, there has been monitoring of mussel settlement densities. Older methods for evaluating mussel settlement are useful for long term population monitoring, for evaluating control treatments via presence vs. absence, and for evaluating changes between populations over many months. The need for new methods has arisen due to old methods being extremely time consuming, lacking precision, and often requiring sample destruction in processing. In the past these traits made monitoring throughout the course of a study, with timely feedback for study adjustments, difficult.

This method includes storing settlement plates in flow through biobox systems, with control and treated plates stored in the same locations when not in treatment. The new evaluation techniques include both digital microscope imaging, and traditional plate counts and mass measurements to verify the imaging method.

This presentation will describe the new methods used for settlement evaluation as part of determination of dreissenid treatment efficacies, and will also include discussion of a sample set of data collected using the methods.

NOTES

Potential Use of the Calcite Saturation Index as an Indicator of Environmental Suitability for Dreissenid Mussel Survival

***Katherine Prescott** and Renata Claudi, RNT Consulting Inc.; Jeffrey Janik and Tanya Veldhuizen, California Department of Water Resources*

Water quality parameters are used as indicators of environmental suitability for dreissenid mussel success in a new location. Typically, calcium is considered the most important limiting variable followed by pH. A minimum calcium concentration of 12 mg/L and a minimum pH of 7.3 are considered necessary for long term dreissenid survival. In earlier studies, we found that low calcium waters generally considered unsuitable for dreissenids were able to support mussels through their entire lifecycle if the pH was elevated. Therefore, it is necessary to consider these water quality parameters in combination rather than independently when developing management strategies for dreissenid mussels.

We explored the use of the calcite saturation index as an indicator of environmental suitability for dreissenid mussels. This parameter considers the interaction of calcium, pH, conductivity, total alkalinity, and water temperature, and provides a one-number index that could be used to classify lakes as able or unable to support dreissenid mussels more definitively than using calcium or pH alone. In this study, we present the results of our examination of data from more than 500 North American lakes, and we discuss the potential use of the calcite saturation index as a tool in dreissenid mussel management programs.

NOTES

Objective Method for Determining Mortality in Larval and Juvenile Lifestages of Dreissenid Mussels

***Carolyn Link**, Marrone Bio Innovations; Renata Claudi and Carolina Taraborelli, RNT Consulting Inc.*

Finding an objective method for rapid determination of mussel mortality at the juvenile or larval stage is one of the most challenging obstacles faced by invasive mussel scientists today. Those that monitor populations, decontaminate waters and vessels, and study new treatments for population control all face this same common problem. As mussels at all life stages are able to close their shell and stop moving when observed, determining if a mussel is alive or dead, particularly at the early life stages, is difficult. Currently, determination of mortality requires long periods of observation of each individual test subject for any sign of life, a task that is often further complicated by post mortem infestation of tissue with decomposers such as ciliates. Such an infestation of a dead veliger may give appearance of movement of internal organ movement leading to a conclusion that the observed individual is alive.

Fast Green, also called Food Green 3, is a stain commonly used for food coloring, tissue staining, and more recently for staining of mussel spat in salt water mussels. Upon exposure to this stain, only expired cells will absorb the stain. Based upon the positive results obtained with the use of fast green in salt water mussel spat studies, studies were conducted on the Lower Colorado River and at Lake Ontario in the summer of 2012. The studies focused on the ability of fast green to selectively dye dead mussels at both the larval and juvenile life stages for quick differentiation between live and dead individuals.

This presentation will summarize the findings of these studies, as well as recommendations on the future use for research and commercial field applications.

NOTES

Dreissenid Veliger Detection and Enumeration Technology Enhanced to Improve Reliability and Sample Processing Using a Continuous Imaging Particle Analyzer (FlowCAM®)

***Victoria Kurtz**[1], **Denise Hosler**[2], Harry Nelson[1], Kevin Bloom[2], Ben Spaulding[1], [1]Fluid Imaging Technologies; [2]Bureau of Reclamation*

In 2008 Fluid Imaging Technologies adapted their imaging particle analyzer FlowCAM® for use in the detection and identification of zebra and quaqqa mussel veligers by offering a version of the FlowCAM® equipped with Cross Polarizing optical filters for the purpose of detecting the natural birefringence seen on veligers. A number of organizations in the Western U.S. have since been using the FlowCAM® in their veliger monitoring activities. Included among these organizations is the Bureau of Reclamation (BOR) who have recently entered into a "Cooperative Research and Development Agreement" (CRADA) with Fluid Imaging Technologies to further enhance the technology for the express purpose of detecting, identifying, and enumerating Dreissenid veligers. With input from BOR, engineers at Fluid Imaging have taken the proven FlowCAM® technology and improved its ability to detect and identify veligers while at the same time increase its sample volume processing capability. A review of the technological improvements along with supporting data will be discussed.

NOTES

Evaluating the Risk of Non-native Aquatic Species Range Expansions in a Changing Climate in Pennsylvania

***Sara Grisé**, Pennsylvania Sea Grant; Theo Light, Shippensburg University*

The effects climate change may have on non-native species and their impacts are not well understood, and will vary depending on geography and the affected species. However, these two stressors acting synergistically have the potential to create new and emerging threats that could change the face of future ecosystems. Due to the uncertainty involved, there is a need to develop predictive management tools that provide resource managers with strategies for prioritizing establishment risk of invasive species that may benefit from the warming temperatures of a changing climate.

This study explored the vulnerability of Pennsylvania's habitat to the movement and introduction of species responding to changing thermal regimes. The United States Geological Survey (USGS) Nonindigenous Aquatic Species (USGS NAS) database was used to identify over 50 species of aquatic plant, fish, and invertebrate found south of Pennsylvania that have the greatest potential to expand their ranges northward and establish in Pennsylvania. Statistically downscaled climate projections from 14 models were used to predict Pennsylvania's future temperature averages based on data from the Intergovernmental Panel on Climate Change (IPCC) on two potential emission scenarios, the high (A2) and low (B1) scenarios in two time periods (2050-2059 and 2090-2099). According to these models, by 2099 Pennsylvania may have a climate similar to current day Tennessee, Kentucky, Delaware, Virginia, or North Carolina. Climate-matching, using the online tool CLIMATCH, then compared native range information to determine that almost half of these species analyzed could not survive Pennsylvania's current cool climate conditions. However, by 2099 in the A2 scenario, over 50 percent of species showed a total increase in climate suitability, and 33 percent were designated "likely to invade" with climate suitability increases greater than 30 percent. To evaluate the potential for invasive impacts, invasiveness scoring kits were used to identify four high risk species that not only had high habitat suitability scores, but that also scored high in their potential to exhibit invasive characteristics if introduced to Pennsylvania.

Since establishment success and potential impacts of species involves many different factors, the combined effects of warming temperatures, propagule pressure, competition, and other stressors were assessed in case studies for the four highest risk species: banana-water lily (*Nymphaea mexicana*), channeled applesnail (*Pomacea canaliculata*), Mozambique tilapia (*Oreochromis mossambicus*), and the red piranha (*Pygocentrus nattereri*). The information gained from this study can help those involved in invasive species management take a more proactive approach to considering management strategies for prevention, control, and eradication of new and emerging aquatic invasive species in Pennsylvania.

NOTES

An Empirical Analysis of the Causes, Consequences and Predictors of Aquatic Invasive Species in Inland, Freshwater Lakes in Southern Ontario

***Tim Haxton**, Sarah Nienhuis and Tal Dunkley, Ontario Ministry of Natural Resources*

With increasing human use of North American inland lakes for recreational purposes, there is a greater probability of the incidental transfer and introduction of aquatic invasive species within them. This raises concern over the potential ecological and economic impacts that invasive species could have in these highly valued freshwater ecosystems. In this study, we focus our interests on 89 inland lakes distributed across the Southern Ontario landscape in order to evaluate whether concerns over potential adverse impacts of aquatic invasive species (the zebra mussel (*Dreissena polymorpha*), the spiny water flea (*Bythotrephes longimanus*), and the fishhook water flea (*Cercopagis pengoi*)) on native fish communities and targeted game species (i.e., walleye (*Sander vitreus*), smallmouth bass (*Micropterus dolomieu*), lake trout (*Salvelinus namaycush*), and northern pike (*Esox lucius*)) are warranted. Through the analysis of a comprehensive and multivariate dataset comprising fish community, fish metric, zooplankton haul, lake size, water chemistry, seasonal activity count, and human demographic data, we examined the potential causes, consequences and predictors of aquatic invasions in inland lakes through multivariate and spatial analyses. Key findings of this study include the non-detection of the fish-hook water flea in any of the study lakes; condition, growth, and relative abundance of some of the most highly valued game fish in inland lakes significantly varies among lakes with and without AIS; and the discovery that the species composition (i.e., identity and relative abundance) of fish communities within a lake can indicate AIS presence/absence with a high degree of certainty. Furthermore, our study confirms the predictive capacity of several critical lake characteristics, water chemistry variables, and lake access levels as indicators of the invasion susceptibility of lakes with respect to the zebra mussel and spiny water flea. Finally, the results of this study lend support to concerns over the potential ecological and economic impacts of the continued spread of two well-known aquatic invasive species throughout inland lakes in the province, and indicate the importance of human activities as vectors for the secondary spread of these species.

NOTES

Invasive Species, Climate Change, and Emerging Infectious Disease Threats

***David Bruce Conn**, Berry College*

As many as 70% of the world's major infectious diseases of humans are zoonotic, infecting both humans and animals. Many are vector-borne, relying on transmission by mosquitoes and other insects that are aquatic for most of their lifespan. Still others rely on aquatic molluscs, fishes, or other aquatic animals for completion of their transmission cycles. In recent years, new outbreaks of such diseases have occurred in many parts of the world. This may involve introduction of disease vectors into locations where the disease was previously unknown, such as the recent occurrences of mosquito-transmitted diseases such as West Nile Virus in North America, dengue fever in southern Europe, and Chikungunya fever in South America. Alternatively, direct introduction of waterborne pathogens may occur in disease outbreaks such as the cholera outbreak still unfolding in Haiti. Accidental introduction of pathogens or the aquatic vectors and hosts of other infectious diseases is among the primary concerns that affect international trade and travel. This concern is exacerbated by the prospect of warming climate, potentially resulting in primarily tropical diseases encroaching into regions that have historically been characterized by subtropical or temperate climate regimes. Thus, we must be prepared for the possibility of geographic spread of diseases into areas where they have not occurred, or reintroduction into areas where they once occurred but have been eliminated through control measures. For North America, potential for reintroduction of such major "tropical" diseases as malaria and yellow fever must come under increasing scrutiny, starting with surveillance of vector populations and the possible introduction of new invasive species that are competent vectors. It is also critical to monitor for potential introductions of species that have never occurred in a given area, but which could pose a threat of invasion if water temperatures and associated aquatic vegetation changes developed in the coming years. Such a pattern could be conceivable with such major human pathogens as *Schistosoma mansoni*, through introduction of competent intermediate host *Biomphalaria* snails from foci in the Caribbean or Africa. This presentation reviews previous cases in which aquatic invasive species have contributed to infectious disease emergence, reemergence, or increase, and proposes One Health strategies for integrating human, animal, and environmental monitoring and surveillance to better prepare for or prevent geographic spread of major human health threats.

NOTES

Predicting Invasional Vulnerability Using Abundance-Body Mass Spectra

***Yajun Sun** and Mathew G. Wells, University of Toronto, Department of Physical and Environmental Sciences*

In order to better understand biological invasions, we explore a new model of population dynamics that depend upon both the population density and individual body mass. The population dynamics of a species are broken down into three sections: production, natural death, and predation, each of which is modeled by a parsimonious form of density dependence. The model is calibrated in the context of community, i.e., the steady status across community regulates the population dynamics of each species so that the observed allometric spectra (e.g., metabolism, mortality, and abundance over body mass) hold true throughout the whole community. The outcome demonstrates a similar pattern to the logistic model: the population growth rate is a concave function of density, curbed by an unsteady endpoint, the Allee threshold, and a steady endpoint, the carrying capacity. Furthermore, the Allee threshold is found to be linearly related to the carrying capacity, both of which are power-law functions of body mass. The population dynamics also reveal their sensitivity to the trophic transfer efficiency (or the dependent body-mass ratio between consecutive trophic levels).

These findings indicate heterogeneous invasional vulnerabilities in many natural waters (e.g., Lake St. Clair), where distinct ecological zones (pelagic versus littoral water) are associated with different zooplankton abundance spectra and trophic transfer efficiencies. The simplicity of the modeling enables this method to be a helpful tool for the management against biological invasions in natural waters, when combined with other critical factors associated with ballast water discharge, such as the decay rate during voyage and any mixing/dilution during/post discharge in the recipient water.

NOTES

Modelling the Likelihood of Introduction and Establishment of Marine Non-native Species in the UK and Ireland

*Fiona Pearce, Edmund Peeler and **Paul Stebbing**, Centre for Environment, Fisheries and Aquaculture Science*

Non-indigenous species (NIS) pose a major threat to global biodiversity, and incur significant economic costs. The necessity to prevent their introduction and spread is reflected in descriptor 2 of the European Union (EU) Marine Strategy Framework Directive (MSFD). The ability to predict where, and by which pathway, a species is most likely to arrive and establish is very important for combating the impact of NIS on our marine environment.

This study aimed to identify potential hotspots of introduction and establishment of marine NIS across the United Kingdom (UK) and Ireland. Each area of coastline was scored on the likelihood of an NIS being introduced, based on data collected on the intensity of five main pathways of invasion. This was carried out for each of nine identified taxonomic groups of potential marine NIS. For each group, likelihood of establishment for each area was scored using environmental data. The model was applied to *Didemnum vexillum* (DV), an invasive sea squirt already present in the UK and Ireland, as a case study.

The analysis found despite some differences between the nine taxonomic groups, several areas have a particularly high likelihood of introduction for most groups, relative to the UK and Ireland as a whole. These areas also score highly for likelihood of establishment for many taxa.

Known locations of DV correlate well with areas estimated as high likelihood of introduction and establishment by the analysis.

The method presented provides a useful management tool, allowing the identification of areas at risk of introduction and establishment where biosecurity and monitoring can be prioritised.

NOTES

A National Status Report on Aquatic Invasive Species in Canada

*Åsa Kestrup and **David Browne**, Canadian Wildlife Federation*

The number of invasive species in marine and freshwater environments in Canada has increased dramatically over the past 50 years and further introductions are expected. Prevention of future invasions and mitigation of the impacts of previously introduced species will require coordinated action from government as well as non-government organizations and the effective translation of new research findings into applied programs. To help raise the profile of the issue of aquatic invasive species (AIS) and to make constructive recommendations on how to enhance efforts to prevent new introductions or control the spread of established invaders, the Canadian Wildlife Federation is developing a national status report on AIS. The report examines the status and trends of invasive species in aquatic and semi-aquatic environments and the different pathways and vectors that bring them to Canada and contribute to their spread across Canada, provides an overview of current monitoring and control actions, evaluates current government regulations and programs, and reviews existing non-government efforts to control the spread and mitigate the impacts of AIS. The report will identify gaps in our current knowledge of AIS and the regulations and programs in place for control and mitigation at both the federal and provincial level. Based on the analysis, the report will make recommendations for actions to address the problem of AIS in Canada. The report is intended as a document for the general public and decision-makers and will present information on AIS in Canada in an easy to read and understand format.

NOTES

Assessing Needs and Developing Regulatory and Outreach Strategies for Preventing the Spread of Aquatic Invasive Species through Boating

***Samuel Chan**, Oregon State University*

Our paper examines barriers to regulatory approaches, mandatory inspections, outreach, and voluntary actions that can lessen the threat and spread of aquatic invasive species through two related projects. The first project focused on a survey of boater's and law enforcement officer's knowledge on aquatic invasive species, preventative actions and regulations and their suggestions to improve preventative actions. The second project "A Co-learning Workshop on Legal and Regulatory Efforts to Minimize Expansion of Invasive Mussels through Watercraft Movements brought together public attorneys, lead AIS Coordinators and Law Enforcement from the western USA to examine legal barriers and develop an action plan based on legal and regulatory approaches to minimize the spread of invasive mussels :

1) We report on a survey of nearly 900 motorized and non-motorized boater's and interviews with lead law enforcement officers in Oregon USA on their knowledge and suggested solutions for guiding the development of policies, outreach and management programs. Boater's awareness and concern for aquatic invasive species is high in Oregon, but many institutional, legal and personal barriers exists that prevent boaters from taking action. Boaters and law enforcement officials provided specific solution on education approaches, messaging, clear decontamination protocols, to infrastructure improvements, policy changes and even a willingness to regulations and fees to overcome barriers. Over 90% of boaters felt that a combination of both regulations and outreach was necessary for an effective aquatic invasive species prevention program.
2) Outcomes of a workshop convened in Phoenix, Arizona in Aug 2012, by the U.S. Fish and Wildlife Service, the National Association of Attorneys General, Oregon Sea Grant, the National Sea Grant Law Center, and the Western Regional Panel on Aquatic Nuisance Species. The purpose of the workshop was to engage Assistant Attorneys Generals, natural resource agency attorneys, law enforcement supervisors, policy makers, and the Aquatic Invasive Species (AIS) Coordinators from the 19 Western states, interstate organizations, and Federal partners to establish clear legal and regulatory approaches and opportunities for AIS abatement and reform. A critical deliverable from this workshop was the creation of an action plan that articulates needed actions at the federal/national, Bi-national, Canadian/USA, regional, state, and local levels to minimize the expansion of invasive mussels through watercraft movements in the west.

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Aquatic Invasive Species Outreach for Water Gardeners and Aquarium Hobbyists

***Greg Hitzroth**, Illinois-Indiana Sea Grant; Patrice Charlebois, Illinois-Indiana Sea Grant & Illinois Natural History Survey; Erin Seekamp, North Carolina State University*

Forty-two of 182 of species introduced to the Great Lakes arrived via the organisms in trade (OIT) pathway. Illinois-Indiana Sea Grant (IISG) is involved in several projects providing research and outreach on OIT with plans to capitalize on past efforts to build the capacity for OIT outreach in Illinois. IISG is planning on creating outreach for aquarium hobbyists, water gardeners and teachers about the risks of releasing OIT to the environment. This will be accomplished by first creating a needs assessment for these groups as effective outreach cannot be done without this knowledge.

IISG partnered with Erin Seekamp, a natural resources social scientist at North Carolina State University, to conduct a needs assessment of these audiences. Focus groups, interview and survey research will measure pre-campaign knowledge, awareness, concerns and behaviors related to releasing nonnative species into Illinois ecosystems. The focus groups and interviews identified key messages, misunderstandings and the best marketing outlets as well as created a basis for a wider survey. These activities will allow for identification of the best tools and messages for communicating with these audiences.

With this background information, IISG plans to develop a single, clear, simple audience-tested message that can be used across many media and publications. This message will be an effective brand with the broader message of "don't release" that resonates with the main OIT audience: looking at the "Smokey Bear" and "Give a Hoot, Don't Pollute" campaigns as possible models for development. This information will be disseminated via in-person events, presentations, publications, social media and a water garden feature at the Chicago Botanic Garden. This presentation will focus on the results of the focus groups, interviews and preliminary results from the needs assessment.

NOTES

GLANSIS Enhancements

***Rochelle Sturtevant**, Abigail Fusaro and Edward Rutherford, NOAA, Great Lakes Environmental Research Laboratory*

With funding from the Great Lakes Restoration Initiative (GLRI), the Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS) has enhanced its search engine and added new features and new information in support of early detection and rapid response. In addition to it's core list of 182 species nonindigenous to the Great Lakes, GLANSIS now includes information on range expansion species (those native to part of the Great Lakes basin but nonindigenous to other portions of the basin) and watchlist species (those identified in the peer-reviewed literature as likely to invade the Great Lakes via currently operating vectors). Fact sheets for species in the database have been expanded to include qualitative comparative assessments of the impact of those species as well as significant information on regulation and management. New fact sheets for the watchlist species include information from comparative risk assessments looking at risk of introduction, establishment and impact.

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Outreach on Great Lakes OIT Risk Assessments

*Greg Hitzroth, Illinois-Indiana Sea Grant; Danielle Hilibrich, University of Illinois; **Patrice Charlebois**, Illinois-Indiana Sea Grant & Illinois Natural History Survey; Mark Farley, Oregon Sea Grant; Bob Kirschner, Chicago Botanic Garden; Reuben Keller, University of Notre Dame*

Many of the most damaging species introduced into the Great Lakes Basin of North America were introduced intentionally for commerce (e.g., aquarium and water garden trades). As these trades grow, so does the risk that new invaders will establish and increase overall AIS impacts. To facilitate the ability of the U.S. state and Canadian provincial governments to regulate these organisms in trade (OIT), our team is developing transparent, easy-to-use, science-based risk assessment tools. Risk assessments are key to preventing new invasions from the organisms in trade pathway because they give managers the information necessary to regulate high-risk species without affecting trade in benign species. We have developed risk assessment tools for plants and mollusks, and are working on tools for fish, reptiles and amphibians.

In addition to the development of risk assessment tools, we are conducting outreach to resource managers and to the retail and consumer segments of the OIT pathway. Outreach to resource managers has been critical in ensuring that the risk assessment tools will be used by the managers. Outreach to the retail and consumer segments of the pathway will support the regulatory work of the managers by 1) providing context for the overall issue, 2) identifying species determined by the risk assessment tool to pose a high risk for invasion, 3) encouraging consumers to use non-invasive alternatives and 4) enabling commercial entities to access information on state and federal regulations. This outreach includes an OIT website, a database of U.S. state and federal regulations, printed materials, workshops for the green industry, and a demonstration water garden in which only non-invasive species are used. These outreach tools will be highlighted and future outreach plans discussed.

NOTES

Self-management: The Bane or Saviour of Non-Indigenous Marine Species Management?

Marnie L. Campbell *and Chad L. Hewitt, Central Queensland University, School of Medical and Applied Sciences; Dominic E.P. Bryant, University of Tasmania, National Centre for Marine Conservation and Resource Sustainability*

We present an investigation of whether self-management is a viable option for controlling the spread of introduced marine species. Our study involved examining recreational marine users' (including SCUBA divers, boaters and fishers) self-proclaimed awareness of non-indigenous marine species (NIMS) and the accuracy of this awareness in Tasmania, Australia. Four well established NIMS that exist in Tasmania were used to test respondent's introduced species recognition knowledge (*Asterias amurensis, Carcinus maenus, Maoricolpus roseus*, and *Undaria pinnatifida*).

The majority (70.45%) of respondents believe that they are aware of NIMS in Tasmania, yet their recognition accuracy was variable ranging from low to fair (<10% to 54.95%). The recreational activity that people were engaged in did not influence their accuracy of NIMS identification. We conclude that marine users in Tasmania are partially informed about NIMS, but they are not knowledgeable about NIMS. This suggests that NIMS education and outreach in Tasmania has only been partially effective. But more importantly relying on citizens to monitor and manage NIMS may be a risky management strategy. The global implications of our findings is that if marine recreational users are unaware, or if they have inappropriate and faulty awareness of NIMS, then there is a heightened likelihood that they could inadvertently transfer NIMS.

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Aquatic Invasive Species in Inland Lakes: Distribution, Abundance, Impact

M. Jake Vander Zanden*, Professor, University of Wisconsin-Madison, Center for Limnology*

There is widespread concern about the ongoing spread of aquatic invasive species, due to their often undesirable and unpredictable consequences for ecosystems and humans. As a consequence, there is a great deal of interest in preventing their further introduction and spread. But how much do we really know about the distribution, abundance and ultimate impacts of invasive species, and to what extent can we generalize across the many invasive species of concern? We address some fundamental questions along these lines, using north-temperate inland lakes as a study system. First, we conducted a field survey to assess how well current invasive species distribution records reflect their actual geographic distribution for a suite of aquatic invasive species. Occurrence records dramatically under-represent the overall scope of aquatic invasive species distributions. We also examined broad-scale spatial patterns of invasive species abundance. In looking across many sites, invasive species often occurred at low abundances, and only occasionally reached high abundances. The overall pattern was not too different from that of their native counterparts. What does this mean for our understanding of invasive species impacts? We postulate that it depends specifically on how invasive species abundance and impact are related, which tends to be poorly understood. In sum, delving into patterns of aquatic invasive species distribution and abundance reveals a great deal of patchiness. The challenge will be to use this improved understanding to make better decisions in the ongoing efforts to manage and prevent aquatic invasive species.

NOTES

Preventing Aquatic Invasive Species through Management of the Live Bait Pathway: An Introduction

Amy Fowler, *Post-Doctoral Teaching Fellow, Biology Department, Villanova University and* ***Susan Park****, Assistant Director for Research, Virginia Sea Grant*

Prevention is widely acknowledged as the most effective method—both ecologically and economically—for managing aquatic invasive species. Typically, prevention has been focused on species-specific approaches; however, there is a growing movement to develop prevention plans and approaches that target entire vectors or pathways. While much attention has focused on major vectors like commercial shipping, other vectors can also pose considerable threats to natural systems. The live bait trade, which may transport not only the target bait species but also hitchhiking organisms associated with bait and packing materials, is known to move organisms to new environments around the globe. For example, two major invasions to the San Francisco Bay—the European green crab (*Carcinus maenas*) and the rough periwinkle snail (*Littorina saxatilis*)—have been attributed to the live bait trade. Vector management requires an understanding of the biological risks associated with a particular pathway (e.g., diversity of species transported by the vector) as well as the human behavioral dimensions (e.g., how organisms may be released to new environments) to understand both the risks and the most effective points of intervention. This talk will provide a brief overview of live bait vector management, noting important and relevant work that has been done in biological and social science research, and in policy and management. It will highlight the importance of integrating all of these aspects in order to develop effective interventions for vector management.

NOTES

Estimating Bycatch Risk: The Role of Selective Fishing in Species Invasions

Andrew Drake *and Nicholas Mandrak, Fisheries and Oceans Canada*

Selective capture is the ultimate management goal of most commercial and recreational fisheries. In reality, achieving perfect selection, where target species are captured and non-target species are avoided, is difficult because of the species diversity of harvest areas, effectiveness of gears, and volume of catches. Consequences of imperfect selection in most fisheries are injury or mortality of captured non-target stocks. In live capture fisheries, imperfect selection and incidental harvest have implications for AIS removal from donor ecosystems. To recognize the combined influence of ecological and harvest factors contributing to incidental capture, we demonstrate a probabilistic modeling framework that incorporates: 1) background rates of target and non-target stock co-occurrence as the primary ecological basis for incidental harvest; 2) the probability of harvesting at localities exhibiting co-occurrences; 3) the probability of selecting for non-target species with fishery gear; 4) and, as a function of harvest effort, the overall probability of incidental capture for any non-target stock contained in the species pool available for harvest. Simulation models were based on fishery-independent data from a freshwater bait fishery in Ontario, Canada. Harvest simulations indicated that greatest species-specific capture values were over 4000 times more likely than for species with lowest values, indicating highly variable capture probabilities due to the combined influence of stock heterogeneity and harvest dynamics. Most invasive fishes exhibited low bycatch risk, due to their sparse distributions. Certain invasive fishes, such as Round Goby (*Neogobius melanostomus*), exhibited greater capture risk, which is anticipated to increase as the species expands its range. Results indicate that many of the issues associated with biological pathways and invasion risk are founded in selectivity when wild stocks are harvested. Models indicate that improvements in selective fishing, due to spatiotemporal management, effort restriction, or deployment tactics, should continue to be investigated as possible strategies to reduce the risk of invasive bycatch. Estimated bycatch-effort relationships allow managers to evaluate the risk of incidental harvest to evaluate specific ecosystem-based fishery management objectives, such as reducing the overall probability of bycatch while maintaining target landings.

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Bycatch, Bait, Anglers, and Roads: Quantifying Vector Activity and Species Introduction Risk across Lake Ecosystems

Andrew Drake *and Nicholas Mandrak, Fisheries and Oceans Canada*

Long implicated in the invasion process, live-bait anglers are highly mobile vectors with frequent overland transport of fishes between drainage basins. To test hypotheses about anglers' role in invasive propagule transport, we analyze bycatch and angler activities to quantify introduction risk of Round Goby (*Neogobius melanostomus*) to lake ecosystems in Ontario, Canada. We develop a social-ecological model quantifying the opportunity for species transport beyond the invaded range resulting from bycatch during bait harvest and retail operations, and incidental transport, and release to lake ecosystems, by anglers. To incorporate the role of individual actions contributing to propagule arrival, we couple a gravity model with a stochastic, agent-based simulation, representing a 1-year iteration of live bait angling and the dynamics of propagule transport at fine spatiotemporal scales. Vector risk profiles indicated that most angling trips were benign, exhibiting negligible risk: irrespective of travel patterns and lake visitation, anglers failed to purchase and transport invasive propagules (benign trips, median P = 0.99913). Substantially fewer individuals participated in cumulative actions leading to a risky event by purchasing invasive bycatch, traveling to uninvaded lakes, and releasing invasive propagules to ecosystems that currently do not support the species (risky trips, median P = 0.00087 trips; approximately 1 in 1150). Results indicated a strongly skewed vector risk profile, with few individuals bearing a substantial proportion of introduction risk. Two patterns of lake-specific introduction risk emerged and, despite the large number of yearly propagule introductions (total Round Goby propagules introduced/year; median = 3712, total lakes receiving propagules; median = 1244), most lakes did not receive sufficient propagules to warrant management concern given anticipated establishment thresholds (64% of lakes exhibited likely outcomes of 0 propagules introduced/year). However, large lakes supporting substantial angling activity recieved propagule pressure likely to meet or surpass establishment barriers (top 1% of lakes, likely outcomes between 7 and 70 propagules introduced/year). Sensitivity analyses indicated that deviations in risky activities, such as the purchase of invasive bycatch or the release of left-over fishes, have meaningful influence on introduction risk and provide opportunities to test risk management strategies. Results indicate that the combination of invasive bycatch and live bait anglers warrant management concern as species vectors, but that risk is confined to a subset of individuals and recipient sites that may be effectively managed with targeted strategies.

NOTES

One of These Things is not Like the Others – Prevalence of Non-target Species in Commercial Baitfish in Ontario

Jeff Brinsmead[1]*, Brenda Koenig*[1]*, Andrew Drake*[2]*, Nicholas Mandrak*[2]*, David Copplestone*[1]*, Darryl Mitchell*[1]*,*
[1]Ontario Ministry of Natural Resources; [2]Fisheries and Oceans Canada

Commercial baitfish harvest and sale, and subsequent movement by anglers, are potential pathways for the spread of aquatic invasive species in Ontario. These pathways may also allow for movement of native fishes to watersheds where they are not currently found. Such introductions of new species can have a negative impact on native species in recipient ecosystems. Ontario bait harvesters and retailers use best management practices (Hazard Analysis and Critical Control Point or HACCP plans) to reduce the prevalence of non-target species in commercial catches and retail tanks. We compared the rate of occurrence of non-target fish species in commercial sales across two time periods: 2007/08 and 2011/12. Additionally, for the 2011-12 time period, baseline data on the prevalence of invasive aquatic invertebrates associated with commercial baitfish and the water in which they were purchased was collected. Water samples collected in February 2012 were also analyzed for the eDNA of several known invasive fish species. Our results indicate that non-target fishes were found rarely (34 non-target fishes out of a total of 14 970 fishes sampled and 8 of 58 sampling events, but with moderate levels of variability for the occurrence values between sample periods). Previous research indicates that low probabilities of occurrence are not trivial given the substantial number of fishing events involving baitfish in Ontario (estimated to be approximately 4.12 million events per year). Our results confirm that even low non-target species occurrences should continue to warrant management attention. Although no invasive invertebrates were found associated with commercial baitfish sampled in fall 2011, a variety of native invertebrate species were found in the water samples indicating that the possibility of inadvertently transporting invasive invertebrates with commercial bait cannot be dismissed.

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Bait Fish in Quebec: New Regulatory Guidelines

Catherine Brisson-Bonenfant, Ministère des Ressources naturelles et de la Faune and ***Isabelle Desjardins****, Ministère du Développement Durable, de l'Environnement, de la Faune et des Parc du Québec*

Regulating the use of bait fish is necessary because this practice may result in introduction of aquatic invasive species and pathogens (viruses, bacteria, parasites). Consequently, the use of bait fish represents a high risk for the conservation of biodiversity, the persistence of fish stocks and the maintenance of their related economic activities.

Before 1950, the regulation concerning the use of bait fish was almost non-existent in the province of Québec. The use of bait fish was authorized throughout the territory. In the following years, regulatory restrictions on the use of bait fish were set mainly in response to the damage induced to fish populations of inland lakes by introduced species from the St. Lawrence river. The regulation established in 1990 limited the use of bait fish (live or dead) to only certain areas of Quebec.

In 2009, a new line of though was initiated as a result of improved knowledge on aquatic invasive species, which included pathogens such as viral haemorrhagic septicaemia (VHS). Consequently, new orientations arose to restrict even more the use of bait fish. Since April 2012, the importation of bait fish (live or dead) is prohibited in the province. Moreover, starting in April 1, 2013, the use of live bait fish will be prohibited during summer throughout Quebec. In April 2017, this prohibition will also apply to dead bait fish. This will effectively ban the use of bait fish, alive or dead, during the summer. Fishermen may still use bait fish, alive or dead, in winter.

In addition, awareness campaigns will be carried out to provide information to fishermen about the risks related to the use of bait fish as well as to promote the use of artificial lures.

NOTES

A Perspective on the Use of Biological Control Methods for *Dreissena* Management: The Past, the Present, the Future

Daniel Molloy*, Research Scientist and Adjunct Professor, State University of New York at Albany*

People sometimes speak of the quest for the "silver bullet" for *Dreissena* control — a single, economical, environmentally-safe, and effective control method. Of course, this is unrealistic since no single control method will be the sole practical solution in all situations. Solving *Dreissena* problems will require implementation of a wide range of integrated pest management (IPM) strategies. The use of biological control methods in these IPM efforts to control dreissenid infestations in infrastructures, as well as in open waters, is the focus of this presentation. Broadly defined, biological control is the use of one species for the suppression of another. Two groups of organisms have potential as *Dreissena* biocontrol agents: selectivelytoxic microbes and natural enemies. Selectivelytoxic microbes are naturally-occurring soil and water microorganisms which simply by chance (not because of any evolutionary relationship) happen to be toxic to *Dreissena*. In contrast, natural enemies are organisms which by their evolutionary nature will debilitate or kill *Dreissena*, and this group includes predators, parasites (both multicellular and microbial), and benthic competitors (organisms capable of competitively displacing *Dreissena* from substrates). The research progress to date to evaluate these groups of biocontrol candidates, their current status, and what the future may hold for their use will be reviewed, with particular emphasis on the selectivelytoxic microbe *Pseudomonas fluorescens*, the active ingredient of Zequanox®.

NOTES

Quagga Mussels and Lake Mead: Recent Trends and Mitigation

***Todd Tietjen**, Eric Wert, Julia Lew and Peggy Roefer, Southern Nevada Water Authority*

Quagga mussels have been in Lake Mead since 2007 and the population appears to be well established throughout the lake. The Southern Nevada Water Authority has investigated this invasion from the perspective of both the Lake Mead ecosystem and the drinking water treatment infrastructure. In this presentation we will provide information on both of these areas of interest. Veliger production has generally followed a pattern with 2 significant spawning periods; one in the spring and a second in the fall, with intermediate levels of spawning in the summer months. During 2011 the water level in the reservoir increased throughout the spring, summer and fall, the first sustained increase in surface elevation in over a decade. There is some evidence that this change in the water level reduced the number of veligers produced during the typical fall reproduction peak. It is hypothesized that the rise in surface elevation resulted in the adult mussels being "moved" below the thermocline, limiting the migration of the veligers into the upper water column. The Southern Nevada Water Authority has begun using chloramines to prevent settling and colonization of quagga mussels in the drinking water intake tunnel that draws water from Lake Mead. This treatment is intended to provide protection for the intake tunnel and connected treatment facilities. Chloramines were chosen following a bench top experiments evaluating the efficacy of various oxidants. The oxidants included free chlorine (FCl_2), chloramines (NH_2Cl), potassium permanganate ($KMnO_4$) and chlorine dioxide (ClO_2). All were applied to freshly collected veligers from Lake Mead at various concentrations in order to assess the impact on veliger swimming. Of these choices the chloramines were selected based on the combination of their high degree of effectiveness in limiting veliger swimming and the documented decreases in formation of THMs (trihalomethanes), as compared to alternative forms of chlorine. Overall the ecosystem impact of quagga mussels in Lake Mead has not been as large as in other systems throughout the country; nutrient concentrations and phytoplankton and zooplankton communities have not been strongly influenced. The impact on drinking water resources for the Las Vegas Valley has added to the overall cost of treatment, but the chloramines appear to offer a reasonable and effective option to reduce these costs. While the quagga mussel invasion has had serious consequences, these impacts have not been as severe as predicted due to unique characteristics of Lake Mead.

NOTES

UV Irradiation as a Means of Minimizing Downstream Settlement of Quagga Mussel Veligers

***Renata Claudi** and Thomas Prescott, RNT Consulting Inc.; Ytzhak Rosenberg, Benzi Shoval and Yariv Abramovich, Atlantium Technologies Inc.*

Several studies carried out in the 1990s have shown that flow-through UV systems have the ability to prevent attachment of dreissenid veligers to downstream surfaces. Most of the trials were done on the Great Lakes and involved relatively small volumes of water (Lewis and Whitby 1993, Chalker-Scott et.al 1993, Chalker-Scott et.al 1994, Evans et.al. 1995, Lewis and Whitby 1996, Lewis and Cairns1998). The body of evidence gathered suggested that medium pressure lamps with UV wavelengths between 200 and 400nm will inhibit downstream settlement of dreissenids if the veligers are exposed to a radiation dose is approximately 100 mW s/cm². The experiment carried out in a flow through experiment on the Lower Colorado River was designed to test the actual dose required to minimize downstream settlement of quagga mussel veligers. The equipment used, a proprietary medium pressure UV system from Atlantium Technologies Ltd. allowed us to test several UV doses over a period of several month. The dose levels to be tested were selected with the system software and did not require any changes to the installed hardware. Further, the selected dose could be maintained by the software which continuously adjusted the dose delivered regardless of changes to the turbidity of the incoming water. The experiment drew veliger rich water from Colorado River. First the water passed through a small settling tank with twelve settling plates. From this tank the water moved through the UV treatment system and then into a series of drums to achieve post exposure retention time of twenty minutes. In three of the settlement drums, one immediately post exposure, another 10 minute post exposure and the last twenty minute post exposure we placed 12 settling plates. Water flowed through the experimental set up for five to six weeks. At the end of each experiment, settling plates from before and after the UV system were evaluated for settlement. Physical parameters such as volume of water treated, transmissibility of the water, electrical consumption, dose delivered and water temperature were collected continuously. Four separate experiments were conducted between April and September 2012. Each experiment utilized different UV dose. In all experiements mussel settlement was inhibit by a minimum of 98%. The paper will present the results from this study.

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Water Level Manipulation During Harsh Environmental Conditions as a Tool for Mitigating Effects of Invasive Dreissenid Mussels in Impounded River Sections

***Rob Leuven**, Remon (K.R.) Koopman, Frank P.L. Collas, Gerard Van der Velde and Jon Matthews, Radboud University Nijmegen*

The biodiversity of the rivers Rhine and Meuse in northwestern Europe has been strongly decreased due to river regulation and environmental deterioration. In spite of ecological rehabilitation the riverine biodiversity only partly recovered. The aquatic invertebrate communities are still impoverished and strongly dominated by non-native invasive species such as Asiatic clams (*Corbicula fluminea*), zebra mussels (*Dreissena polymorpha*) and quagga mussels (*Dreissena rostriformis bugensis*). During the severe winter of 2012, an unintended large scale experiment unfolded in an impounded section of a Rhine river distributary (i.e. the River Nederrijn in The Netherlands). On 8 February 2012, three weirs in the River Nederrijn were opened to prevent damage of hydraulic infrastructure by drifting ice. This caused a sudden and extreme decrease in water level. The water level in the River Nederrijn and connected water bodies decreased up to 3.4 m and this event lasted more than one week. The extreme event offered opportunities to validate our hypothesis that water level manipulation during harsh environmental conditions could be used as a management tool to control invasive non-native mussels. Data of our fauna monitoring in the Rivers Nederrijn (extreme event) and River Meuse (reference site) allowed us to assess the effects of the extremely low-water event during severe winter on invasive freshwater mussels on hard substrates. Our results clearly show that the overall density of zebra and quagga mussels was negatively affected by the extremely low-water event in the River Nederrijn. No change in density of mussels was recorded in the River Meuse. The slight increase in density after six months in the River Nederrijn indicates re-colonization and full recovery of the mussel population will take several years. This is supported by the significantly smaller size of quagga mussels found six months after the event in the River Nederrijn opposed to that of specimens collected in the River Meuse. The significant larger number of mussels in the wash up on the banks directly after the event indicates that the effect of the extremely low-water event also affected other mollusks including species living in and on sediments. More than 99% of the wash up found directly after the event consisted of non-native species. Creating extremely low water conditions by weir management during severe winters appeared to be an effective tool to control population densities of non-native invasive freshwater mussels in impounded river sections. The full recovery of invasive mussel populations after an extreme mortality event will take several years. The assessment of long term effects of weir management on native as well as non-native species composition and diversity is recommended.

NOTES

Watercraft Interception Programs for Dreissenid Mussels in the Western United States

***Stephen Phillips**, Pacific States Marine Fisheries Commission*

Zebra mussels and quagga mussels have been the most costly aquatic invaders in U.S. history as tens of millions of dollars are spent each year in managing zebra mussel infestations in the Great Lakes, Mississippi and now Colorado River drainages. The introduction of zebra and quagga mussels into the Columbia River Basin could not only threaten native species, but also industrial, agricultural, recreational, navigation, and subsistence use of the infested waters. Dreissenid mussel transfer between basins in the western United States is most likely to occur through the movement of trailered watercraft. Government agencies and organizations in the western U.S. have implemented watercraft interception programs designed to prevent contaminated watercraft from being launched in unaffected waterways. Hundreds of thousands of boats are inspected each year in the western U.S. In 2012, most dreissenid contaminated watercraft came from the Lower Colorado River Drainage (e.g. Lake Mead) followed by the Great Lakes. The PSMFC in cooperation with the 100th Meridian Initiative has surveyed agencies responsible for managing watercraft inspection programs through its Watercraft Inspection Training (WIT) program. We will provide an overview of western watercraft inspection programs, data on number of boats inspected, source waters of infested boats and watercraft destination. This talk will also highlight challenges and successes of watercraft interception programs and future direction of the programs at the state and federal level.

NOTES

Critical Keys to Success Learned from Florida's Aquatic and Wetland Invasive Plant Management Program in Public Natural Areas and Why Invasive Plant Research and Outreach are Essential for Advancement

***Don Schmitz**, Research and Outreach Program Manager, Invasive Plant Management Section, Florida Fish and Wildlife Conservation Commission*

During the past 400 years, Florida's natural areas and waterways have been invaded by mostly tropical and subtropical non-native plants. These invasions increased during the twentieth century with the rise of the ornamental plant industry and through the unintentional contaminants of imported commodities. Because of these plant invasions, Florida has developed one of the most successful and largest invasive plant management programs in the U.S. Its success is largely due to the establishment of a lead state agency that coordinates and funds two large invasive plant control programs. The process that led to the development of a lead Florida government agency began in 1899 after the U.S. Congress passed the Rivers and Harbor Act authorizing the U.S. Army Corps of Engineers to remove South American water hyacinth (*Eichhornia crassipes*) that was impeding navigation in the St. Johns River. For the next seventy years, water hyacinth removal, and beginning in the 1960s, hydrilla (*Hydrilla verticillata*) management, were generally piecemeal, uncoordinated, and often resulted in failure. In 1970, the Florida Legislature passed the Aquatic Weed Control Act creating a statewide Invasive Plant Management Program.

Within a few years, the lead state agency developed a standard management system with the goal of achieving maintenance control of invasive non-native plants in Florida's waterways and wetlands. Florida's invasive plant management program consists of clear management objectives, yearly surveys, and statewide standardization (including a resource protection plan, a statewide distribution of available funds, and statewide consistency in policy, goals, and control methods). It also requires extensive coordination and cooperation with federal, tribal, state, and local government agencies, universities, CISMAs, homeowners, and public groups.

Recognizing that research and public education are critical to environmentally and economically sound invasive aquatic and wetland plant management programs, Florida began funding invasive plant research and outreach in 1970. Since then, more than $22 million have been spent on more than two hundred scientific research and outreach projects to develop better cost-effective methods of controlling invasive plant invasions and increasing public information about invasive plant management in Florida. A brief history of Florida's invasive plant management research and outreach program will be presented.

NOTES

Registration of Minor Use Pesticides for Control of Aquatic Nuisance Species

*Lyn Gettys and **William Haller,** University of Florida, Institute of Food and Agricultural Sciences (IFAS), Center for Aquatic and Invasive Plants (CAIP)*

In the mid 1990s there were only six herbicides registered for aquatic weed control in the United States. The discovery of fluridone-resistant hydrilla in Florida led to a major cooperative effort between private industry, research scientists and resource managers to screen, evaluate for selectivity and register new modes of action for aquatic use. Since 2000, seven new herbicides have been registered for use in aquatic systems, which we hope will facilitate rotation programs that should reduce the likelihood of development of additional herbicide-resistant aquatic weed populations. The experience gained through this process over the past decade is highly relevant to the development of "new" pesticides such as molluscicides and piscicides. Pesticides are not screened for activity on invasive animals; therefore, public agencies must select and screen potential aquatic animal control candidates in cooperation with private industry. A complicating factor in aquatic animal control is the issue of selectivity, or the ability to control an invasive animal without harming closely related native species. The major factors influencing a chemical company's willingness to participate in this process include, but are not limited to, a particular product's patent life, the costs associated with obtaining aquatic registrations and the potential market value of the product.

NOTES

Application of the Aquatic Weed Risk Assessment Model to Manage Aquatic Weeds

Paul Champion *and John Clayton, National Institute for Water and Atmospheric Research (NIWA)*

The Aquatic Weed Risk Assessment Model (AWRAM) has been developed to assess the potential weed risk of aquatic plants. The key variables evaluated in the model are invasiveness or ability to establish and displace other plants, potential geographic distribution, and extent of potential impacts. Invasive attributes include habitat versatility (tolerance of ranges of temperature, salinity, substrate, flow and water depth), competitive ability compared with other species, and effective dispersal measured as a combination of reproductive output and mechanisms of spread. Potential distribution depends on availability of suitable habitat. Impacts include damage to natural ecosystems, changes to biodiversity, obstruction of water uses, and resistance to management activities. This model provides a robust and scientifically defensible decision support tool for managers. Ministry for Primary Industries (formerly MAF) have used the results obtained for various weedy aquatic plants using AWRAM in their process to decide which species are managed under the Biosecurity Act. These include: determining species prohibited entry into New Zealand, determining species that are managed nationally in eradication programmes under the National Interest Pest Response (NIPR) programme and banning the propagation, sale and distribution of ornamental pond and aquarium plants under the National Pest Plant Accord (NPPA). These management actions assist New Zealand's biosecurity system by keeping risks offshore, prevents future impacts of high risk species and reduces the volume of plant propagules being spread around New Zealand. The model has been used in Australia and in Micronesia to determine which species should be banned form sale and prioritised for other management activities. Recently AWRAM has been validated and accuracy of this model tested for the U.S. by independent ranking of known invasive and non-invasive species. More than 120 species were tested and divided into major invaders minor invaders and non-invaders. The system has 91% overall accuracy when minor invaders 22 are considered non-invaders and a threshold score of 40 is used to differentiate the two groups. Using this approach the model correctly identifies major invaders 85% and non-invaders 94% of the time. The verification of high accuracy of detection of high-impact invasive versus non-invasive aquatic species provides a tool to prioritise management internationally.

NOTES

Pet Stores, Aquarists and the Internet Trade as Modes of Introduction and Spread of Invasive Macrophytes in South Africa

Julie Coetzee and ***Grant Martin****, Rhodes University*

Submerged aquatic invasive plant species are increasingly being recognised as a major threat to South African water ways. Pet stores, aquarists and the internet-mediated trade were investigated as pathways for submerged invasive macrophyte introductions into South Africa. Online and manually distributed surveys were used to determine the extent of movement of invasive as well as indigenous submerged plant species in South Africa. Sixty-four stores and twenty-three aquarists were surveyed. Four areas of risk were identified in this study. Firstly, and most importantly, a variety of invasive and/or prohibited plants are sold by pet stores. Secondly, there is a lack of knowledge regarding identification as well as regulation of submerged species, which may then result in the unintentional trade of potentially invasive species. It seems that, in many cases, the pet stores are ignorant or misinformed of the potential dangers, rather than intentionally attempting to breach the legislation. Thirdly, aquarists own, trade and move plants in and around the country, which makes it very difficult to monitor which species are being moved around South Africa and to what extent. Finally, the internet is a pathway of potential concern, but it is difficult to quantify its contribution to the trade of invasive species in South Africa.

NOTES

Do Codes-of-Conduct Increase Public Awareness and Engagement in Problems with Aquatic Invasive Plants?

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Ornamental trade and horticulture are important vectors for the spread of non-native aquatic plant species. Plants that 'escape' can cause severe ecological and economic impacts in the recipient area. Examples of invasive plants are *Hydrocotyle ranunculoides, Ludwigia grandiflora* and *Myriophyllum aquaticum*. In The Netherlands, a code-of-conduct was initiated to stop the spread of aquatic invasive species. This voluntary agreement between the government and horticulture sector (i.e. plant nurseries and retailers) has the objective to ban the sale of harmful invasive species and to increase public awareness. Interaction with the general public is important to prevent new introductions as individuals act as facilitators of spread. The objective is to inform the customer about harmful effects and to advise on how to dispose of plant waste. Education campaigns included flyers and posters displayed in stores and labeling of plant species with warning messages. Similar campaigns exist in other European countries, such as Belgium (AlterIAS) and the UK (Be Plantwise). However, at present, public awareness campaigns are far from evidence-based. In this study, face to face interviews gave the opportunity to question customers about their motivations and personal engagement regarding invasive aquatic plants in ponds and aquaria, and this provided the first evidence of deliberate release of aquatic plants in The Netherlands. Furthermore, we performed ex ante and ex post surveys to measure the change in public awareness and in engagement of store owners. Policy makers have a specific need for this type of information in order to evaluate and improve their policies.

NOTES

How Other Exotic Bivalves Differ From Invasive Ones, or Why They Aren't Invasive

Gerald L. Mackie*, Professor Emeritus, University of Guelph and Owner, Water Systems Analysts*

Invasive bivalves have several traits in common but are lacking in other alien bivalves. The traits of invasive species ultimately relate to dispersal prowess, supported by rapid development, high intrinsic rate of increase due to lack of competition from other epifaunal species, early reproduction, external fertilization, relatively short life spans and small sizes, multivoltinism, and iteroparity. Invasive species tend to have wide physiological and ecological tolerances and requirements but optimal conditions result in massive numbers of young per parent per brood and per lifetime by up to four to five orders of magnitude. Non-invasive alien species on the other hand have poor dispersal mechanisms, are competitive with other infaunal species, have delayed reproduction, internal fertilization with development in brood sacs or marsupial, and tend to have relatively long life spans and larger sizes, univoltinism and either semelparity or iteroparity. Non-invasive bivalves may also have wide physiological and ecological tolerances and requirements but under optimal conditions result in numbers of young per parent per brood and per lifetime by only two to three times their average brood size.

NOTES

Forecasting the Invasion of *Limnoperna fortunei* in Brazil: Experimental Knowledge Versus Environmental Niche Modeling

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The golden mussel, *Limnoperna fortunei*, is an Asian mussel that has caused economic and environmental impacts in South America and Asia. Because of the real threat that it poses, there has been an effort to forecast its invasion through environmental niche models. Although the utility of these models is undeniable it remains a question whether they are the best option to model aquatic invasive species on a smaller scale, as these models depend on a proper representation of the niche occupied by the species.

In the recent invasions, such as that of the golden mussel, the species has not occupied its entire potential niche yet. The invasion in Brazil began in 1997, so the mussel is still spreading and data inserted doesn't represent the whole niche. That means any forecast based on this data will probably be an underestimate.

As there are many research groups working on invasive species, these data appear as an alternative to model these species. For the golden mussel in particular, there is laboratory research on the limits of its tolerance to some limnological variables like: pH, water temperature, dissolved oxygen and calcium, and there is also some information of its tolerance to other variables. Using these limits and the data gathered from two water monitoring programs in Brazil, it was possible to develop a GIS model for the whole country that is not influenced by the presence data.

The model was developed in the ArcGIS software, using the tool Raster Calculator to divide the stations into two categories: High Probability and Low Probability of Invasion. We have developed two models for the Brazilian territory, one for the State of Minas Gerais and another for the whole country. The limnological variables utilized were pH, water temperature, calcium, dissolved oxygen, conductivity, turbidity and chlorophyll. In total 7 ArcGIS models were developed, three for Minas Gerais and four for the whole country (for each area one model with all the variables, one without turbidity and one without conductivity were developed, for the whole country one model without dissolved oxygen and chlorophyll *a* was also developed because of the large amount of points without data for these variables).

To compare the results we have run a model in the Maxent software using the same data, in addition 158 niches were used (144 from South America and 14 from Asia).

We found, in general, that the ArcGIS model gave a satisfactory result, with correct predictions in areas already occupied and also made it possible to analyze the variables individually, providing a better comprehension of the model. For Minas Gerais, high probability of invasion, ranging from 47 to 74%, was obtained, and for Brazil as a whole, it ranged from 40 to 59%.

The Maxent model had a threshold of 0.2 and if we divide the stations into high and low probability, more than 95% of the stations fall in the high probability category. However, all the stations demonstrated a low probability of occurrence, not going beyond 0.5%.

NOTES

Forecasting the Invasion of *Limnoperna fortunei* at a Global Scale

*Bárbara Gomes Kunzmann[1], Danielle Diniz Galvão[1], **Mônica de Cássia Souza Campos**[1,2], Fabiano Silva[1], André Felipe Alves de Andrade[1], Hellen Regina Mota[3], Marcela David de Carvalho[1], Antonio Cardoso[1], [1]Centro de Bioengenharia de Espécies Invasoras de Hidrelétricas (CBEIH); [2]Fundação Centro Tecnológico de Minas Gerais (CETEC); [3]Companhia Energética de Minas Gerais (CEMIG)*

Limnoperna fortunei (Dunker, 1857) is a freshwater mussel, native of Southeast Asia, which has a great invasive potential due to its rapid growth, early maturation, successful recruitment and paucity of natural predators. Its invasion can cause real environmental problems (competition, ecological imbalance) and economic problems (fouling in hydroelectric plants, water treatment plants and other facilities that use raw water). The golden mussel, as it is popularly known, has already invaded Hong Kong, Taiwan, Japan, South Korea and continues spreading over South America (Argentina, Uruguay, Paraguay, Bolivia, Brazil). Potential predictive distribution models are important tools in the studies of invasive species like *L. fortunei*, indicating locations that need efforts to prevent invasion and those that need major attention to contain the invasive bivalve.

In this case, for a global model of potential distribution for the species under study, *L. fortunei's* occurrence data were used from South America (249 points) and Asia (71 points). Eight BIOCLIM's environmental layers of air temperature and precipitation, from Worldclim database, were used as well. The algorithms utilized in the analysis were Domain from OpenModeller Desktop 1.1.0 and Maxent 3.3.3k.

Considering the species' invasive potential according to its ecological and adaptive characteristics, the models generated from the Domain and Maxent tools were excellent predictors, forecasting correctly in lakes and rivers where the golden mussel's occurrence is already known, like the Paraguay Basin, Parana and Uruguay River Basins, all from South America, also Oshio Lake, Uji River, Kasumigaura Lake, Kokaigawa and Tone River (all from Japan), Sindian, Daham, Sun Moon Rivers (from Taiwan) and its native habitats in the rivers of China, South Korea, Cambodia, Laos, Thailand, Indonesia and Vietnam. According to these models, the specie *L. fortunei* would be able to enlarge its distribution area, occupying even the Amazon Basin, Bolivia, the South of Chile, part of Venezuela and Colombia, a great part of Central America, the Antilles, the South and west of Mexico. In Africa, it may invade all of the South-Central region, and finally, it could also occupy India and Mediterranean Europe. In the United States of America, it could invade the West Coast and the South and the East, which coincides with the Great Lakes region invaded by *Dreissena polymorpha* (Pallas, 1771), which has similar ecological characteristics as *L. fortunei*. In relation to Kluza & McNyset (2007)'s work which also simulated the distribution of the golden mussel using environmental layers, our results showed an increase in the potential distribution area in the Americas.

As expected, *L. fortunei* has great potential as an attacker in much of the world. Therefore it is necessary to prioritize places where there is still no record of occurrence, directing efforts at preventive measures, since the impacts of the establishment of this species can cause great environmental and economic damage.

NOTES

Comparing Spatial Distribution Models to Predict the Potential Invasion Area of the *Limnoperna fortunei* (Dunker 1857)

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Predictive modeling of species distribution is an important tool in biogeography, evolution, ecology, conservation, and invasive species management. In this study we applied three different algorithms Mahalanobis Distance, Domain and Maxent using them to predict the potential distribution of *Limnoperna fortunei*, a freshwater mussel native to southeast Asia and a major fouling pest of water supply systems in Hong Kong, Japan, and South America. For model input, we compiled native and invaded occurrence data from Asia (71 points) and South America (249 points) from the literature and our database (http://base.cbeih.org/view/Limnoperna+fortunei) and eight BIOCLIM's environmental layers related to air temperature and precipitation. To evaluate the model's quality we used different sets of "training" and "test" data. On the Mahalanobis Distance and Domain algorithms three sets of training data were used: 1) Asia points; 2) South America points; 3) both Asia and South America points. For Maxent the combinations were: 1) South America points (25% test data/75% training data); 2) Asia points (25% test data/75% training data); 3) South America training data/Asia test data; 4) Asia training data/ South America test data; 5) Asia + South America points (25% test data/75% training data).

Comparing the responses of the three types of algorithm used, it was found that Maxent was the most conservative model (i.e it produced a smaller area of suitable habitats) followed in order by, Domain and Mahalanobis Distance which proved to be the more wide-ranging while Domain presented better performance. Maxent tended to restrict the predicted habitat to locations close to records of existing niches while Mahalanobis Distance projected the potential habitat of *L. fortunei* to all over the world, with high suitability level.

The responses of Domain and Mahalanobis Distance Models showed the importance of a larger amount of training data, including a wide geographical area (with occurrence data coming from South America and Asia) to improve the accuracy of the model in terms of transferability. Domain models that used only Asia training data, or just South America, resulted in increased idiosyncrasies. The use of occurrence data only from South America by Mahalanobis Distance has generated overfitting.

For Maxent, again, the best results corresponded to models in which the points of occurrence covered a greater environmental variability (Asia+South America 25% test data/75% training data and South America training data/Asia test data). The first showed better performance in predicting correctly the occurrence of known regions of the species. Conversely, the worst model (Asia training data/South America test data) used the few training data from Asia with a high degree of spatial autocorrelation resulting in an underestimate.

The Domain and Maxent performed well in assessing the potential global distribution of *L. fortunei* besides presenting relatively friendly interfaces and not requiring the use of grained abiotic variables. However, for the prediction of potential distribution of a highly aggressive species, such as *Limnoperna fortunei*, the use of Maxent is less recommended, as it restricts to areas potentially suitable for the species, proving that it is more conservative.

NOTES

Characterization of the Foot of Invasive Species *Limnoperma fortunei* (Dunker, 1857) by Electron Microscopy

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Limnoperna fortunei (Dunker, 1857) is a bivalve mollusc known as the golden mussel and represents a typical example of an invasive species capable of inducing significant changes in natural or artificial water systems. Its rapid expansion imposes the need for research to increase knowledge about the mussel attachment process, which may facilitate the development of techniques for efficient and environmentally sustained control. In the present study we have employed SEM and TEM for the microstructural characterization of the golden mussel's foot due to the efficiency of electron microscopy in the characterization of materials and biological structures. The information obtained from the SEM and TEM images is different. While the SEM produces direct surface images, TEM provides three dimensional information at a cellular level. Adult golden mussels were collected and transported to the laboratory in refrigerated and aerated boxes. Samples were collected in the cultivation laboratory in the CETEC facilities. The animals were dehydrated, the feet were dissected and properly prepared for scanning and transmission. The images were produced with the technological support of the Microscopy Center (UFMG). In the images obtained, at SEM, we observed ciliary structures over the whole extension of the foot, and not only on the back, as described in the literature. These small filaments that cover the foot of the mussel are also found covering the toes of geckos, particularly in the genus Gecko, and they may indicate a similar adhesion effect and explain the strong adherence of mussels to almost any substrate. The images obtained in TEM provided us with information at a cellular level, and allowed the observation of a significant number of mitochondria, organelles related to an activity with a great expenditure of energy, and with a structure similar to the axoneme, a fundamental structure that composes the bodies of cilia and flagella, which may define these microstructures as true cilia.

NOTES

The HACCP Approach to Prevent the Spread of Aquatic Invasive Species by Aquaculture and Baitfish Operations

***Ronald Kinnunen**, Michigan State University; Jeffrey Gunderson, University of Minnesota*

The potential exists for aquatic invasive species (AIS) to spread to uninfested waters through the transport of wild harvested baitfish and aquacultured fish. Baitfish and aquaculture industries are diverse and complex, as are their risks of spreading AIS. Most industry segments pose no or very low risk of spreading AIS. To deal effectively and fairly with this potential vector, it is important to characterize the industry according to their risks of spreading AIS. Without adequate risk assessment of individual operations, regulations could be imposed which would unnecessarily negatively impact the economy of these industries and still not effectively reduce the risk of spreading AIS. One approach to this problem is to apply the Hazard Analysis and Critical Control Point (HACCP) concept similar to that used by the seafood industry to minimize seafood consumption health risks. The advantages of this system are that it can effectively deal with a diverse industry, it has proven to be a good partnership between industry and government regulators, and when properly applied is effective. The HACCP approach concentrates on the points in the process that are critical to the safety of the product, minimizes risks, and stresses communication between regulators and the industry. The baitfish and aquaculture industries have been proactive in using the HACCP approach to prevent the spread of AIS by participating in training programs and implementing HACCP plans that are specific to their operations.

NOTES

Arkansas Certified Commercial Bait and Ornamental Fish Program: A Method to Prevent Aquatic Invasive Species Introductions

***Anita Kelly** and Nathan Stone, University of Arkansas at Pine Bluff*

In the United States, fish farms in Arkansas produce over 6 billion baitfish annually. These farms provide a reliable source of a few known species of fish that are already widely distributed. Fish are raised under controlled conditions in levee ponds, using groundwater. However, the farmed product must compete with wild-caught baitfish, and increasing concern has been voiced by many state and federal regulators regarding shipments of wild baitfish and their potential to spread exotic diseases, plants, fish, and mollusks. Farm raised baitfish producers in Arkansas believed they had a product that was superior to wild bait, but realized that verification was needed. In 2005, the Arkansas Bait and Ornamental Fish Growers Association worked with the state lawmakers to authorize a comprehensive certification program that included fish disease, aquatic nuisance species, and farm biosecurity. This law provided for the State of Arkansas to set standards for participation in the certification program, inspect farms and farm records, evaluate biosecurity plans, and to oversee fish health inspection protocols. The certification program is fee-based, and farmers must also pay for veterinary supervision of sample collection and laboratory fees. More than 95% of all Arkansas bait and ornamental fish production acreage is undergoing the inspections needed for participation in this voluntary program. Fish Health Specialists at the University of Arkansas at Pine Bluff worked with the industry and the State to develop details of the bait and ornamental fish certification program and to provide the needed training for farmers and Arkansas Department of Agriculture Inspectors. Additionally, the Fish Disease Diagnostic Laboratory at the University of Arkansas at Pine Bluff (UAPB), an approved USDA/ APHIS laboratory for inspections of fish for export, provides laboratory testing. To enhance biosecurity efforts among farm workers, UAPB has produced a video entitled "Protecting the Farm" in English and Spanish. The Arkansas Certified Commercial Bait and Ornamental Fish program provides assurances that products from participating fish farms are free of listed pathogens, plants, animals and other contaminates. This program serves as a model for other state and national programs designed to prevent the spread of aquatic diseases and aquatic invasive species.

NOTES

Live Bait as a Potential Vector for Crayfish Introductions in Pennsylvania: Problem and Potential Solutions

David A. Lieb, *Pennsylvania Fish & Boat Commission and Western Pennsylvania Conservancy; John R. Wallace, Millersville University, Department of Biology*

Although exotic crayfish pose a serious threat to aquatic communities worldwide and are thought to be expanding their ranges in many areas as a result of bait-bucket introductions, most regulators and natural resource managers have been slow to react to the problem. Part of the issue is that, although bait-bucket introductions have been identified as a major vector, a complete mechanistic understanding of how these introductions occur is often lacking. Effective regulations and management practices cannot be developed without a mechanistic understanding of the vector being regulated and managed. A lack of awareness of the threat that bait-bucket crayfish introductions pose, either by regulators and natural resource managers or by the constituents that they represent, has also slowed progress. In this paper, we first describe the problems that exotic crayfish have caused in Pennsylvania and nearby areas. We then describe efforts to understand how bait-bucket crayfish introductions occur in these areas. Finally, we describe regulatory, management, and outreach activities and initiatives that have been developed or are being developed in Pennsylvania to prevent bait-bucket crayfish introductions, highlighting the strengths and weaknesses of these efforts..

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Live Bait in Maryland: What We Know, Don't Know, but Need to Know to Effectively Manage this Invasive Species Vector

Jay Kilian *and Ronald Klauda, Maryland Department of Natural Resources, Resource Assessment Service*

The use of live bait by anglers is an important vector of both aquatic and terrestrial invasive species. Bait-bucket introductions of invasive crayfishes, fishes, earthworms, pathogens, and other organisms have reduced biodiversity and altered ecosystem function and structure throughout the United States. In Maryland, the use of live bait is the most likely vector responsible for the introduction of at least five fish, four crayfish, and several earthworm species. In recent years, we conducted surveys of bait shops and anglers to obtain information on the trade and use of bait in Maryland. Our survey of bait shops confirmed that this industry is a source of non-native and invasive species. We documented at least six non-native bait species for sale. With the exception of a few locally collected bait species, bait sold in Maryland originated from sources outside of the state, and in some cases, outside the Mid-Atlantic region. Results of our angler survey indicated that 64% of Maryland freshwater anglers, both resident and non-resident, used live bait and that the release of unused live bait was quite common and occurred statewide. The release of unused bait by anglers varied with bait type. Anglers more readily released aquatic than terrestrial baits. For example, 65% and 69% of Maryland anglers using fishes and crayfishes released their unused bait; whereas only 18% and 10% of anglers released their unused earthworms and grubs-mealworms-maggots, respectively. Our surveys indicated that any non-native, potentially invasive species imported into the state via the bait industry is likely to be released by anglers into Maryland's aquatic and terrestrial ecosystems. Many of these species have the potential to become established. Based on the results of our surveys and the known effects of non-native bait species on Maryland's aquatic biodiversity, it is clear that we need 1) greater oversight of the bait industry along the entire vector pathway – from aquaculturist or harvester to retailer; 2) regional cooperation in the development of consistent regulations on bait use; and 3) funding to develop and implement a region-wide angler education campaign to reduce further bait-bucket introductions and provide protection against invasive bait species in Maryland and the Mid-Atlantic region.

NOTES

Bait Shop "Toolkit" and Outreach: Engaging Bait Shops as Opinion Leaders in the Prevention of Aquatic Invasive Species

Bret Shaw and ***Allison Howell****, University of Wisconsin*

Bait shops are on the front lines in the battle to stop the spread of invasive plants, animals and diseases in Wisconsin's lakes and rivers. Research indicates that bait shop owners and employees are considered "opinion leaders" by the transient boaters and anglers they interact with on a daily basis. In light of this, we have conducted in-depth research with a number of bait shops around the state in the form of interviews, site visits, and surveys to identify opportunities and obstacles that exist for bait shop employees in encouraging their customers to adopt practices that prevent the spread of aquatic invasive species (AIS). Several key points emerged from this research, including challenges such as uncertainty about the topic, time constraints and lack of self-efficacy, as well as opportunities for sharing information. Based on this research, we developed an intervention in the form of a "toolkit" of outreach materials designed specifically for use in bait shops around the state to assist bait shop employees in engaging in AIS contains a number of items developed with key social marketing concepts in mind. Research suggests that when individuals are encouraged to publicly express commitment to a behavior, they are more likely to adopt an identity that is consistent with that behavior. Building on this social marketing strategy, the toolkit contains several items that encourage public commitment, including a certificate of recognition and media relations in the form of advertising and press releases. The toolkit also contains items that provide conversational 'prompts' and reminders to adopt AIS-prevention behavior. The informational materials in the toolkit provide bait shop owners and employees with important information so they are prepared to answer questions and share information with their customers. Bait shops in Wisconsin were approached to participate in this initiative during the 2012 fishing season. Ongoing efforts are currently being made to evaluate the effectiveness of this outreach strategy by monitoring possible changes in awareness, knowledge, attitudes and engagement in AIS prevention related activities. These changes are measured through the use of pre- and post-test survey instruments. Additionally, we are directly evaluating the success of the toolkit through feedback from bait shop employees and AIS county coordinators throughout the state using a combination of qualitative and quantitative measures. We will report on the results of this initiative and offer suggestions for targeting AIS outreach efforts at businesses that sell live bait.

NOTES

Integrated Approach to Managing Mussels – Resources and Benefits

Stanley B. Pickles*, Bruce Power*

There are many aspects and disciplines associated with the implementation of a program to manage the effect of mussels on any facility affected. We have identified many of the technical problems at least, but success depends on human performance management – people are the key to success or failure.

Awareness of six key elements of performance can assist reducing the challenges that one faces in accomplishing the program goals.

1) Support those helping you and manage the managers.
2) Develop a long term plan – there is no silver bullet or quick fix.
3) Document and communicate – memories can be short and convenient.
4) Engineering / Science – be aware of the multiple disciplines involved and that each does not necessarily speak the same language.
5) Work management – plan on Murphy's law and Mother Nature's propensity for surprise.
6) Monitoring and feedback – if you don't know where the problem is then you don't know whether or not you are successful.

Each of these aspects need to be considered with the appropriate significance and reviewed as circumstances change. If any aspect is emphasized or minimized more than appropriate, then the overall effectiveness of the effort is less than optimum.

NOTES

Evaluating Aquatic Herbicides for Potential Control of Quagga and Zebra Mussels

Carolina Taraborelli *and Renata Claudi, RNT Consulting Inc.; Scott O'Meara, Bureau of Reclamation; Jeffrey Janik and Tanya Veldhuizen, California Department of Water Resources*

Dreissenid mussels, zebra and quagga, arrived in the United States from Europe in the 1980s and quickly spread to many Eastern waterways, rivers, and lakes. In 2007, dreissenid mussels crossed the continental divide and were present in the lower Colorado River and in a number of locations in Arizona, Nevada, California, Kansas, Nebraska, Oklahoma and Texas. Recently, dreissenids were detected in New Mexico and Utah. The mussel populations exploded in many of these western locations. Mussel biofouling may negatively impact the extensive water conveyance and irrigation systems in the West. Many of these systems are currently being treated with various chemicals to control blooms of undesirable algae and growth of aquatic weeds. The objective of the experiment described in this paper was to evaluate the collateral damage to dreissenid mussels from various herbicides currently used in irrigation and drinking water canal systems in the West. The chemicals tested were: 1) two endothall formulations, the amine salt of endothall and the di-potassium salt; 2) three formulations of sodium carbonate peroxyhydrate, and 3) copper sulfate crystals. All products were tested both on quagga and zebra mussels. Dose response curves were developed for each product for a minimum of 96 hour exposure. The experiment utilized a semi-flow-through set-up. Short term exposure and recovery test were also carried out to determine the presence or absence of post-exposure mortality.

NOTES

Release Coatings Combat Fouling in Power Generation and Water Treatment Facilities – Four Case Histories

Steve Escaravage*, FUJIFILM Hunt Smart Surfaces, LLC*

With the continued spread of animal and plant fouling organisms, more and more facilities have become negatively impacted by their presence. Silicone fouling release coatings offer barrier technology to combat initial attachment, as well as, facilitate ongoing maintenance challenges created by both indigenous and invasive species.

The author will use four case histories (two in power generation and two in water treatment facilities) to demonstrate the effectiveness of application of silicone fouling release coatings. Each case history will briefly look at the fouling circumstances prior to coating application, the nature of the structures to be coated, the coating system selection and, finally, the outcome of the application.

One power generation case history will look at invasive didymo algae in New Zealand while a second will focus on indigenous barnacles on an intake structure along the southeast coast of Florida.

The first water treatment case history will discuss combating potential invasive quagga and zebra mussels in a water delivery pipe from a lake in central Colorado to a municipal potable water process facility. The final case history will explore the use of silicone fouling release coatings to combat algae growth in the weirs of a waste treatment clarifier in coastal Virginia.

As silicone coating systems are commercially available, the author will also provide financial justification for their use compared to coating systems that do not provide fouling combative capabilities.

NOTES

Control of Dreissenid Mussels through pH Adjustment

Renata Claudi *and Thomas Prescott, RNT Consulting Inc.*

Several field experiments were carried out using a custom built flow-through laboratory to test the effect of continuous pH adjustment on dreissenid mussels. One experiment was carried out in the Great Lakes, one on the Lower Colorado River in Arizona and two were carried out at San Justo Reservoir in California. All experiments tested the ability of dreissenid pediveligers to settle under conditions of elevated or depressed pH and the long-term survival of the adult dreissenids under the same conditions.

In addition, short term experiments testing the response of zebra mussels to both low and high pH extremes were carried out at San Justo Reservoir. We will discuss mortality curves which were constructed for zebra mussels under conditions of extremely high and extremely low pH to determine if such pH alterations could be used as an end of season treatment for dreissenid populations.

From this study, we concluded that pH adjustment could be used both as a preventative treatment to eliminate settlement by dreissenid mussels and as an end of season treatment to eliminate adults. However, high pH treatment would have to be tailored to site specific water quality to prevent or minimize formation of precipitate during treatment.

NOTES

Protecting Irrigation Systems from Dreissenid Mussel Infestation – Case Study

Andrew Jamieson*, Agriculture and Agri-Food Canada*

In 2009, as a result of increasing drought-like conditions and increasing costs of municipal supplied irrigation water, a group of processing tomato growers in Southwestern Ontario completed construction of an irrigation water pipeline from Lake Erie. At the time of construction certain steps were taken to protect the system against dreissenid mussels, including; a special coating on the intake screen, a filtration barrier and a chemical treatment. A significant dreissenid infestation in the irrigation pipeline could impact the performance of the system to deliver water at crucial times and could plug up irrigation equipment. The water pipeline system is composed of a central pumphouse and a pressure pipe system that distributes water from Lake Erie to the fields. The pumphouse uses five 150 hp electric pumps to take water from the main intake located 500 feet out into Lake Erie. From there, water is distributed through a network of PVC pipe that totals 36km in length. The PVC pipe has two pressure booster stations along the way to ensure water flows to all 61 water delivery points. This pipe ranges from 6 to 24 inches in diameter and is buried below the frost line to allow water movement and year round delivery. A significant dreissenid mussel presence and the change from a closed-loop to an open discharge system presented a new set of challenges. Recently, staff from Agriculture and Agri-Food Canada examined the use of phosphoric acid as a method of control with a mortality trial followed by a trial on the pipeline to evaluate the capability of maintaining a stable pH of 7 at different flows and lake conditions. The issue of dreissenid mussel infestation is a new problem for the agriculture industry and the use of water for irrigation purposes presents its own set of challenges for solving the problem. Challenges such as; the impact on irrigation equipment, the crop being grown, the variation in flow demand and the method(s) of filtration. This paper/presentation will provide some insight into the challenges facing a group of Southwestern Ontario farmers and how the lessons they have learned could help others in the agricultural industry deal with this issue.

NOTES

Invasion Pathways for Invasive Aquatic Species: Case Studies from Florida (USA)

***Lyn Gettys**, William Haller and Kathryn Wilson, University of Florida, Institute of Food and Agricultural Sciences (IFAS), Center for Aquatic and Invasive Plants (CAIP)*

Florida's tropical climate provides a hospitable environment to tourists and exotic species alike because air temperatures rarely dip below freezing for extended periods of time. Bodies of water in Florida are among the most highly invaded aquatic systems in the world owing to their ability to serve as incubators for a wide range of introduced aquatic species. An important issue that is rarely explored is how these invaders reach Florida in the first place. Vectors or introduction pathways for exotic aquatic species are many and diverse; although some non-native species are introduced via natural phenomena such as extreme weather events or movement of fauna, many invaders arrive as a result of anthropogenic actions. To compound the situation, isolated introductions can quickly expand to widespread invasions because the majority of waters in Florida are interconnected. In this paper, we will outline the events that led to the introduction to Florida of several historically problematic aquatic species, including water hyacinth (*Eichhornia crassipes*) and hydrilla (*Hydrilla verticillata*). Also on the slate will be a discussion of the likely introduction pathways responsible for a number of new invaders, including feathered mosquitofern (*Azolla pinnata*), giant salvinia or kariba-weed (*Salvinia molesta*), rotala (*Rotala rotundifolia*), redroot floater (*Phyllanthus fluitans*), crested floating-heart (*Nymphoides cristata*) and tropical American watergrass (*Luziola subintegra*). A number of these exotic species are federally listed noxious weeds, which in theory should virtually eliminate their movement and introduction, at least by anthropogenic means. In practice, new invaders are routinely discovered in Florida; despite existing legislative prohibitions of their importation and distribution, their presence is often attributed to intentional or accidental introduction by water garden, aquarium or fish pond owners. It is therefore clear that the most effective strategy to reduce the introduction and spread of invasive aquatic species is through diligent monitoring of waters and increased public awareness of the environmental damage caused by non-native aquatic invasive species.

NOTES

Patterns of Impact of Three Invasive Plant Species on Freshwater Ecosystems

***Iris Stiers** and Ludwig Triest, Vrije Universiteit Brussel*

Alien plant invasions have been responsible for the degradation of natural habitats worldwide, yet the relative importance of different mechanisms of impact on native freshwater ecosystems is poorly understood. Within the framework of the ALIEN IMPACT project we investigated the impact patterns of three highly invasive aquatic species in Belgium: *Hydrocotyle ranunculoides*, *Myriophyllum aquaticum* and *Ludwigia grandiflora*. The study focused on impacts on native plants as well as on other functional groups, and both direct (via resource competition) and indirect (via pollination) mechanisms of impact were studied. Native plant / invertebrate richness, abundance and composition were compared between invaded and uninvaded sites in close vicinity. To study the impact on pollinators an experimental design was set up to estimate the pollinator-mediated effect of the floral abundance of *L. grandiflora* (difference in cover of the alien plant) on native potted *Lythrum salicaria* plants. Our research on 32 sites in Belgium indicated that the reduction in the native plant species richness was a common pattern to invasion. However, the magnitude of impacts was species specific. A strong negative relationship to invasive species cover was found, with submerged vegetation the most vulnerable to the invasion. Impacts proliferated to other functional groups with a strong negative relationship between invasive species cover and invertebrate abundance, probably due to unsuitable conditions of the detritus for invertebrate colonization. Competition for pollinator services seems minor as there was no evidence for decreased pollinator visitation rate or seed set of the native counterpart. On the contrary, results show that more insects were recorded on the native counterpart when the cover of the invasive species was low compared to the control plants (weak 'facilitation' effect). Overall, the impacts on the different functional groups were variable, but related to cover of the invasive plant.

NOTES

Decrease of Macrophyte Species Diversity of Pond Ecosystems by an Invasive Wetland Plant: *Alternanthera philoxeroides*

Anindita Chatterjee *and Anjana Dewanji, Indian Statistical Institute*

One of the immediate crisis facing us today are the loss of freshwater and wetland ecosystems, which are being both qualitatively deteriorating and quantitatively diminishing at an alarming rate. The main reasons behind this are global warming, anthropogenic pollution and biological invasion. Failure to address the issue of biological invasions could result in severe global consequences, including loss of native biodiversity and the creation of homogeneous ecosystems.

Ponds form a lifeline of people in many developing countries, including India, serving as a source of recreational and domestic water in many villages and suburban towns. Apart from hosting a large number of native species, they also serve as landscape sinks, accumulating sediments and nutrients. All of these facilitate invasions by opportunistic plant and animal species and make the pond ecosystem especially vulnerable to biological invasions.

This paper aims to study the impacts of an invasive wetland plant, *Alternanthera philoxeroides* on the associated macrophyte diversity and abundance in pond ecosystems. *A. philoxeroides* grows along the littoral zone of aquatic bodies and can extend its stems into the open surface of the water to forms dense floating mats. To investigate the effect of *A. philoxeroides* infestation on the associated macrophyte diversity of pond ecosystems, twelve ponds, each having varying degrees of *A. philoxeroides* infestation, were chosen for this study. To capture any difference in the seasonal growth pattern of the aquatic macrophytes, a temporal study, covering the three main seasons of India (namely: summer, monsoon and winter) was done in these twelve selected ponds for one year. Macrophyte abundance (cover percentage) was estimated by the quadrat method of biodiversity estimation. The infestation of *A. philoxeroides* was categorized into four groups based on its cover percentage. Chi-square tests of the data showed a significant decrease in the diversity of associated macrophytes across all the four groups of *A. philoxeroides* cover percentage. The frequency of occurrence of each of the macrophytes also showed a decreasing trend with the increase in cover percentage of *A. philoxeroides*. This pattern was similar for all the three study seasons. Highest number of associated macrophytes was obtained during the summer and monsoon, and it was slightly lower during the winter. This is one of the first study in India to show that with the increase in density (cover percentage) of *A. philoxeroides*, there is a significant decrease of both, the abundance and the diversity of associated macrophytes in pond ecosystems. *A. philoxeroides* has a high environmental resilience and ability to grow throughout the entire year in India, and can cause a decrease of biodiversity in pond ecosystems. Thus, it is of urgent need to prevent the further invasion of *A. philoxeroides* and focus on its effective management and control.

NOTES

Monitoring the Spread of *Alternanthera philoxeroides* in the Indian Context

Anjana Dewanji*, Anindita Chatterjee and Achyut K Banerjee, Indian Statistical Institute*

Plant invasions, a main component of global change, are a source of agricultural and economic problems worldwide. They are also a major ecological threat for biodiversity, which makes it crucial to understand the key mechanisms that can lead to invasions in an ecosystem. *Alternanthera philoxeroides* (Mart.) Griseb., a South American weed of the family Amaranthaceae, is regarded as one of the worst weeds of the world because of its invasiveness, potential for spread, and economic and environmental impacts. It is an especially troublesome weed of the wetlands and has been reported to have spread to more than 32 countries of the world.

An attempt has been made in this paper to review the spread of this invasive species in India since its first reported presence in 1965 and also to generate a baseline map of infestation of *A. philoxeroides* in the city of Kolkata. The literature surveyed shows a steady increase in the number of reports of the presence of this plant all over the Indian sub continent. Out of 140 aquatic weeds, *A. philoxeroides* is now regarded as one of the twelve weeds of primary concern in India. The Indian wetland ecosystems, the extent of which is quite huge thus lie at a great risk of invasion by *A. philoxeroides*. Monitoring the status of its infestations and understanding its mechanism for responding to environmental change are, thus, much needed in the Indian context. Early detection could help improve efforts to prevent invasive species establishment.

Extensive field surveys were conducted in the Greater Kolkata area (spread over 1,886.67 km^2) to locate the presence of this plant in ponds and terrestrial habitats. A map of Kolkata city (Greater Kolkata) was georeferenced and 89 grid points generated around which the survey was conducted and points were marked denoting presence. This preliminary survey found the luxurient presence of *A. philoxeroides* in 60% of the areas surveyed so far. The presence of this plant in aquatic habitats was recorded in 28 sites while it was 25 sites under terrestrial conditions thereby showing its ability to grow in urban areas also.

NOTES

The Invasive Bivalve Genus *Corbicula* as a Key Model to Androgenesis

***Karine Van Doninck**, Emilie Etoundi and Lise-Marie Pigneur, University of Namur*

Sexual reproduction is predominant in the animal kingdom. However a few animals can reproduce asexually, persist and even be successful, as the highly invasive basket clams *Corbicula*. The genus *Corbicula* includes both dioecious sexual species and hermaphroditic androgenetic species. Androgenesis is an astonishing asexual reproductive mode in which the maternal nuclear chromosomes fail to participate in zygote development and the descendants are therefore paternal nuclear clones.

Even if a few other organisms are known to reproduce by obligate androgenesis, basket clams *Corbicula* are the best model to study androgenesis. Indeed, in this genus, the androgenetic cytological mechanisms have been described and are studied in detail. In *Corbicula*, unique androgenetic sperm is biflagellate and unreduced. After fertilization, the maternal nuclear genome is expulsed as two polar bodies while the mitochondria in the oocyte are retained; the zygote thus only inherits the nuclear chromosomes coming from the sperm.

On the one hand, this talk will review the evolutionary consequences of androgenesis. On the other hand, we will focus on the consequences and mechanisms of androgenesis that may explain the invasive success of *Corbicula* clams. This talk refers to our recently published review in Heredity (Pigneur et al., 2012).

NOTES

The Key to Being a Successful Invader? Be Asexual?! The Case of *Corbicula* Clams

*Jonathan Marescaux[1], **Emilie Etoundi**[1], David Aldridge[2], Lise-Marie Pigneur[1], Nina Yasuda[3], Karine Van Doninck[1],*
[1]University of Namu; [2]Cambridge University; [3]University of Miyazaki

Native to Asia, Middle-East, Africa and Australia, basket clams of the genus *Corbicula* are among the most invasive pest bivalves ever introduced in North America, in the early 1920s. In only 50 years, they spread all over America, North and South to finally reach Europe in the early 1980s.

This incredible invasion ability may be linked to reproductive features of basket clams. Indeed, in the genus, gonochoric and sexual lineages cohabit with hermaphroditic and androgenetic ones. Androgenesis, aka "all male asexuality" may undeniably confer advantages to androgenetic lineages and be the key of the invasive success of the genus.

However until now, reproductive status of invasive lineages remains questionable and no clear link between androgenesis and invasion has been made.

Androgenesis is characterized by unique properties such as biflagellate and unreduced sperm, cytonuclear mismatches… but also by properties specific to asexuality and clonality such as lack of diversity, high level of heterozygosity… These features make the determination of reproductive mode in *Corbicula* populations easy.

We have thus extensively explored, at genetic and cytological levels, reproduction in invasive *Corbicula* lineages from America and Europe and compared our results to those found in native lineages. While sexual *Corbicula* clams are restricted to their native range, androgenetic clams show a worldwide distribution. Moreover, our results prove that androgenesis is the unique reproductive mode in invaded area, suggesting a likely role of androgenesis in invasive success of basket clams.

NOTES

An Examination of the Potential Vectors and Pathways of Spread for *Corbicula fluminea* in Ireland

Rory Sheehan *and Frances Lucy, Institute of Technology Sligo; Joseph M. Caffrey, Inland Fisheries Ireland*

The highly invasive Asian clam, *Corbicula fluminea* was first reported from the island of Ireland in 2010 in the River Barrow. *C. fluminea* has subsequently spread to the Rivers Nore and Shannon. Within the Shannon River, *C. fluminea* is now present throughout much of its length, with two established populations separated by a distance of c. 100km. A study was devised to identify the principal vectors of spread for *C. fluminea* in the northern section of the Shannon river basin. In an attempt to prevent or slow the pace of spread of the invasion it was deemed important to identify invasion pathways, with a focus on the specific conditions in Ireland. The vectors most likely to spread *C. fluminea* within the study area are unintentional movement by anglers, recreational boaters and waterfowl.

A hub of lakes radiating out from the Shannon River, at the town of Carrick-on-Shannon, was chosen for the study. This sampling area was selected for a number of reasons. These included the proximity of an established *C. fluminea* population in the main river corridor, the number of lakes in the area that are subject to angling pressure and the fact that this area represents an active navigable waterway and habitat for migratory waterfowl.

The survey was designed to examine various vectors and pathways of spread. Sampling sites were selected on the basis of angling activity, boater movement, and a navigable connection to the Shannon River. Control sites were selected on the basis of remoteness and lack of boating or angling activity.

The popularity of the Carrick-on-Shannon lake hub with tourist anglers renders the area particularly susceptible to the introduction of non-native aquatic species, including *Corbicula*.

This paper will present results from the survey work carried out between June 2012 and March 2013 along with the planned future works under the scope of the project. An overview of the current state of the *C. fluminea* invasion on the Island of Ireland will also be presented.

NOTES

Factors Affecting the Distribution, Abundance and Condition of an Aquatic Invader (*Corbicula fluminea*) along a Thermal Gradient

Anthony Ricciardi, Redpath Museum, McGill University; ***Rowshyra Castaneda****, Groupe de recherche interuniversitaire en limnologie et en environnement aquatique (GRIL), Biology Department and Redpath Museum, McGill University; Anouk Simard, Ministère des Ressources naturelles et de la Faune*

The Asian clam *Corbicula fluminea* – one of the world's most invasive bivalves – was introduced to North America from Asia in the early 19th century and has spread throughout the United States, South America and Europe. Although the clam's physiological requirements appear to restrict its distribution to habitats where water temperatures exceed 2°C, it occurs in north temperate regions in artificially heated waterbodies.

In November 2009, a population of the Asian clam was discovered in the St. Lawrence River in the thermal discharge plume of the Gentilly-2 power plant (G2PP). During June-August 2011, sampling of the benthic community of the thermal plume at G2PP was conducted to determine the distribution, abundance and condition of the Asian clam population. Benthic grabs were taken at sites inside and outside the thermal plume to test the following hypotheses: 1) *C. fluminea* has established reproducing populations within the plume; 2) its occurrence in the river is restricted to sites within the plume; and 3) its abundance and condition decline with distance from the power plant. Results show that *C. fluminea* is well established throughout the 4-km length of the plume and, moreover, it has achieved high densities similar to those in natural subtropical and tropical systems. Its occurrence is restricted to the plume, and it declines in density along the gradient. Its condition is also affected by location along the plume, but modally. An empirically derived model identified temperature, flow velocity, depth and transparency as important predictors for the presence and abundance of *C. fluminea* at a given site within the river.

NOTES

Progression of Asian Clam (*Corbicula fluminea*) in the St. Lawrence River: Is the Species Restricted to the Thermal Plume of Gentilly Nuclear Station

Anouk Simard[1], *Rémi Bacon*[2], *Rowshyra Castaneda*[3], *Kayla Hamelin*[3], *Annie Paquet*[1], *Sophie Plante*[1] *and Anthony Ricciardi*[3], [1]*Ministère du Développement durable de l'Environnement de la Faune et des Parcs (MDDEFP);* [2]*Ministère des Ressources naturelles, Trois-Rivières;* [3]*Université McGill, Montréal*

All introduced invasive species do not necessary results in an invasion. Sometimes invasive species are introduced in areas that are not favourable for their survival, reproduction or dispersal. This should be the case of the Asian clam (*Corbicula fluminea*) population recently discovered in the St. Lawrence river, because this species is unlikely not survive when water goes under 2°C for an extensive period of time. So far this population precisely established in the thermal plume of the Gentilly-2 nuclear power station, where water temperatures are much higher than under natural circumstances. Since its discovery, in 2009, we monitored the population to insure that it would not extend downstream where thermal pollution has no effect. We also measured the size of *Corbicula fluminea* at different locations downstream of Gentilly-2 to account for cohort and mortality growth. Eleven thermographs have been installed in fall 2010 to accurately measure the temperature at different locations. Results obtained so far suggest that the population slowly progressed downstream of the power station. Census suggested that the limit of the population was 2 km in 2009, 4 km in 2010 and 5 km in 2011. Results from 2012 are not available yet and neither are cohort analysis, but we expect *Corbicula* size to decrease with the thermal gradient. Density of *C. fluminea* increased from 368 ± 176 individuals/m^2 in 2009 to 3380 ± 1315 in 2010. Five thermographs retrieved at 1.7, 2.4, 3.0, 3.5 and 4.0 km downstream the power station registered daily average temperatures bellow 2°C during respectively 40%, 28%, 91%, 60% and 90% of recording winter days. Preliminary results suggest that Asian Clam may possibly extend outside the thermal plume of the nuclear power station, but the long term viability of individuals established in colder area is still uncertain. At this point, a careful tracking of the population is advised.

NOTES

Bait Worm Packaging as a Conduit for Organism Introductions: Research and Outreach Lead to Policy Considerations

Nancy Balcom[1,2], *Charles Yarish*[2], *Christina Haska*[3], *George Kraemer*[4], *Senjie Lin*[2], *Robert Whitlatch*[2], *Noreen Blaschik*[2], *Huan Zhang*[2], [1]*Connecticut Sea Grant;* [2]*University of Connecticut;* [3]*Great Lakes Fishery Commission;* [4]*Purchase College*

Researchers assessed the vulnerability of Long Island Sound to the introduction of non-native organisms imported via marine bait worms (*Nereis virens*) from the Gulf of Maine and the seaweed known as wormweed (*Ascophyllum nodosum*) traditionally used as packing material for them. Purchases of live bait worms from retailers in Connecticut and New York were examined for non-native invertebrate animals, macroalgae (seaweeds), and harmful, toxin-producing microalgae. Visual and microscopic inspections, and molecular biological techniques to detect the presence of microalgal cells, were used to determine whether non-native organisms were being imported with the bait worms. Seaweed subsamples were cultured in the laboratory and any growth of associated macro- and microalgae monitored. All marine invertebrate species were identified and quantified. Results indicated 14 species of macroalgae and 23 species of invertebrates were associated with the boxes of live bait worms. A highly diverse microbial assemblage was detected, including two species of potentially toxic marine microalgae, *Alexandrium fundyense*, and *Pseudonitzschia multiseries*. These species were found both prior to, and after, incubation at various temperatures, indicating these harmful algae are being brought to and can survive in receiving waters of Long Island Sound.

As follow-up, a pilot outreach program was initiated to raise awareness among coastal anglers that the practice of discarding the contents of bait boxes, including the seaweed, into the water could lead to the introduction of non-native, and potentially invasive, organisms into Long Island Sound. Outreach materials included multi-lingual signage posted at coastal access points, displays at fishing and boating shows, a fact sheet, "ruler" stickers for coolers, and the application of "Don't Dump Bait" stickers to bait purchases at point-of-sale by retailers. Coastal anglers were surveyed during summers 2011 and 2012 to document individual practices for disposal of unused live bait and the bait packing material at the end of fishing trips, and to determine familiarity with the outreach campaign materials. Our ongoing findings will be presented.

The Gulf of Maine now harbors a diverse suite of non-native organisms. These may be exported to other areas of the U.S. via national bait wholesalers and cause ecological harm to the receiving ecosystems. In addition to potential ecological impacts associated with the import of non-native organisms, economic harm is also possible. For example, commercial shellfishing beds may be closed when harmful microalgae bloom in coastal waters. Prevention programs similar to what Connecticut Sea Grant is conducting would help reduce the probability that potential invaders could be introduced and established within coastal waters. In addition to the algae included with the samples, it is possible that the worms themselves are vectors of other non-native organisms. If these were found to be carriers of harmful species, then individual states would need to assess the risk of importing these worms into their marine coastal systems. Policy considerations or recommendations could be made to develop a system of certification and best practice guidelines to include guarantees that wholesalers and retailers market "invasives-free" bait-worm products and take active steps to reduce the risk of invasive species introductions.

NOTES

Preventing AIS Introductions through Vector Management: The Value of Connections

Fredrika Moser[1], *Susan Park*[2], *John Ewart*[3], *Sara Mirabilio*[4], *Peter Rowe*[5], *Sarah Whitney*[6], *Jenny Allen*[1], [1]*Maryland Sea Grant;* [2]*Virginia Sea Grant;* [3]*Delaware Sea Grant;* [4]*North Carolina Sea Grant;* [5]*New Jersey Sea Grant;* [6]*Pennsylvania Sea Grant*

Limiting the introduction of aquatic invasive species (AIS) has been shown to be a more effective management strategy than attempting to control already introduced AIS. Vector management is a well-established and effective approach for limiting the introduction of unwanted aquatic species to new environments. The best-known example of vector management involves the uptake and discharge of ballast water. Scientific and engineering knowledge is coupled with policy concerns to specify ballast water uptake and discharge in a manner that minimizes the introduction of multiple aquatic species while balancing economic and political issues. Vector management of other potential AIS introduction pathways (e.g. pet trade, live food-fish and water garden industries) lag behind ballast water management. Typically, state and federal agencies' AIS management efforts emphasize single species rapid response and control strategies – efforts that rarely result in the eradication of an unwanted species or the prevention of new introductions.

To explore how vector management could be applied more broadly, the Mid-Atlantic Regional Panel on Aquatic Invasive Species (MAPAIS) and Maryland Sea Grant conducted a workshop to develop recommendations on how vector management might be more widely applied as an AIS prevention approach. NOAA subsequently funded the mid-Atlantic Sea Grant programs and their partners to apply the workshop recommendations through a research project targeting a live bait vector. In this coupled biological and social science research and outreach effort, researchers examined the pathway of the live bait marine bloodworm, Glycera dibranchiate, and its live algae packing material – a material that is known to contain numerous 'hitchhiker' species that may be a source of unwanted introductions.

This presentation will discuss how our project demonstrates the value of conducting multidisciplinary research that fosters collaboration with researchers, the MAPAIS and the Sea Grant programs. By understanding the underlying biological science and human influences on this vector and engaging the different participants (from the bait harvester to the angler) along this vector, we were able to identify key intervention points and communication tools that could contribute to reducing the risk of AIS introduction. The potential for designing effective strategies to manage the vector is enhanced by the combination of multiple audiences including academia, researchers, the bait industry, anglers, Sea Grant extension specialists and state agencies. We think this approach can serve as a useful model for the management of other vectors.

NOTES

Harvest to Hook: An Anthropological Look at the Worm Weed Vector for Aquatic Invasive Species

Jeremy Trombley*, University of Maryland College Park*

For the past 100 years, harvesters in Maine have been gathering bloodworms, and selling them to distributors who ship them all over the world to be used as live bait. Recently, it has become apparent that this practice has resulted in the spread of aquatic species such as snails, bugs, and other organisms from Maine to other regions where they may potentially become invasive. The purpose of this collaborative project between the Smithsonian Environmental Research Center (SERC) and the University of Maryland Department of Anthropology has been to develop a better understanding of the bloodworm industry and the practices that lead to the spread of potentially invasive species "from harvest to hook." Furthermore, we hope that this research will indicate possible methods for preventing the spread of invasive species. This presentation will provide a summary of our research on the bloodworm industry, which has helped us to understand how the worms are harvested, packed, and shipped, and the practices that lead to the potential introduction of invasive species. This has allowed us to work with the biologists at SERC to develop and promote alternative methods for packing and shipping that could prove effective at reducing the quantity of potential invasives transported through this vector. Additionally, we will present the results of a survey of anglers conducted across the six Mid-Atlantic States. The survey has allowed us to evaluate angler beliefs, values, and practices around the use of bloodworms and the threat of aquatic invasive species in the region. Data from the survey will be used to develop an intervention and outreach strategy that will effectively communicate the importance of properly disposing of bait and bait packing materials.

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Importation of Baitworms and their Live Algal Packing Materials to the Mid-Atlantic: Vector Characterization and Management

Amy Fowler[1], *A. Whitman Miller*[2], *Fredrika Moser*[3], *April Blakeslee*[4], *Joao Canning-Clode*[5], *Gregory Ruiz*[2], [1]*Villanova University;* [2]*Smithsonian Environmental Research Center;* [3]*Maryland Sea Grant;* [4]*Long Island University;* [5]*University of Lisbon*

In recent years, the Maine baitworm industry has become recognized as a significant contributor to the spread of invasive species, nationally and globally, through the association of hitchhiking individuals with locally collected algal packing materials (primarily *Ascophyllum nodosom ecad scorpiodes*). Currently, this vector remains active, and to date, there is little management to prevent the potential spread of invasives; thus continued pressure of invasive propagules with the vector remains high – in particular, this includes the movement of multiple individuals (including less visible ones), genes, and new species. Previous efforts have shown this vector to be responsible for the transfer of numerous individuals to the U.S. west coast and Long Island Sound, and most recently to the mid-Atlantic (a companion paper by Fowler et al.); however, an experimental study demonstrating evidence of mechanisms for limiting associated biota with the algae has yet to be accomplished. Therefore, to assess the feasibility of such endeavors, we designed an experiment to dislodge or kill hitchhikers associated with the algal packing materials using methods easily and readily implementable by the baitworm industry. In particular, we exposed the algae to different combinations of tap water (0 ppt), hyper salinity (60 ppt), and vigorous shaking. We also included controls where the algae were handled in the same manner as they would by a Maine baitworm distributor (Harbor Bait, Boothbay). Following treatment, algae were brought to the Maine distributor and combined with polychaete bloodworms (*Glycera dibranchiata*) and then shipped either to the Smithsonian Environmental Research Center or to the University of California, Davis. Once the boxes of bait and treated (or not treated) algae had reached their shipping destinations, we systematically examined every piece of algae for associated organisms, and then removed, identified (to the lowest possible taxonomic level using published keys and experts in the field) and counted them under a stereo dissecting microscope. Our results showed a reduction in species richness and species abundance for all treatments compared to controls, but in particular, our tap-hyper treatment showed the greatest reduction in species richness and abundance, as a result of induced osmotic shock. In addition, we found that the percentage of live organisms in all treatments were significantly lower than in the controls. Finally, we found that vigorous shaking had a strong impact on species richness and abundance, particularly for larger organisms like snails and crabs. Altogether, our methods effectively and clearly demonstrated that hitchhiking species can be removed or killed by simple, easily implementable and inexpensive methodologies. In fact, we found that the simplest and cheapest treatment (tap water and shaking) effectively reduced the number of living organisms arriving to shipping destinations by about 200% (conservatively). Therefore, our results suggest that if the baitworm industry implemented these simple steps as they package baitworms with locally collected algae, it could effectively and significantly reduce the number of hitchhiking species, which will help limit the potential for invasions nationally as well as globally.

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Importation of Baitworms and their Live Algal Packing Materials to the Mid-Atlantic: Experimental Treatment of Algae to Reduce Live Hitchhikers

April Blakeslee[1,2], *Amy Fowler*[1,3], *A. Whitman Miller*[1], *Fredrika Moser*[4], *Joao Canning-Clode*[1,5], *Gregory Ruiz*[1], [1]*Smithsonian Environmental Research Center ;* [2]*Long Island University;* [3]*Villanova University;* [4]*Maryland Sea Grant College;* [5]*University of Lisbon*

Maine polychaetes (*Glycera dibranchiata*) are used extensively as bait in the Mid-Atlantic (New Jersey, Maryland, Delaware, Virginia, and North Carolina, USA) and abroad, and dealers ship live baitworms from Maine, USA, packed in live algae (mainly *Ascophyllum nodosum* ecad scorpioides) globally over-night. Packing algae used are associated with numerous organisms (mostly small invertebrates), which can hitchhike with bait shipments, thus providing opportunities for possible introductions. For example, three key invasions on the U.S. West coast have been attributed to this vector – European green crab (*Carcinus maenas*), rough periwinkle snail (*Littorina saxatilis*), and the packing algae itself. Little is known regarding possible impacts of this vector in the Mid-Atlantic, nor is there any baseline information regarding diversity and abundance of organisms transported to the region. Therefore, our study assessed diversity and abundance of macro-organisms associated with baitworms/packing algae at three levels along the vector pathway: 1) Maine source habitats; 2) bait-boxes shipped from Maine distributors; and 3) bait-boxes sold in the Mid-Atlantic (in the five States listed above). Organisms were counted and identified to lowest taxonomic level seasonally from 2011-2012, and preliminary results indicate that diversity and abundance of associated biota decreases along this stepwise operation. However, there remains a large number and diversity of viable invaders arriving in recipient regions. Given the active nature of this vector, results from our study reflect the risk of introduction to other recipient regions, including global destinations like Europe, and serve as a model system for understanding live bait vectors around the world.

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Evaluation of New Coating Technologies for Mitigation of Zebra/Quagga Mussel Colonization – An Update

David Tordonato, *Allen Skaja and Bobbi Jo Merten, Bureau of Reclamation*

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

Field testing is ongoing and is currently focused on foul-release coating technologies including silicone based coatings, and so-called durable foul release coatings with a greater resistance to abrasion damage. In general, silicone foul release coatings have been successful in preventing mussel attachment while durable coatings have limited attachment forces but failed to prevent fouling. In addition, an oil-free version of one silicone foul release coating was recently tested and no decrease in performance was observed. In contrast, silicone foul release coatings containing silicone oil have been known to foul in marine exposure and require sufficient hydrodynamic drag to achieve release. Present findings show that silicone oils may not be required in freshwater foul release formulations. In addition, it may be possible to tailor coatings formulations to suit freshwater applications while optimizing mechanical properties to increase durability.

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Zebra Mussel Control Using Zequanox® in an Irish Waterway

Sara Meehan *and Frances Lucy, Institute of Technology Sligo; Bridget Gruber, Marrone Bio Innovations*

Due to the invasion of zebra mussels in European and North American waters there is currently a need for an environmentally friendly mussel control method to replace chlorine and other control products currently utilised. Marrone Bio Innovations (MBI), an American company that develops natural pesticides, is commercialising a natural product, Zequanox®, comprised of *Pseudomonas fluorescens* CL 145A, which effectively controls zebra and quagga mussels. Since invasion in the 1990s, Ireland's waterways, including navigation canals require a management method to deal with the zebra mussel infestation, as they attach to the canal walls as well as boats. The Grand Canal at Tullamore harbour has a zebra mussel infestation with no control measures in place. The objectives of this study were to: demonstrate an effective method of zebra mussel control in inland waterways using Zequanox®; trial a method which could be used by Waterways Ireland (government body that manages canals) for zebra mussel fouled jetties, pontoons, navigational structures; reduce the spread between waterways; and evaluate water quality to demonstrate "no negative impact" and to monitor product dispersion. A curtain made of scaffband was placed into the canal sealing off an 8 x 0.5m section on either side of the canal wall. This section was treated with Zequanox® at a concentration of 150mg/l for an 8 hour treatment period. During this time water turbidity was monitored as a means of controlling the product concentration. After the 8 hour treatment the curtain was kept in place for a total of 24 hours, to allow for natural degradation of the product where after the curtain was removed and the product naturally dispersed. Water quality was monitored before during and after treatment of this area as well as the selected control area. Natural zebra mussel settlement on the canal wall as well as adult mussels seeded into the treatment and control area were monitored for mortality after treatment. The results of this study will be presented and compared with other similar studies carried out in North America using Zequanox®. These results provide important insights into zebra mussel control methods and potential future use of Zequanox® to control zebra mussel populations whilst conserving and maintaining the ecology of Ireland's waterways.

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Zequanox® Demonstration Trials at DeCew II Generating Station at Ontario Power Generation to Control Dreissenid Mussels

***Tony Van Oostrom**, Ontario Power Generation; Bridget Gruber, Carolyn Link and Sarahann Rackl, Marrone Bio Innovations; Kelly Murray, ASI Group*

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

NPG has been working with Marrone Bio Innovations (MBI) to conduct full-scale treatments of the cooling water system at DeCew II Generating Station using Zequanox® – a natural, environmentally benign alternative to chlorination. This work is an extension of previously completed research by MBI and NPG that was presented at ICAIS in 2010. Zequanox® is comprised of dead cells of a naturally occurring soil bacterium, *Pseudomonas fluorescens* CL145A, and is lethal to dreissenid mussels, yet poses little to no risk to other aquatic organisms. Zequanox® is commercially developed by MBI and demonstration treatments have been conducted in the United States, Canada, and Ireland. Zequanox® is registered with the U.S. Environmental Protection Agency and currently under review with Canada's Pest Management Regulatory Agency.

In 2012, two successful full-scale treatments were executed on the cooling water system within DeCew II Generating Station. Over 90% adult mussel mortality was achieved after the first treatment in August, 2012 and results are forth coming on adult mussel mortality after the second treatment in September, 2012.

The presentation will review the results and observations from the 2012 demonstration trials at DeCew II Generating Station. Additional research completed in 2011 at DeCew II Generating Station (including *in situ* ecotoxicology studies and water quality monitoring results), the new mixing and application process used during the 2012 trial, and results of other demonstration trials completed will also be presented.

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Strategies for Controlling Invasive Zebra and Quagga Mussels in Open Water Bodies

*Dave Roberts and **Megan Weber**, Marrone Bio Innovations*

Both in Europe and North America, invasive zebra and quagga mussels are becoming an increasingly difficult and devastating environmental and ecosystem management problem. Invasive mussels are voracious filter feeders that grow rapidly, eliminating food sources and destroying native habitat critical to other aquatic organisms. Where invasive mussels are present, the abundance of native organisms decreases dramatically while the growth of unwanted weeds and algae increases, negatively impacting fisheries, recreational life, facility operations and property values. Colonies can cause expensive repair and maintenance costs which underscore the need to develop environmentally responsible and effective management options.

There is a need for both products and application approaches that can provide effective and flexible mussel control that can achieve a variety of open water management objectives including:

- Minimal ecological impact
- Habitat restoration support
- Shoreline restoration and recreation enhancement
- Protection of infrastructure and facilities

In addition to being able to address management objectives, products and application methods need to be able to address the challenges of open water application including:

- Sensitivity of non-target species to treatment options
- Variability and changes in natural systems effecting product application and efficacy
- Volume of water needed to be treated and ability to maintain product in treatment areas
- Public concerns with treatment and application of control products

Unfortunately, there are currently no commercially available products that can address the wide spread environmental, economic and recreational damage caused by invasive mussels. Consequently, there are very few methodologies and standard practices for application of treatment options. This presentation will describe the rapidly progressing development of Zequanox® for open water applications and the development of the treatment/management programs to use such a product.

Development of a naturally derived molluscicide, Zequanox®, offers effective and environmentally sensitive application flexibility for controlling invasive mussels during all their life stages, and is now expanding into open water use with research and development completed in 2012 and additional evaluations planned for 2013. Building on extensive toxicology evaluations and effective industrial applications, Zequanox® is currently being applied in field trials as part of developing open water application methodologies. These studies include field trials at locations such as Deep Quarry Lake. In July 2012 a field trial was completed at Deep Quarry Lake, Illinois, which provided the opportunity to study the application of Zequanox® in a natural, open water setting utilizing in-lake barriers to section off multiple small sections of the lake for treatments.

Treatment at Deep Quarry Lake achieved greater than 97% mortality in zebra mussels placed in chambers inside the treated barriers with no adverse non-target effects. The trials were conducted in coordination with Southern Illinois University that received grant funding and support from the Illinois Department of Natural Resources. Personnel from Southern Illinois University conducted post treatment sampling of native substrate in both treated and untreated barrier location to determine adult mussel mortality after treatment. This sampling was conducted independently, using different sampling methodology, and documented greater than 96% mortality in treated areas.

Effectiveness of an Algaecide for Killing Invasive Quagga Mussels and Preventing their Colonization

David W.H. Wong, *Ashlie Watters and Shawn Gerstenberger, University of Nevada Las Vegas*

Quagga mussels (*Dreissena rostriformis bugensis*) have created economic and ecological impacts in the western United States since their discovery in 2007. This study focuses on chemical control for preventing thespread of quagga mussels. The effectiveness of EarthTec®, an algaecide agent, on killing quagga mussels (adults, juveniles, and veligers) in Lake Mead, NV-AZ was evaluated at six doses, 0, 1, 5, 10, 17, and 83 ppm. 100% mortality occurred at 96h treated with 17ppm EarthTec® for adult mussels;100% mortality occurredat96h with 5 ppm EarthTec® for juvenile mussels;100% veliger mortality occurred within 30 min at 3 ppm EarthTec®. The effectiveness of EarthTec® on preventing veliger colonization from 2010 to 2012, was also evaluated. Veligers were dosed 0, 1, 2, and 3 ppm EarthTec® and 3 ppm EarthTec® was effective against veliger colonization. Study results showed EarthTec® is an effective antibiofouling agent against invasive quagga mussels.

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Taking No Prisoners: Beating Back Invasive Species

Leonard Willett, *Bureau of Reclamation*

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.

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Establishing Research and Management Priorities for Monoecious Hydrilla as it Invades Northern Tier States

***Michael Netherland**, U.S. Army Corps of Engineers, Engineer Research and Development Center; Mike Greer, U.S. Army Corps of Engineers Buffalo District*

The submersed plant hydrilla (*Hydrilla verticillata* L.f. Royle) is highly invasive in Florida and the mid-Atlantic coastal states. As hydrilla continues to spread into northern tier water bodies, resource managers seek information on the biology and management of this plant. These requests are confounded by the fact that there have been separate introductions of a dioecious and a monoecious biotype of hydrilla into the United States. The majority of biology, invasion ecology, and management information on hydrilla have been developed for the dioecious biotype that thrives in the southern United States. The monoecious biotype of hydrilla has demonstrated a propensity for movement northward and given the significant differences between the hydrilla biotypes, predicting the invasive potential of monoecious hydrilla has proved to be quite difficult. For example, the ability of monoecious hydrilla to establish throughout long stretches of the Ohio River and several other rivers was initially considered a low probability event by numerous aquatic plant scientists. This has led several researchers to suspect the monoecious biotype may be more tolerant than predicted to harsh environmental conditions such as turbidity, high flow, significant water fluctuations and cold winters. Moreover, the likelihood of implementing successful control measures for hydrilla in rivers is very low and therefore rivers may serve as a continuous source of new introductions into northern lakes. As hydrilla becomes our first national aquatic weed, the invasion ecology of the monoecious biotype in northern lakes requires additional research attention. Recent discoveries of hydrilla in Lake Cayuga, NY as well as the Erie Canal have been of particular concern to resource managers as these sites represent high profile infestations that may facilitate further spread to nearby waters or regions (e.g. Finger Lakes, Great Lakes, Adirondack Park Lakes, Lake Champlain, Upper Midwest, Canada etc). While the Cayuga and Erie Canal sites have currently been slated for long-term eradication programs, the continued introduction of hydrilla into northern waters is of concern for the following reasons: 1) thousands of glacial lakes support diverse plant communities and the introduction and spread of hydrilla in these systems may significantly alter these communities; 2) triploid grass carp are widely used for large-scale monoecious hydrilla control in the mid-Atlantic states, but given their non-selective nature, use of carp in natural lakes that support abundant native vegetation is highly unlikely ; 3) current eradication strategies demand that lakes be managed for 6+ consecutive years in order to remove hydrilla; 4) the source of new hydrilla introductions remains largely unknown; 5) public waters tend to have strong stakeholder groups and they are often very adamant about active management of invasive plants; and 6) spread of hydrilla in this region will likely create both strong advocates and opponents for and against aggressive and widespread management. To address many of the knowledge gaps associated with monoecious hydrilla biology and management, a 2-day Symposium was held in Syracuse, New York in September 2012 to identify and prioritize research and management needs for monoecious hydrilla. Discussions from this meeting will be presented.

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The Distribution and History of *Myriophyllum spicatum* L. (Haloragaceae) in Southern Africa, with Reference to Potential Origins, Modes of Introduction and Spread

***Philip Weyl** and Julie Coetzee, Rhodes University*

Myriophyllum spicatum L. (Haloragaceae) is considered a significant weed in South Africa and control efforts in infested water bodies need to be initiated. In North America where *M. spicatum* is also problematic, it is most frequently controlled by the use of herbicides and mechanical harvesting, which is expensive and often has non-target effects on native organisms, and biological control is considered the only sustainable and cost effective control option. However, origins of *M. spicatum* in southern Africa are uncertain. Historical records from herbaria, field notes and published articles and books hold a wealth of information that can be extremely important in tracing the history, mode of introduction and spread as well as the potential origins of a plant. *M. spicatum* has a wide recorded distribution in southern Africa, ranging from the Aghulus Plain in the Western Cape to the highlands of the Amathola mountains to the sub-tropics of northern KwaZulu Natal, Botswana, Namibia, Zimbabwe, Zambia, Tanzania and Malawi. Examining specimens in the South African Museum (SAM) herbarium, the first record of *M. spicatum* collected was in November 1829 from the Swartkops River, Eastern Cape, South Africa. Since then there have been numerous collections of this plant throughout the country, and southern African region. Genetic analysis suggests that the plants found in North America are not closely related to those found in South Africa, however analysis of European samples will give insights into the origins of the plants found in southern Africa. The timing, spread and distribution of this species does not follow any obvious routes or modes of spread such as horticultural or fish introductions which is in contrast to the distribution and spread of the plant in North America and other aquatic plants globally.

NOTES

Range and Survival of Two Alien Macrophytes (*Eichhornia Crassipes* and *Pistia Stratiotes*) in the Great Lakes

Amanda Eyraud *and Hugh MacIsaac, University of Windsor, Great Lakes Institute for Environmental Research*

There are at least 182 non-indigenous species (NIS) currently reported in the Great Lakes. Though ballast water is the most common vector for introduction of aquatic NIS, the pond and aquarium trade play a role as well. The latter vector is the most probable cause for the introduction of two alien macrophytes, water lettuce (*Pistia stratiotes*) and water hyacinth (*Eichhornia crassipes*). Both plants are native to South America, and are believed intolerant of winter temperatures in temperate areas, like the Laurentian Great Lakes. We surveyed the Canadian shoreline of the Great Lakes by boat to determine the species' current range, whilst also investigating three hypotheses that may account for the species' continued presence in the area: 1) adult plants survive winter exposure; 2) adult plants perish during the winter, but produce viable seeds that germinate the following spring; and 3) the adult plants die each year and do not reproduce, but are reintroduced annually. Surveys conducted in fall 2010, 2011 and 2012 demonstrated that the species are recurring in some Great Lakes tributaries in consecutive years. We deployed a series of cages in Lake St. Clair and the Detroit River, with pre-measured plants, to assess whether plants are capable of surviving (or reproducing) during winter conditions. Results to date suggest that neither species are capable of surviving winter conditions. However, evidence has been found that water hyacinth is capable of reproducing sexually. Seeds have been collected directly from a plant population in Essex County and have been extracted from local sediment. Germination experiments were carried out in a temperature and light controlled room with collected seeds to determine their viability. Specimens were randomly selected and appointed to one of four treatment groups. Current results show a germination rate of up to 53% with some amount of germination occurring in three of the four groups. Therefore, it is likely that water hyacinth, if not water lettuce, is established in Essex County.

NOTES

Linking Native and Exotic Aquatic Plant Palatability to Herbivores with Shared or Unshared Home Ranges: A Trait-Based Approach

Bart M.C. Grutters *and Elisabeth S. Bakker, Netherlands Institute of Ecology, Department of Aquatic Ecology*

Anthropogenic forces greatly increase the amount of exotic species introductions to previously isolated ecosystems. Being novel, exotic species leave behind their natural enemies (enemy release hypothesis) and introduce new traits to the local species assembly (novel weapons hypothesis). This has been shown to be a major setback in the arms race for resources between species and puts the newcomer at a distinct advantage thus enabling their settlement and rapid spread. However being forced to adapt to new stressors, after having lost its co-evolved life-history advantages countering its previous enemies, could imply ecosystem resilience resulting in a disadvantage after introduction (biotic resistance hypothesis). Merging these seemingly paradoxical hypotheses leads to the question: do exotic species benefit from or suffer outside their home range?

Widespread nuisance species and failed introductions (visible or not) reveal that the truth probably lies somewhere in the middle. Research addressing these questions has been performed using snails and crayfish as proxies to test for the palatability of taxonomically paired invasive and native aquatic plants. These inquiries led to evidence supporting and arguing against enemy release and biotic resistance. Additionally, trials testing for characteristics explaining the palatability of aquatic plants have been performed. However a union of the concepts has not been conducted to study the mechanisms or traits related to feeding behaviour on invasive and native aquatic plants. Further depth is provided by incorporating herbivores of different origin using no-choice feeding trials (*Pomacea canaliculata* and *Lymnaea stagnalis*). We analysed the palatability of over 40 aquatic plant species varying greatly in home range as well as in their traits but in a way allowing morphologically similar native and exotic species to be compared. Also a comparison within and between plant genus is catered for.

This study shows that species traits are fundamental in plant-herbivore relations and newcomers can introduce new traits to ecosystems which herbivores did not encounter before. Additionally, plant-herbivore relation is analysed from a shared home range perspective. Low palatability of *Myriophyllum* species (and other fine-leaved analogues) can contribute to their dominance, as can a high palatability of some broad-leaved Potamogeton species make invasive behaviour highly unlikely.

NOTES

Effects of Supplemental Stocking of Milfoil Weevils (*Euhrychiopsis lecontei Dietz*) on Eurasian Watermilfoil (*Myriophyllum spicatum* L.) Density in a Heavily Infested Lake

Paul M. Skawinski *and Ronald Crunkilton, University of Wisconsin-Stevens Point, College of Natural Resources*

Eurasian watermilfoil (*Myriophyllum spicatum* L.) is an invasive aquatic plant that has spread throughout much of North America. Chemical and mechanical management options are frequently used to control *M. spicatum*; a possible biological control option uses a native aquatic weevil, *Euhrychiopsis lecontei* Dietz (Coleoptera: Curculionidae). The purpose of this study was to examine the response of *M. spicatum* over a five-year period following two years of high-density stocking of *E. lecontei* into Lake Joanis, a 24-acre artificial lake in Stevens Point, Wisconsin, USA that had recently become infested with *M. spicatum*. Approximately 500 milfoil weevils per acre were stocked in each August of 2008 and 2009. Weevil density increased from approximately 0.04 weevils per stem in June 2008 prior to stocking to approximately 0.06 weevils per stem in June of 2009, but dropped below pre-stocking densities in 2010-2011. *M. spicatum* showed an initial increase after the weevil stocking events, but has since declined by about 50% from peak density measures. There was a high correlation between measures of stem damage and weevil abundance, suggesting weevils may be connected to *M. spicatum* decline. However, the efficacy of supplemental stocking of high numbers of weevils in lakes that have existing weevil populations is not demonstrated. The importance of biotic and abiotic attributes on weevil abundance in Joanis Lake is discussed.

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Invasive Species Surveillance of the Great Lakes Basin Commercial Bait Trade Using Environmental DNA Surveillance

Lucas Nathan[1]*, Michelle Budny*[2]*, Christopher Jerde*[2]*, Andrew Mahon*[1]*,* [1]*Central Michigan University;* [2]*University of Notre Dame*

In the Great Lakes region, over 180 non-native species have established, and this poses risks to native biodiversity and ecosystem functioning. One potential pathway for introduction of new species is the commercial bait trade. Bait bucket introductions pose a high risk due to contaminated samples being dumped into bodies of water by unknowing or unconcerned anglers. Previous bait surveillance studies have used visual inspection in retail stores to identify and and evaluate the risked posed by invasive species. Manual inspection of bait is time consuming and requires a trained individual that can rapidly and accurately identify cryptic species. Thus, methods that are quicker and easier to implement are warranted. Environmental DNA (eDNA), a molecular surveillance tool that has been used in aquatic environments, has the ability to detect individuals at low abundances. In 2012, we surveyed and collected samples from over 400 retail bait shops throughout the Great Lakes basin. Retail bait shops in Indiana, Illinois, Wisconsin, Michigan, Ohio, and New York were visited. We then applied eDNA techniques to screen these samples for targeted invasive species including bighead carp (*Hypophthalmichthys nobilis*), silver carp (*H. molitrix*), round goby (*Neogobius melanostomus*), tubenose goby (*Proterorhinus marmoratus*), and Eurasian rudd (*Scardinius erythrophthalamus*). These surveillance efforts provide a spatial assessment of areas in the Great Lakes region that are at a high risk of invasive species introductions through bait bucket vectors. To date, we have found non-native species at three different commercial shops. This assessment is helping to gauge the potential for invasive species to be spread through the bait trade and will aid in future management and control of invasive species.

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DNA Shedding Rates of Asian Carps, for Use in Understanding Field Collections of eDNA

***Katy Klymus**, University of Missouri; Duane Chapman, U.S. Geological Survey, Columbia Environmental Research Center; Cathy Richter, U.S. Geological Survey; Craig Paukert, U.S. Geological Survey–University of Missouri*

The use of environmental DNA (eDNA) as a tool for species detection has come to the forefront in the fight against aquatic invasive species. The technique works by extracting DNA shed into an organism's environment and using polymerase chain reaction (PCR) to identify species specific DNA. The tool has been successful in detection of extinct fauna, hard to study microorganisms, and rare species. Because the tool only requires the presence of a DNA molecule, the sensitivity of the technique is higher than that of more traditional methods (surveys) of species detection. This increased sensitivity in detection is especially important because invasive species likely exist in low densities at the beginning of an invasion and the eradication of invasives is more successful at this early stage. Currently, eDNA is being used to detect Asian carp, (silver carp, *Hypophthalmichthys molitrix*, and bighead carp, *H. nobilis*) in the Chicago Area Waterways (CAWS). Positive eDNA samples have been found in the CAWS, but intense fishing in these areas has only found one bighead and no silver carp. This raises the question of what eDNA can really tell us about the presence of an organism. Through a collaborative effort with the U.S. Army Corps of Engineers, U.S. Geological Survey, and U.S. Fish and Wildlife, we aim to better understand the information that this tool can provide managers. We are looking at how DNA of Asian carps gets into the environment and how quickly it degrades. In a controlled laboratory setting, we first investigated how much DNA a single fish sheds into the environment and the variability of these eDNA measurements using quantitative PCR (qPCR). Then using a series of manipulative lab experiments, we studied how factors such as temperature, biomass, and diet affect the shedding rate of eDNA by these fish. The ultimate goal of this work is to use this information on shedding rates, along with data from studies that investigate rates of eDNA deposition and degradation, in a probabilistic model that can be used by resource managers as a way to statistically infer the presence of live Asian carps from positive eDNA hits.

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A Real-Time PCR Assay with Internal Controls to Detect and Quantify the Fish Viral Hemorrhagic Septicemia Virus (VHSv): Conversion from StaRT-PCR

***Vrushalee Palsule**, Lindsey Pierce, Carol Stepien, James Willey, Jiyoun Yeo and Erin Crawford, University of Toledo*

Viral Hemorrhagic Septicemia virus (VHSv) is one of the world's most important finfish diseases, killing >80 species across Eurasia and North America, for which present diagnostics are inaccurate. A new and especially virulent strain (IVb) emerged in the North American Great Lakes in 2003, threatening fisheries, baitfish, and aquaculture industries. Weeks-long and costly cell culture is the OIE and USDA-APHIS approved diagnostic. Here we present and evaluate a new real-time two-color fluorometric assay to detect and quantify VHSv, which we adapted from our StaRT-PCR (Standardized Reverse Transcriptase Polymerase Chain Reaction) test. Our tests, unlike other PCR-based tests, uniquely incorporate internal standards to improve accuracy and prevent false negatives. Results show that both of our diagnostic assays are specific to a single VHSv molecule (100% accurate at six molecules), and have no false negatives. In comparison, false negatives ranged from 14-47% in SYBR® green real time qRT-PCR tests, and 47-50% in cell culture. VHSv molecules quantified using StaRT-PCR ranged from 1-1.2x10^5 VHSv/10^6 actb1 molecules in wild caught fishes and 1-8.4x10^5 in laboratory challenged specimens. Laboratory-challenged muskellunge with VHSv lesions had a greater mean number of viral molecules (1.9x10^4) than those without (1.1x10^3). VHSv infection was detected earlier in yellow perch that were injection-challenged (2 days) than in those that were immersion-challenged (3 days). Number of molecules in both the injection- and immersion-challenged yellow perch were similar and remained relatively consistent over the remaining six-day course of the experiment. Our new real-time test is designed to be rapid, highly accurate, and easy to use, facilitating detection and control of this disease.

NOTES

First Discovery of Golden Star Tunicate in Conception Bay, Newfoundland and a Case Study Mitigation Attempt to Control its Spread

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The Department of Fisheries and Oceans (DFO), in collaboration with the Department of Oceans Sciences of Memorial University of Newfoundland (DOS), began a survey and monitoring program focused on detection of AIS at high risk ports in 2006. In December 2006, golden star tunicate, *Botryllus schlosseri*, was identified in Argentia, Placentia Bay, on the southwest coast of the Avalon Peninsula. It was later detected in 6 additional harbours in Placentia Bay, and was most recently (2011) discovered in Foxtrap Marina, Conception Bay. This was the first record of golden star tunicate on the eastern Avalon Peninsula.

Golden star colonies were found primarily on large *Laminaria* sp. kelp on a large portion of floating docks on the breakwater side of the marina, and on kelp on the breakwater itself. A small patch was also found on one vessel. No golden star was found on permanent wharf structures within the marina. Research being conducted on invasive tunicates in Newfoundland (Deibel et al NSERC Strategic Grant) has provided valuable information on the ecology of this colonial species and was crucial to determining the mitigation strategy.

Stakeholder discussions were held and due to the location of golden star at the marina, the type of affected structures, and the onset of cold winter temperatures, a mitigation attempt was determined to be a viable option to eradicate, or to prevent potential spread, to surrounding harbours in Conception Bay. During December 2011 the mitigation strategy was carried out in Foxtrap Marina in collaboration with DFO Small Craft Harbours and the local Harbour Authority. Floating dock removal and manual collection were chosen as the preferred treatment methods since the majority of golden star observed was on floating docks and one vessel. Additional follow-up SCUBA dive and video surveys were conducted after the mitigation and during the summer-fall months of 2012. Inspection after dock removal determined 3 of the 15 floating docks were heavily infested with golden star tunicate. The majority of the other 12 docks had patchy growth. During the inspection, samples were collected for research on invasive tunicates currently underway at the DOS. This research will include genetic analysis which will provide more information on the distribution and ecology of this species. Public awareness of the role recreational vessels and fishing gear play in the spread of aquatic invasive species was increased through the media attention surrounding this mitigation. Details of the mitigation effort and results of follow-up surveys will be discussed.

NOTES

Early Warning Program to Manage the Introduction and Spread of Invasive Species in the Wadden Sea, a World Heritage Protected Ecosystem

Andrea C. Sneekes, *N.H.B.M. Kaag, H. Van Pelt, B. van der Weidde, A. Gittenberger, K. Philippart, J. Boon, S. Rajagopal and J.M. Jansen, IMARES, Wageningen UR, Institute for Marine Resources and Ecosystem Studies*

The Wadden Sea is an unique wetland ecosystem with an ever present tension between economic activities and ecological protection. It is a UNESCO World Heritage area and is protected under national and international laws. Nevertheless, the economic activities in this area, such as shipping and shellfish culture facilitate the unwanted introduction and spread of potential aquatic invasive species (AIS). Therefore, the three countries bordering the Wadden Sea, Denmark, Germany and the Netherlands, are developing a trilateral program to identify and monitor the vectors of AIS and the current pressure of AIS in the Wadden Sea. The program includes early-warning monitoring applying an innovative metabarcoding approach, and case studies to gain knowledge on effectiveness of mitigation measures. These mitigation measures will address the major vectors of AIS: ballast water, hull-fouling and shellfish transportation. Continuing where the previous Life program left off, the Life+ program intends to develop this further so that scientists can deliver sound advice to authorities and others on the proper management of invasive species in the Wadden Sea. The ideas and lay-out of our Life+ project in relation to Natura 2000 and the European marine framework strategy will be presented.

NOTES

Pathways for Introduction of Alien invasive Species Exclusive of International Shipping: A Canadian Experience

***Hugh J. MacIsaac**, Professor, University of Windsor, Great Lakes Institute for Environmental Research and Director, NSERC Canadian Aquatic Invasive Species Network II*

International shipping has dominated concern regarding introduction of alien invasive species (AIS) to aquatic ecosystems globally, as both ballast water and hull fouling are potent pathways for introduction of new species. In the Great Lakes, ballast water release from mainly European-source ships has accounted for at least 55% of known established AIS introductions.

Recently however, this pathway has diminished in importance and attention has turned to other pathways, including domestic 'Laker' vessels that typically operate exclusively within the Great Lakes, but on occasion some of these vessels travel to ports on the St. Lawrence River where they may load fresh or brackish water for subsequent discharge in the Great Lakes. Our surveys indicate that the ports of Montreal, Sorel, Tracy and Trois Rivières are most likely to contribute new species to the Great Lakes through domestic ballast transfers. In addition to these vessels, attention is also focused on the trade of live organisms, particularly the pond, aquarium, and live food trades. We have documented two alien plants - water lettuce and water hyacinth - in the lower Great Lakes on a recurring basis.

In situ experiments indicate that neither species can tolerate current winter conditions, and we have found no evidence of seed production in water lettuce. However, water hyacinth will produce seeds, which will germination when scarified. We have also confirmed human introduction of these plants at two locations in the lower Great Lakes. Live importation of alien fishes remains problematic in Ontario despite implementation of laws to the contrary. Four interceptions of live Asian carp species were made in Ontario during 2012, and eDNA records suggest possible occurrence of the fishes at some locations in the Great Lakes.

Elsewhere, British Columbia conducted an eradication campaign for a single northern snakehead fish, and implemented legislation prohibiting release of these fishes into provincial waters. The province is also working with agencies in the western USA to prevent introduction of live zebra and quagga mussels on boats trailered from infested areas in the southwestern part of the country. Clearly, the issue of AIS introductions has not gone away, rather the problem continues to evolve as species ranges and our knowledge of pathways changes.

NOTES

Pilot Project to Eradicate Invasive Alien Smallmouth Bass Using a Piscicide from a Conservation Priority River in South Africa: Rationale, River Treatment and Way Forward

***Johannes Adriaan van der Walt** and Ben van Staden, CapeNature*

Invasive alien fishes are a serious ecological problem in South Africa, especially in its internationally unique Cape Floristic Region (CFR). This region has a very high percentage of endemic freshwater fishes (24 of 27 taxa), of which 18 taxa are endangered. The most severe threat is the impact of invasive alien fish species, especially the predatory smallmouth and spotted bass from North America.

Eradicating invasive alien fishes from large river systems is no easy task, but eradications are possible in river areas above physical barriers using piscicides which have a proven track record of success, notably in the USA and Norway. To succeed, projects to eradicate alien fishes, which are very popular angling fishes in South Africa, should have as much support as possible from fellow environmental organisations, riparian land-owners and angling organisations. This project involved the first use of a piscicide in a river in the CFR to achieve a conservation objective. On 29 February 2012, the Rondegat River in the Cederberg mountains of the Western Cape Province of South Africa was treated with CFT Legumine at a concentration of 50ppb active rotenone for six hours.

The impact of the piscicide treatment on the river is being quantified through a research project funded by the Water Research Commission of South Africa under the leadership of the South African Institute of Aquatic Biodiversity. We await the outcome of this research before proceeding with further projects on other river areas in the CFR that have been identified as priorities for alien fish control.

NOTES

Biological Control of Golden Apple Snail by Black Carp in a Freshwater Wetland

Kelvin K.L. Ip *and Qiu Jian Wen, Hong Kong Baptist University*

Golden apple snail *Pomacea canaliculata* (Lamarck), a native of South America, has invaded freshwater wetlands worldwide. With a large size and huge appetite, this herbivory snail is well-known for causing dramatic loss to crops in agricultural areas. Current studies have also revealed its threat to the structure and function of natural freshwater wetlands. Biological control using fish has been proposed as one of the few management methods for apple snails, with little attention to the side effect of fish on flora and fauna.

We are therefore conducting a year-round field experiment in freshwater wetlands to test for the effectiveness of the black carp in removing the apple snails, as well as their potential side effects on macrophytes, benthic invertebrates and water quality parameters. Our preliminary results show black carp survives well under the field conditions, and is a highly effective predator of the apple snails. Yet, it also preys upon non-target macroinvertebrates, especially mollusks. Therefore, risk in loss of biodiversity should be weighed against the benefits before adopting this fish for managing invasive apple snails.

NOTES

Management of Alien Invasive Algae in Kaneohe Bay, Oahu through the Use of Mechanical Removal and Bio-control Efforts

Jonathan Blodgett *and Frank Mancini, Hawaii Department of Land and Natural Resources, Division of Aquatic Resources*

Kaneohe Bay on the windward side of the island of Oahu (21°27'35"N 157°48'15"W) is the largest sheltered body of water in the Main Hawaiian Islands. Kaneohe Bay is a complex estuarine and coral reef ecosystem consisting of fringing, patch and barrier reefs that is struggling with multiple anthropogenic stressors. Stressors include, but are not limited to: land based pollution, recreational activities, fishing pressure and the introduction and establishment of alien species. One group of alien algae in particular, the *Kappaphycus/Eucheuma* spp. complex (K/E), poses a serious threat to coral reefs. The K/E species are some of the largest tropical red algae and have extremely high growth rates. K/E is palatable to both vertebrate and invertebrate herbivores, however where herbivory is low and conditions are favorable, K/E can invade coral habitat and form large mats that overgrow and kill reef-building corals. Since being introduced to Kaneohe Bay in 1974, K/E has spread throughout the Bay and has the potential to cause a phase shift from a coral to a macro-algal dominated ecosystem. The negative impacts of invasive algae on Hawaii's coral reefs have been well documented however, relatively few management techniques have been developed to protect threatened and restore impacted coral reefs. The State of Hawaii's, Division of Aquatic Resources (DAR) and partners have developed novel approaches to manage invasive algae. The partnership developed a modified dredge, nicknamed the "Super Sucker," that is capable of removing large quantities of alien invasive algae (5000 lbs. per day). K/E was physically removed from a small patch reef (0.75 acre) in Kaneohe Bay and algae regrowth was monitored monthly for one year. Alien algae rebounded to pre-removal levels suggesting that physical removal alone is not an effective means of eradication in a compromised ecosystem such as Kaneohe Bay. Anthropogenic stressors, favorable physical conditions, fast growth rate of K/E and low herbivore density were likely contributing factors. As a supplement to physical removal, DAR experimented with enhancing herbivory. K/E was again physically removed from the same reef, adult wild native collector sea urchins, *Tripnuestes gratilla*, were transplanted and algae regrowth was monitored for one year. Physical removal with urchin bio-control successfully maintained regrowth of K/E to acceptable levels in this small scale experiment. DAR has since expanded their efforts by building a sea urchin hatchery and *Tripneustes gratilla* are being successfully raised at the Anuenue Fisheries Research Center in Honolulu. Wild broodstock are collected and spawned on a monthly basis and within three to five months, juvenile urchins are ready for outplanting. K/E is currently being physically removed from three large patch reefs (13 acres total) in Kaneohe Bay which are then being stocked with hatchery raised urchins at a density of 2/m^2. These reefs are being surveyed quarterly to monitor changes in the benthic, fish and invertebrate communities and assess effectiveness of bio-control efforts. The artificial propagation and out-planting of the native sea urchin, *T.gratilla*, is a viable management approach until longer-term, ecosystem wide, solutions can be implemented.

NOTES

Reproductive Sterility as a Tool for Prevention and Control of Aquatic Invasive Species

***John Teem**, Florida Department of Agriculture and Consumer Services*

The South American apple snail *Pomacea bridgesii* is a popular ornamental aquarium product that is the only species of apple snail permitted for sale in the U.S. by the USDA. Compared to other apple snail species such as *Pomacea insularum* it has a low food preference for aquatic plants and has a low incidence of establishment in the Florida environment. In contrast, *P. insularum* readily consumes a wide variety of aquatic plants and is established in many water systems in Florida as well as other Gulf and South Atlantic states. The high reproductive capacity of *P. insularum* apple snails plays an important role in their ability to become established and spread within the environment. Egg masses containing 300 or more eggs and are produced in abundance throughout the mating season, providing a large reservoir of new recruits to maintain the population of reproductive adults and to initiate new populations when snail hatchlings are spread during flooding events. If it were possible to produce reproductively sterile apple snails, this might serve two useful purposes with regard to aquatic invasive species issues. First, it could provide a means to produce an apple snail aquarium product that has reduced potential for establishment if introduced into the environment. Sterile apple snails could thus aid in the prevention of new introductions resulting from the aquarium trade. Secondly, sterile apple snails could have potential as a tool for eradication of existing populations in a sterile-release approach. Eradication of apple snails may be possible in some situations where the invasive population is relatively isolated and the characteristics of the water body are amenable to the sterile-release methodology. As a template for sterile-release, sterile insect control (SIT) is a genetic biocontrol strategy that has been successful in controlling or eradicating a variety of insect pests in the U.S. such as screwworms and Mediterranean fruit fly. The strategy is based on the use of radiation to sterilize insect pupae which are then subsequently reared and released as adults. Large numbers of sterile males released into the environment compete with normal males in matings with females. Because normal females will most likely mate with a sterile male, they are unable to produce viable progeny. Over time the population declines resulting in eradication. The potential of producing sterile apple snails (both eggs and adults) by gamma irradiation treatment was investigated using *P. insularum* and *P. bridgesii*. Snails were irradiated and subsequently mated with nonirradiated partners to determine the optimal dose required to produce reproductive sterility. High mortality was associated with radiation doses that affected fertility, suggesting that radiation-induced sterility is associated with a corresponding loss of viability. This high mortality has important consequences for both the practical application of a sterile-release effort to eradicate apple snails and the production of sterile apple snails for the aquarium trade. The results suggest that genetic alternatives to using radiation to sterilize snails, such as triploidy and translocation heterozygotes, should be investigated for their potential to generate sterile snails with high viability.

NOTES

Developing a Theoretical and Experimental Framework for the Trojan Y Chromosome Eradication Strategy

***John Teem**, Florida Department of Agriculture and Consumer Services; Juan Gutierrez, University of Georgia*

Two autocidal genetic biocontrol methods have been proposed as a means to eliminate invasive fish by changing the sex ratio of the population: the Trojan Y Chromosome (TYC) strategy and the Daughterless Carp (DC) strategy. Both strategies were modeled using ordinary differential equations that allow the kinetics of female decline to be assessed under identical modeling conditions. When compared directly in an ordinary differential equation (ODE) model, the TYC strategy was found to result in female extinction more rapidly than a DC strategy (in each of three models tested in which the Daughterless autocidal fish contained an aromatase inhibitor gene in either two or eight copies). The TYC strategy additionally required the introduction of fewer autocidal fish to the target population to achieve local extinction of females as compared to the DC approach. The results suggest that the relatively lower efficiency of female reduction associated with the DC approach is a consequence of a greater capacity to produce females and also a reduced capacity to produce males as compared to the TYC system. Practical application of the TYC strategy requires the development of YY broodstock (male and female fish containing two Y chromosomes) in order to produce the autocidal fish. The process involves hormone-induced sex-reversal of juvenile fish that are selectively bred to produce YY fish. In the absence of sex-specific DNA markers to identify the sex chromosomes in sex-reversed fish, the time and resources required to develop YY broodstock can be lengthy and prohibitive. The identification of sex-specific DNA markers for invasive fish species of interest is thus an important first step in developing a Trojan Y Chromosome eradication strategy. Three invasive fish species relevant to the Gulf and South Atlantic states are currently being screened for sex-specific DNA markers using RAPD PCR; Nile tilapia (*Oreochromis niloticus*), silver carp (*Hypophthalmichthys molitrix*), and African jewelfish (*Hemichromis bimaculatus*). By identifying sex-specific DNA markers for one or more of these species it is anticipated that YY broodstock can be constructed and used in an experimental test of the Trojan Y Chromosome strategy.

NOTES

Integrated Pest Management of the Common Carp in the American Midwest

Peter Sorensen *and Przemek Bajer, University of Minnesota*

The common carp is one of the most abundant and destructive invasive fish in both North America and Australia where it has severely damaged hundreds of thousands of hectares of shallow-water ecosystems. Carp control in North America has traditionally attempted to use rotenone (a nonspecific fish poison) and water-drawdowns, but success has been elusive and short-lived. Recently, we discovered that adult carp aggregate in the winter, and that carp population abundance is often driven by seasonal fluctuations in the numbers of egg-eating native fish in outlying regions of many Midwestern watersheds (Bajer & Sorensen 2010). These insights have allowed us to initiate an experimental integrated pest management (IPM) scheme that focuses on targeted adult removal using Judas fish and suppressing carp recruitment by re-balancing native fish populations in carp spawning habitat. We have been able to suppress carp populations to about 10% of their initial levels in three lakes for five years at modest cost. Significant improvements in water quality have also been noted and there has been no recruitment. (Minnesota Environment and Natural Resources Trust Fund, Riley Purgatory Bluff Creek Watershed District, Ramsey-Washington Metro Watershed District and Invasive Animals Cooperative Research Centre).

NOTES

Invasive Species Fouling and Industrial Cooling Water Systems

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Invasive species are often characterized by features such as rapid reproduction, fast growth rate and tolerance to a wide range of environmental conditions, reaching high population densities. Many of the recent invasive species are sessile benthic in their habitat and hence are potential biofouling organisms. Industries all over the world will have to cope with an increasing number of invasive species that find their way into their cooling water intakes. This has been amply demonstrated in the case of species such as Asiatic clams, zebra and quagga mussels in the Great Lakes and in the river Rhine. In this paper, we shall discuss the key features of some of those prominent non-indigenous species, whose success as invasive species merits close examination. Many of these species are transported by ships, either via ballast water or via ship hulls, as part of the fouling assemblage. Another main cause of their introduction is the shellfish culture industry and construction of canals for shipping purposes. In addition to threatening the bio-diversity of the locality, some of the introduced species continue to place enormous burden on the economy of the countries affected. Biofouling of industrial cooling water systems is but one aspect of their wide-ranging economic impact.

We treat some important marine, brackish water and freshwater invasive sessile bivalves and some other important invasive fouling species in relation to control. Often it appeared that the invaders are much better equipped to tolerate adverse environmental conditions than the native species they replace. Hence the control measures adopted should be such that they address the invasive species rather than the native ones. Tolerances with respect to control measures differ between species. Control measures used for the most tolerant species are expected to be effective in the case of other less tolerant species also. Unfortunately, adequate toxicity data are not available for several of the potential biofouling invasive species. This lacuna needs to be addressed and it is expected that researchers would pay attention to the generation of such data, so that environmentally acceptable control measures can be evolved for the ever-increasing number of exotic biofoulers.

NOTES

Non-Indigenous Species Transported on Tsunami Marine Debris: Learning and Informing Response to a Natural Disaster Driven Invasive Species Pathway of Emerging Concern

***Samuel Chan**, Oregon State University*

The catastrophic 9.0 Japanese earthquake and tsunami of March 11, 2011 resulted in the tragic loss of over 4000 lives, billions of dollars in damages and the unintentional movement of millions of tons of terrestrial and marine infrastructure debris into the currents of the Pacific ocean. The role of natural disasters such as tsunamis in transporting non-indigenous species and facilitating bioinvasions, received little consideration until a large 188 ton marine dock from the tsunami ravaged fishing port of Misawa in Northern Japan, landed June 2012 on Agate Beach, Oregon, USA, after drifting for 15 months in the Pacific Ocean. The beached dock transported about 92 species and over 2 tons of marine organisms from its estuarine moorage in Japan on its way to Oregon. With taxonomic identification still on-going, approximately 1/3 of the species are identified as common to both sides of the Pacific and the remaining 2/3 are not known to be in Oregon. At least four species, not known to be present on the Oregon Coast are deemed invasive outside of Japan, including the sea kelp Wakame (*Undaria pinnifida*), the Japanese shore crab (*Hemisgraspus saguineus*) and, the Northern Pacific Sea Star (*Asterias amurensis*). The beaching of the Misawa dock on a state park with an easily accessible beach and proximity to Hatfield Marine Sciences Center enabled, researcher, managers, educators and policy makers to respond rapidly to and learn from the event.

Though tsunamis are a natural phenomenon over geologic time, the transport of a large community of marine estuarine organisms across the Pacific has not be documented in recent history and thus represents a potentially new pathway of concern – one where risk analyses, early detection and rapid response (EDRR), outreach and engagement and coordinated response are still at an early stage of development. Conducting an invasive species risk analysis on marine tsunami debris risk is challenging given that we are just starting to learn about this pathway and the uncertainty over: 1) debris flow models and detection methods, 2) what type, size and substrate of debris are most likely to transport non-indigenous species, 3) the species being transported, 4) how long can estuarine communities like those found on the Misawa dock survive in the open ocean and 5) what mechanisms facilitate their survival and establish. For example, the sheer size of the dock (as compared to a large log that can drift across the ocean) may have provided suitable substrate and facilitated habitat for the abundance, diversity and high density of organisms found on the dock. Early detection and rapid response is complicated by the vast and rugged coastlines that need to be monitored, a reporting system in development and the lack of experience in rapid response treatments of organisms and marine tsunami debris. Effective EDRR is also dependent on consistent protocols and clear messages for first responders, management agencies and the public. Although the frequency of catastrophic tsunamis are about every 300 years in the Pacific NW, the intensity of human development of marine infrastructure on the Pacific coastlines since the 1900s and number of active rupture zones near the heavily developed Pacific coasts could mean that the potential threat from tsunami driven bioinavasions will likely continue and warrants the need for effective protocols and activities to prepare for future threats from transport of aquatic invasive species on tsunami marine debris.

NOTES

Are Anglers and Kayakers Acting as Vectors for Alien Invasive Species in UK Freshwaters?

***Lucy Anderson**[1], Piran White[3], Paul Stebbing[2], Grant Stentiford[2], Allison Dunn[1], [1]University of Leeds; [2]Centre for Environment, Fisheries & Aquaculture Science; [3]University of York*

Alien invasive species (AIS) pose an enormous threat to biodiversity and are a major economic problem, costing the UK economy almost £2 billion per year. Nine out of ten of the UK Environment Agency's 'Most Wanted' alien invaders are aquatic or riparian species. These invaders, which include the zebra mussel (*Dreissena polymorpha*), American signal crayfish (*Pacifastacus leniusculus*) and – more recently – the killer shrimp (*Dikerogammarus villosus*), have a range of ecological and economic impacts which include the collapse of river banks through burrowing, blocked water pipes and the introduction of new pathogens which threaten the existence of the UK's native freshwater species.

Evidence suggests that many of these freshwater AIS as well as the aquatic pathogens that they may introduce such as *Aphanomyces astaci*, the oomycete pathogen responsible for the disease crayfish plague, and amphibian ranaviruses, are able to survive in damp environments for a number of days, sometimes weeks. As such, they have the potential to be transported between water catchments on the equipment used by recreational boaters and anglers. Studies into recreational water users in the USA have reported that anglers and boaters travel hundreds of kilometres between sites and frequently transport muddy equipment, the remnants of invasive aquatic plants and buckets containing water and live bait within the time frame that pathogens could remain viable. Despite these concerning results, research into the actions of recreational water users in the UK is limited.

Here we present the results of a questionnaire survey which we conducted with 1600 UK anglers and kayakers in 2012. The aim of the survey was to assess the potential biosecurity threat posed by these groups by quantifying their movement patterns and investigating their equipment use, cleaning and storage practices. We present results about how regularly anglers and kayakers took part in their activities, how far they travelled between sites and how frequently they moved between water catchments. We also report on the proportion of anglers and boaters who were currently undertaking the necessary biosecurity procedures to prevent the movement of AIS and discuss the relative biosecurity awareness of different groups.

The results of this survey enable us to identify which groups of anglers and kayakers pose the greatest biosecurity risk in the UK so that awareness campaigns can be targeted towards those groups. Our results also provide a valuable baseline against which to evaluate the effectiveness of biosecurity education messages and enable us to parameterise laboratory experiments to empirically test the likelihood of transmission on different types of equipment.

NOTES

Evaluating the Risk of Direct Movement of Fishes through the Welland Canal

*Nicholas Mandrak and **Jaewoo Kim**, Fisheries and Oceans Canada*

The Welland Canal has been identified as a pathway for direct (dispersal) and indirect (shipping) bi-directional movement of aquatic invasive species between Lake Ontario and the remaining Great Lakes. Although substantial study is ongoing on the movement of AIS through the shipping vector, there has been virtually no study of the direct movement of AIS through the Welland Canal. The U.S. Army Corps of Engineers will be spending $25.5M by 2015 to evaluate the risk of AIS movement across 31 connections between the Great Lakes and Mississippi basins. However, the study does not evaluate the risk of AIS movement between Great Lakes. To effectively minimize the spread of NIS in the Great Lakes basin, a better understanding the risk of AIS movement through the Welland Canal is required to identify effective management options. In 2011, DFO conducted a pilot study to determine the best methods to sample fishes in the Welland Canal. Hydroacoustics indicated that many organisms are present in and around lock chambers. In 2012, DFO placed 30 acoustic receivers throughout the Welland Canal tagged 100 fishes. The results of the 2011 and 2012 field seasons will be presented.

NOTES

Fish Behavior and Abundance at the Electric Dispersal Barrier in the Chicago Sanitary and Ship Canal, Illinois, USA

***Aaron Parker**, P. Bradley Rogers, Jeffrey Stewart, Samuel Finney and Robert Simmonds Jr., U.S. Fish & Wildlife Service*

The Chicago Area Waterway System (CAWS) is a network of man-made canals and heavily-modified rivers that artificially link the Great Lakes and Mississippi basins. Following substantial water quality improvements, with the passage of the Clean Water Act, aquatic animals began colonizing the CAWS, which now serves as a potential conduit for inter-basin species exchange. In 2002, an electric dispersal barrier (Demonstration Barrier) began operating in the Chicago Sanitary and Ship Canal (CSSC) with the intention of inhibiting the downstream migration of round goby (*Neogobius melanostomus*) into the Mississippi Basin from Lake Michigan. In 2009 and 2011, Barriers IIA and IIB were installed, respectively. These barriers have higher voltage-producing capabilities and were installed in the CSSC with a new primary focus on preventing the upstream migration of bighead (*Hypophthalmichthys nobilis*) and silver carp (*H. molitrix*) from the Mississippi River Basin to Lake Michigan. One of these barriers operates at all times along with the Demonstration Barrier. When our work began in the summer of 2011, Barrier II was operating at 6.5 ms, 15 Hz, 2.0 V/2.54cm (2.0 V/2.54 cm). In November, 2011, barrier operating parameters were changed to 2.5 ms, 30 Hz, 2.3 V/2.54cm (2.3 V/2.54 cm). Experimental work at the barrier consisted of pulling encaged gizzard shad (*Dorosoma cepedianum*) through the barrier and recording their behavior throughout various points in and around the electric field. Three weeks of caged-fish trials took place while barrier operating parameters were at 2.0 V/2.54 cm. Seven of 270 gizzard shad (mean total length = 125.0 mm ± 2.8 SE) that were moved through the barrier were able to avoid becoming incapacitated, but did show behavioral changes in the form of erratic swimming at the highest voltages. After the barrier operating parameters were increased to 2.3 V/2.54 cm, seven additional weeks of caged-fish trials were performed and review and analysis is on-going. In addition, we conducted observational work that involved recording 10-minutes of footage at 80 different fixed locations throughout the barrier system using a dual-frequency identification sonar (DIDSON). Fixed recording locations covered the entire electrical field from downstream to upstream, starting with downstream areas of no in-water voltage, to areas directly within the highest in-water voltage directly above the barrier arrays, and upstream beyond the barrier, with no in-water voltage. Recorded DIDSON footage review is on-going and will examine fish behavior and wild fish abundance estimates by manual counting. Three DIDSON sampling events took place when barrier operating parameters were 2.0V/2.54 cm and five have taken place since parameters were changed to 2.3 V/2.54.

NOTES

Restoring the Natural Divide: Separating the Great Lakes and Mississippi River Basins in the Chicago Area Waterway System

Erika Jensen *and Tim Eder, Great Lakes Commission; Dave Ullrich, Great Lakes and St. Lawrence Cities Initiative*

For more than a decade federal and state agencies have been taking action to prevent Asian carp from reaching Lake Michigan via man-made waterways in the Chicago area. Many observers believe that a long-term and permanent solution to this threat is needed, and that this must entail separating the Great Lakes and Mississippi River watersheds, beginning in the Chicago area. Such a solution would protect these two great watersheds from the transfer of all AIS between the basins, not just Asian carp. Separation would avoid continued reliance on control measures that are considered, at best, imperfect and unreliable in the long term, while at the same time accommodating the substantial benefits currently provided by the Chicago waterway system. If done right, separation will be accomplished in a way that improves transportation and water quality, and ensures that flood management, tourism and recreational benefits currently provided by the CAWS are accommodated and enhanced.

Responding to this issue, the Great Lakes Commission and the Great Lakes and St. Lawrence Cities Initiative (GLC/Cities Initiative) developed the report, Restoring the Natural Divide, which outlines three alternatives for physically separating the Great Lakes and Mississippi River watersheds in the Chicago area. This report demonstrated that separation of the watersheds to prevent the movement of aquatic invasive species (AIS) is possible, while also maintaining or improving other beneficial uses of the waterway including transportation, water quality and flood management. The report, along with associated technical documents, provides a detailed evaluation of potential options for separation, including costs, benefits and impacts. The key goal is to demonstrate to Great Lakes policy leaders, including federal officials, that separation is feasible, practical, and effective by illustrating and analyzing realistic options to achieve it. The report also provides a characterization of baseline conditions for current uses of the waterway system, quantifying the existing system's costs and benefits to stakeholders in the Chicago area and the Great Lakes region in general. The GLC/Cities Initiative closely engaged with a broad stakeholder group to ensure a credible range of potential solutions was investigated and that benefits and costs of solutions were fully understood.

NOTES

Addressing the Champlain Canal as a Vector of AIS

Margaret Modley, *Lake Champlain Basin Program*

A significant number of the known 49 aquatic non-native and invasive species in Lake Champlain arrived through the Champlain Canal, which remains an open vector that connects the Hudson River and the Great Lakes systems to the Lake Champlain basin. The Water Resources Development Act of 2007 authorizes the U.S. Army Corps of Engineers to conduct a feasibility study for a Champlain Canal barrier, construct, and operate and maintain it. Partnerships between key Lake Champlain Basin stakeholders and the New York State Canal Corporation have led to the identification of shared goals in reducing the risk of aquatic invasive species spread. The recent discovery of spiny water flea in the Champlain Canal triggered the Lake Champlain Rapid Response Task Force to make recommendations about the feasibility of containment, eradication, and spread prevention for a species in the canal system. The scientific, state agency, public, media, and congressional response has brought more focused attention to addressing the Champlain Canal as a vector of aquatic invasive species spread.

NOTES

Examination of Asian Swamp Eels (Synbranchidae: *Monopterus* spp.) from Ethnic Food Markets in Florida, Georgia, New York and Four Wild Populations in New Jersey and Florida, for the Presence of Zoonotic Advanced L3 of *Gnathostoma* spp. (Nematoda)

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Over the last two decades large numbers of wild caught and farmed live swamp eels (*Monopterus* spp.) have been imported from countries in Asia into the United States and parts of Canada. The eels are sold in ethnic food markets and are on occasion retained live by customers. *Monopterus* spp. are not native to North America however there are five documented wild populations – all identified as belonging to the *Monopterus albus* species complex – in the continental United States. It is most likely that ethnic food markets are the source for all or most of the wild populations established in North America. There is no information on the species of parasites in eels from markets in the United States, therefore the potential for eels to serve as sources of non-native parasites or intermediate hosts of zoonotic parasites is not known. We examined a total of 114 swamp eel specimens, including: 47 *Monopterus* (Amphipnous) *cuchia* specimens obtained from markets in three different U.S. cities (Atlanta, Georgia [n = 12], Orlando, Florida [n = 25], and New York City, New York [n = 10]); and 67 wild-caught *Monopterus "albus"* taken from four separate wild populations, including three in Florida (Tampa Bay, Homestead and Miami populations) and from a lake in New Jersey. The eels were examined for the presence of advanced L3 of *Gnathostoma* spp. This nematode has been reported as a human pathogen at high prevalences in Mexico, Japan, Thailand and Vietnam. Liver, kidney, gastrointestinal tracts and musculature were separated and removed from eels immediately after euthanasia. Individual tissues were examined grossly then macerated and subjected to pepsin hydrochloric acid digest at 37° C for up to 24 h. Live *G. spinigerum*, which is native to Southeast Asia, were found in 42% (5) of the Atlanta, Georgia market eels, 20% (5) of the Orlando, Florida market eels, and 40% (4) of the New York City Chinatown Market eels. Some eels were infected with up to 12 *G. spinigerum*. Wild-caught eels from Tampa Bay were infected with *G. turgidum* and *G. lamothei* which have been reported in North, Central and South America and North America respectively.

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Interaction of a Chemical Stress and a Predation Risk on the Behaviour of Two Prolific Species: The 'Killer Shrimp' *Dikerogammarus villosus* and the Naturalised Amphipod *Gammarus roeseli*

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Predation is considered as a fundamental mechanism that controls a population dynamic in aquatic ecosystems. We investigated the influence of a chemical stress (cadmium, Cd, a non-essential heavy metal) on both antipredator behaviours in the invasive *Dikerogammarus villosus* and the naturalised *Gammarus roeseli* under laboratory conditions. Amphipod behaviour (i.e. refuge use, aggregation with conspecifics, exploration and mobility) was recorded following a 4-min test-exposure to a sub-lethal concentration with or without a 24-hrs Cd pre-exposure and in the presence or absence of a high perceived risk of predation (i.e. water scented by fish predators and injured conspecifics). Following behavioural tests, malondialdehyde (MDA) levels, as a biomarker of toxic effects, and energy reserves (i.e. lipid and glycogen contents) were assessed.

On both species, Cd exposures induced (1) cell damages as reflected by high MDA levels and (2) a depletion in energy reserves, highlighting that cadmium caused a toxic effect. Globally, no differences were observed between 4-min test-exposed and 24-h pre-exposed individuals. In response to chemical stress *Dikerogammarus villosus* exhibited an erratic behaviour quantified by decreasing refuge use and exploration, and increasing mobility, whereas *Gammarus roeseli* were less active than in control.

When exposed to predation risk, the two species increased the time spent in refuges but no one aggregated differently with conspecifics. *D. villosus*, which was the fastest in control water, stopped moving under predation risk. Both *G. roeseli* and *D. villosus* decreased their exploration activity and spend more time in refuge.

The two species exposed to Cd had a disturbed perception of the alarm stimuli. *D. villosus* increased the time spent outside of refuges and displayed a higher mobility compared to individuals exposed to unpolluted water. *G. roeseli* has a risky behaviour in presence of Cd and predation risk, with an increased time spent outside of refuges and that, without mobility.

Our results suggest that Cd exposure rapidly disrupts the normal behavioural responses of gammarids to alarm substances and strongly alters predator-avoidance strategies, which could have potential impacts on population dynamic of each species.

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Loss of Pathogens in an Island Population of the Killer Shrimp *Dikerogammarus villosus*

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Dikerogammarus villosus, an invasive amphipod, has recently been detected in UK fresh waters. To assess the potential for pathogen introduction with the invader, a year-long histopathology survey of the *D. villosus* population inhabiting the initial invasion site (Grafham Water, Cambridgeshire) was conducted. Additional samples were assessed from two other invasion sites within the UK (Cardiff Bay and the Norfolk Broads), and from continental invasions sites in France (River Rhine) and Poland (River Vistula). The cumulative data allowed for comparison of the pathogen profile between continental and island (UK) populations, revealing a range of known and novel pathogens. Several of these were not present within the UK populations. Pathogenic microsporidian parasites likely comprise a significant mortality driver for *D. villosus* within its native and Continental invasive ranges. The absence of this pathogen group in populations from UK sites may impart significant survival advantages to *D. villosus* over native fauna, increasing its success as an invader. The contrast in pathogen profile between UK and continental-invasive populations of *D. villosus* provide strong evidence for *'enemy release'* in the island populations and may reflect single-point, rather than continual incursion events in the case of the UK invasion. Furthermore, pathogen loss in UK populations of *D. villosus* provides an impetus to investigate the potential for biological control of invasive populations. By utilising natural enemies of *D. villosus*, lost through enemy release, a decrease in population success may reduce the invasive potential for this species, thereby benefitting native biodiversity.

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Impact of Invasive Crayfish on Macrophytes: Are Some Species Worse than Others?

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The number of exotic crayfish is rapidly increasing in Europe. In The Netherlands 10 crayfish species have been observed, from which one native species (*Astacus astacus*). The native species persists in a single pond, whereas multiple exotic species are spreading rapidly throughout the country. Whereas it is generally known that exotic crayfish can decrease the abundance of freshwater macrophytes and affect water quality negatively, it remains unclear whether all species of exotic crayfish have equally strong negative effects on the macrophytes.

Crayfish can affect macrophytes through direct consumption, bioturbation and deteriorating water quality. We tested the preferences for macrophytes or small crustaceans by feeding them to four species of exotic crayfish that are rapidly expanding in The Netherlands. In the field we documented the food web position of these crayfish species by sampling crayfish muscle tissue along with the abundant potential food sources and performing stable isotope analysis of the crayfish and the potential food sources. We found that there were differences in the willingness of the crayfish to consume macrophytes, which corresponded to their food web position in the field. Still, in the field all four crayfish species were mainly carnivorous. Subsequently, we tested the impact of two of these crayfish, *Procambarus clarkii* and *Orconectus limosus*, on the growth of macrophytes and nutrient turnover in mesocosms. We used two macrophyte species (rooted and non-rooted) and two sediment types (peat and sand) to test whether the robustness of the macrophyte vegetation depended on sediment and macrophyte species. We found that the crayfish particularly affected the rooted plant species and increased nitrogen cycling in the mesocosms. This effect was stronger for *P. clarkii* than for *O. limosus*, which corresponded to their feeding preferences in the lab. Finally, we tested whether exotic crayfish could be a novel factor limiting macrophyte recovery in lake restoration. We performed an enclosure and exclosure experiment in a restored peat lake where *P. clarkii* became particularly abundant during the last decade. As no vegetation had developed spontaneously, despite clear water conditions, we introduced macrophyte plants inside and outside the cages. We found that crayfish strongly reduced macrophyte growth in enclosures and thus have a strong potential impact on macrophyte establishment. With factorial exclosures we could show that macrophyte growth was strongly limited at natural crayfish densities, whereas waterfowl and fish had no additive effects to the crayfish impact.

We conclude that invasive crayfish *P. clarkii* may strongly inhibit macrophyte development once favourable abiotic conditions for macrophyte growth are restored. Strong emphasis should be put on the prevention of crayfish introduction and their expansion. Once present, crayfish are very difficult to control and may pose constraints on the successful development of submerged aquatic vegetation.

NOTES

Third Prototype Shipboard Filter Skid (p3SFS): Results of Shipboard Installation and Testing

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To reduce the transport and delivery of aquatic nuisance species, the United Nations International Maritime Organization and the United States Coast Guard are promulgating standards for the allowable concentrations of living organisms in vessels' discharged ballast water. Regarding organisms ≥ 50 µm in minimum dimension (nominally zooplankton, but also including protists and microinvertebrates), < 10 organisms may be discharged per m^3 of ballast water. To obtain valid estimates of such sparse concentrations of organisms, relatively large volumes of water (i.e., cubic meters) must be concentrated and evaluated. Plankton nets are commonly used—both at land-based ballast water test facilities and during shipboard testing—to concentrate aquatic organisms. An alternative approach is to use an array of closed filter housings, each containing a filter bag (i.e., a filter skid). The third prototype of a shipboard filter skid (p3SFS) was recently designed, constructed, and validated at a land-based test facility and subsequently installed aboard a bulk carrier operating in the Great Lakes, the M/V Indiana Harbor (owned and operated by the American Steamship Company). The p3SFS contains two filter housings arranged in parallel. The filter skid also accommodates a 'drip sampler', that is, a port immediately upstream of the filter housings used to collect whole (unfiltered) water. The presentation by Moser et al. will discuss the design specifications for the p3SFS, while this presentation will discuss the engineering and biological results from shipboard trials conducted in May 2012. Three successful sampling events occurred over the course of one deballasting operation aboard the vessel. The sample flow rate through the p3SFS, which was automatically logged every second, was relatively constant around the target flow rate of 50 gpm (189 L min^{-1}), with coefficients of variation < 20%. The differential pressures across each filter housing, which were logged every second, were all lower than 4.5 psi (31 kPa). For biological analyses, samples collected in the two filter bags were pooled into a single sample and compared to a sample of whole water collected from the drip sampler. Although the volumes of the samples differed (the total water volume filtered through both filter bags was 4.8 – 5.1 m^3, and the volume collected by the drip sampler was 4 – 5 L), it was useful to compare the mortality and the community composition between the samples. Mortality was < 3% in both types of samples. Additionally, there was no qualitative difference in the community composition between the filter bags and the drip sampler. In both cases, the community of living organisms ≥ 50 µm was dominated by soft-bodied organisms (rotifers and ciliates). In the final sampling event, high concentrations of living, motile organisms (> 2 x 10^5 individuals m^{-3}) were recovered, demonstrating the p3SFS is capable of capturing relatively small (50 – 100 µm), soft-bodied organisms. Based on these data (and the results from land-based trials, which are not discussed here), the p3SFS is a valid device for collecting samples from an in-line flow stream, such as piping used to transport ballast water aboard ships.

Life after Treatment: Detecting Viable, Aquatic Microorganisms Following Exposure to UV Light and Chlorine Dioxide

Matthew First[1], *Lisa Drake*[2], *Scott Riley*[1], *Stephanie Robbins-Wamsley*[1], [1]*SAIC, Inc.;* [2]*U.S. Naval Research Laboratory*

Limits on the concentration of living organisms in several size classes—including ≥ 10 µm and < 50 µm (nominally protists) and <10 µm (here, a pathogen and two indicator microorganisms)—are central to U.S. regulations and proposed international regulations for vessels' ballast water discharges. For these size classes, the most definitive approach to determine the number of living organisms is to use regrowth assays, in which microorganisms (i.e., microalgae and bacteria) are cultured in the laboratory to verify viability. Regrowth assays, however, are time-consuming and applicable only to those organisms amenable to culturing. Rapid analytical methods are needed to distinguish between living and dead organisms in ballast water after treatment, and the purpose of this study was to evaluate potential alternative approaches to regrowth assays.

Ambient organisms from an oligotrophic, marine environment as well as laboratory cultures of marine microalgae were used to determine their response to two simulated ballast water treatments: exposure to UV light and dosing with chlorine dioxide. Samples were measured using standard regrowth assays and epifluorescence microscope counts of organisms labeled with a combination of two vital stains; both assays are time consuming, requiring hours to weeks to complete. Additionally, samples were evaluated by determining the concentration of the universal molecule for energy storage, adenosine triphosphate (ATP), which was measured with a portable, handheld luminometer. Finally, samples were assessed using pulse amplitude modulated (PAM) fluorometry with a portable, handheld instrument. Both the ATP and PAM analyses were rapid, requiring minutes to complete.

In samples treated with UV light, ATP was not predictive of regrowth of microalgae, and in some cases, intermediate dosages of UV led to an increase in ATP concentrations. However, concentrations of ATP decreased with increasing chlorine dioxide concentrations, and ATP was significantly lower in samples treated with 10 ppm of chlorine dioxide than in untreated samples. The response of both ambient organisms and mixed microalgal cultures to UV and chlorine dioxide was evident in PAM measurements of photochemical yield (Y). However, initial values of Y were variable and species-specific; for example, the Y measured from actively growing cultures ranged from 455 ± 1 (mean ± 1 SD, n = 3) for the phytoflagellate *Tetraselmis marina* to 712 ± 4 for the dinoflagellate *Prorocentrum micans*. In some instances, the initial fluorescence (F0; a proximal measure of chlorophyll a concentration), increased at intermediate UV dosages; this phenomenon could lead to an overestimation of total biomass. For mixed assemblages, variations between species resulted in data that could not be easily interpreted. In sum, some approaches for assessing organisms in ballast water discharges (e.g., ATP) may not be suitable for all ballast water treatments, although PAM fluorometry shows promise for use with the treatments tested in this study. Regardless, analyzing complex samples, such as those collected from ballast water, will require a deeper understanding of the approaches' limits and their sensitivities, as well as rigorous validation of all approaches.

What is the Uncertainty Associated with the Measurements of Living Organisms' Concentrations at Ballast Water Test Facilities?

***Lisa Drake**, U.S. Naval Research Laboratory; Scott Riley, Stephanie Robbins-Wamsley, Matthew First, SAIC, Inc.; Evan Parson, Vision Point Systems*

To address the issue of transporting and delivering potential aquatic nuisance species by ships' ballast water, the United Nations International Maritime Organization (IMO) and the United States Coast Guard (USCG) are promulgating standards for the allowable concentrations of living organisms in vessels' discharged ballast water. In response, vendors are developing ballast water management systems (BWMS) to treat ballast water. To verify the performance of BWMS, the USCG and the U.S. Environmental Protection Agency's Environmental Technology Verification (ETV) Program—along with input from stakeholders and technical experts, and informed by a series of full-scale experiments—developed and published the ETV protocol for the land-based testing of BWMS, with the goal of generating reliable, reproducible results.

Verifying the efficacy of BWMS at land-based test facilities is not an easy task. First, large volumes of water (≥ 200 m^3) moving at high flow rates (≥ 200 $m^3\ h^{-1}$) are needed to replicate shipboard conditions, and the volumes and flow rates must be accurately measured. Thus, a large facility with multiple large tanks, and at least some degree of automation to measure physical parameters (flow rate, pressure, etc.), is necessary. Additionally, the difficulty of accurately counting living organisms in treated water is pronounced. In the IMO and USCG discharge standards, the requirement for the largest size class of organisms presents a challenge: each m^3 of treated water must contain < 10 living organisms ≥ 50 µm (nominally zooplankton, but including large phytoplankters as well). To estimate the concentration of these sparse organisms with statistical confidence, relatively large volumes of water (i.e., cubic meters) must be filtered while inducing minimal mortality to living organisms.

It follows that in any procedure as complex as BWMS testing there are many opportunities to induce error, which can be defined in general terms as the inevitable uncertainty contained within any measurement. While this uncertainty can be introduced through a variety of mechanisms, it is important to note that it cannot be eliminated. As such, an uncertainty analysis may be used to estimate the overall error of a process and ensure that such errors are reduced as much as possible. Furthermore, error propagation analysis allows researchers to examine how error compounds (i.e., propagates) through equations involving measurements that contain individual error terms.

The purpose of this work was to construct a model to assess the uncertainty associated with measurements of living organisms at a land-based test facility. Using the facility at the Naval Research Laboratory in Key West, FL, USA as a template, the model was applied. Here, historical data were used to inform the model, and laboratory experiments were performed to assess sampling and analysis error.

The 'Sample Port Calculator': A Design and Analysis Tool for Ballast Water Sampling Ports

***Jonathan Grant**, Battenkill Technologies, Inc.; Cameron Moser and Lisa Drake, U.S. Naval Research Laboratory; Timothy Wier, U.S. Naval Research Laboratory-Excet Incorporated*

The United States Coast Guard (USCG) and the International Maritime Organization (IMO) G2 guidelines require both land-based and shipboard testing of ballast water management systems (BWMS) to receive Type Approval. Protocols for both types of testing call for the use of in-line sample ports to collect time-integrated samples of ballast flows. While the USCG has provided guidance for the design and installation of sample ports that result in sub-isokinetic flows from a main ballast line (Richard et al., 2008), the design guidance is specific for a single set of flow conditions, and on vessels, a range of flow conditions and desired sample volumes will likely be encountered. Thus, multiple calculations are needed to examine the tradeoffs over various flow regimes and sample volumes. Calculations are further complicated when converting between U.S. standard units, metric units, and associated standard piping sizes. Recognizing the need for a tool to simplify, guide, and standardize the design process, a Sample Port Calculator (SPC) was created using Microsoft Visual Basic. The SPC runs within and is saved as an Excel™ spreadsheet.

The SPC allows users to input various parameters—main ballast flow, main ballast line diameter, sample flow, and either sample time or sample volume—to determine the optimal sample port diameter using standard, commercial-off-the-shelf (COTS) pipe sizes, consistent with USCG guidance and the protocol for land-based testing of BWMS. Along with this basic function, the SPC automatically generates graphics to visually examine the tradeoff between design parameters and illustrates the overlap in acceptable flow regimes for multiple port diameters. The user interface was designed to simplify and standardize the sample port design process by providing the user with immediate tabular and graphical feedback to parameter choices, including the valid operational ranges for all sample port sizes. Models used to design a sample port can be printed and saved for subsequent recall. This process allows the user to examine the valid range of sample conditions in a given ballast pipe, for example, at different flow rates encountered when using one vs. two ballast pumps, or to examine how a single size port might operate in two different ship ballasting systems.

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The Canadian Aquatic Invasive Species Network II (CAISN) is comprised of university and government based scientists with expertise in various aspects of aquatic invasive species (AIS), in collaboration with industries and NGOs. The Network is in its second term of funding, following highly successful achievements in the study of the vectors of invasion and in improving our understanding and management of AIS in CAISN I (2006-2011). The Network allowed universities, government agencies, NGOs, and industry to address AIS issues in a highly collaborative and efficient manner. CAISN I achieved substantial breakthroughs in invasion ecology, a number of which have had influence on government policy in Canada.

CAISN's research and administration is overseen by a Scientific Steering Committee and Board of Directors ensuring CAISN's partners and stakeholders are well represented. Training of a highly talented pool of graduate students and postdoctoral fellows with specialization in aquatic invasive species is a key outcome of the network and is providing them access to world-renowned lake and marine ecologists, modellers, mathematicians and statisticians whom will explore AIS issues under the following research themes:

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Using state-of-the-art techniques, CAISN II will be addressing the need for post-incursion detection of AIS.

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AIS As Part of Multiple Stressors
Multiple stressors affect aquatic ecosystems, though their interactions with AIS are not known. CAISN II will explore key stressors, such as climate change, and their interactions in lake, river and coastal marine ecosystems.

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Fisheries and Oceans Canada is a key partner and leading scientific contributor to the ICAIS 2013 in areas of invasive species risk assessments and vector analyses, and is currently focusing on Asian carps, ballast water, live trade, and the role of baitfish in invasion scenarios. Expertise is provided through the Centre of Expertise for Aquatic Risk Assessment (CEARA), established in 2006 to evaluate the biological risks of invading species and provide key advice to the department. The Centre brings experts together to carry out risk assessments nationwide and assess threats posed by both existing and potential invader species to Canadian waters. In addition, the department's Sea Lamprey Control Centre continues its work as the Canadian agent of the Great Lakes Fishery Commission, and is responsible for keeping Sea Lamprey populations in the Great Lakes basin at a minimum.

For more information on CEARA, see our website at http://www.dfo-mpo.gc.ca/science/coe-cde/ceara/index-eng.htm

For more information on the Sea Lamprey Control Centre, see our website at http://www.dfo-mpo.gc.ca/regions/central/science/sea-lamprey-lamproie-mer/index-eng.htm

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FujiFilm Hunt Smart Surfaces, LLC develops, manufactures, markets and sells advanced technology silicone coating systems formulated for the purposes of combating aquatic biofouling organisms and enhancing the performance and efficiency of marine vessels and immersed equipment and structures of power generation and water/wastewater treatment facilities.

The FujiFilm Hunt Smart Surfaces' advanced silicone Duplex Fouling Release Coating System technology combats fouling in fresh or salt water by indigenous or invasive aquatic organisms such as barnacles, zebra mussels and quagga mussels. And the combating takes place without the use of toxins, poisons or heavy metals! Additionally, power generating and water/wastewater plant owners and operators will experience enhanced performance and operating efficiencies from immersed equipment and structures due to the superior hydrodynamic properties of the silicone topcoat. The highly durable Duplex system is versatile and can be easily applied to almost all properly prepared substrates including ferrous and non-ferrous metals, poured and precast concrete, fiberglass, wood and high density plastics.

In addition to combating fouling and improving flow efficiency, employing the technology has the potential to:

- reduce maintenance costs and down time
- improve revenues from operations
- achieve eco-sustainable objectives
- provide significant return and rapid payback on investment in the technology

Great Lakes Fishery Commission

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The Great Lakes Fishery Commission is an international organization established by the United States and Canada through the 1954 Convention on Great Lakes Fisheries. The commission was established partially as a response to one of the most noxious invaders to enter the Great Lakes system: the sea lamprey. Sea lampreys, primitive fish parasites native to the Atlantic Ocean, invaded the Great Lakes through shipping canals in the early 1900s. Lacking predators, sea lamprey were able to wreak catastrophic damage on the ecosystem and cause significant economic harm to the fishers of the region. The commission's control program has been successful, reducing sea lamprey populations by 90% in most areas of the Great Lakes.

The convention also directs the commission to formulate a coordinated bi-national research program. The program goals are to identify ways to nurture the maximum sustained productivity of Great Lakes fish stocks and, based on that research, to recommend specific management initiatives to the governments. The commission's research program is based upon two broad priorities: research in support of healthy Great Lakes ecosystems and research in support of sea lamprey control. Additionally, the commission directs and supports projects designed to transfer science to managers.

Finally, the commission is charged with facilitating the implementation of A Joint Strategic Plan for Management of Great Lakes Fisheries, a provincial, state, and tribal fisheries management agreement. While there exists no binding, centralized authority to compel cooperative fishery management on the Great Lakes, the jurisdictions realize that the Great Lakes fishery is interconnected and the actions of one jurisdiction affect the others. To manage the resource in this unique setting, the sub-national governments developed and adhere to The Joint Strategic Plan, an agreement that calls for cooperation among the jurisdictions, development of shared fish community objectives, data sharing, and adherence to ecosystem management.

Invasive Species Centre

Catalyst for research and response

Canada-Ontario Invasive Species Centre

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The Invasive Species Centre (ISC) is a not-for-profit entity which is co-located with the Great Lakes Forestry Centre in Sault Ste. Marie, Ontario, Canada. The ISC was established in March 2011 to enhance coordination of natural and social scientific research as well as information and technology transfer within the broad invasive species network.

The projects supported by the ISC, by way of an annual call for proposals, are related to invasive species prevention, early detection, rapid response, and/or management. While the immediate focus of the ISC is Ontario and the Great Lakes, there are linkages to adjacent provinces, the U.S. Great Lakes states, and international partners.

The ISC is currently supporting projects related to aquatic invasive species including, but not limited to Asian carp, round goby, water soldier, and water chestnut. For more information, visit www.invasivespeciescentre.ca or contact us at (705) 541-5771.

The International Joint Commission

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The International Joint Commission prevents and resolves disputes between the United States of America and Canada under the Boundary Waters Treaty of 1909.

It does so through making fact and science-based findings and recommendations in reports to the governments and public, responding to formal requests from the two national governments called "references" and approving applications regarding structures affecting transboundary waters.

The IJC also has a role under the Great Lakes Water Quality Agreement (Agreement) where the United States and Canada commit "to restore and maintain the chemical, physical and biological integrity of the waters on the Great Lakes Basin ecosystem." Given that biological integrity was threatened by Aquatic Invasive Species, in 1988, both the Great Lakes Fishery Commission (GLFC) and the International Joint Commission (IJC) alerted the governments that aquatic alien invasive species (AIS) in ballast water posed a significant threat to the Great Lakes. While they recognized that new and continuing investigations of all vectors and prevention strategies were needed, the more immediate concern of AIS introductions from ballast water discharge was the focus of subsequent IJC reports.

Recently revised by the parties, Annex 6 of the 2012 Agreement commits Canada and the United States to use a binational prevention-based approach informed by risk assessments to develop appropriate measures to eliminate new introductions of aquatic invasive species into the Great Lakes.

To support this annex, the IJC has taken action to develop a pilot binational AIS rapid response plan with input from representatives of affected U.S. and Canadian jurisdictions. Great Lakes Restoration Initiative funding enabled the IJC to take this important step, which provides a foundation for further planning and binational response coordination under Annex 6. While the IJC recognizes that prevention is a top priority, rapid response planning is a necessary and responsible precautionary measure.

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Marrone Bio Innovations, Inc. (MBI) is a leading provider of biopesticides for use in water and agricultural applications to control pests, weeds, and plant diseases. MBI developed ZEQUANOX® to address the increasing economical and ecological impact of invasive aquatic mussels. The company is also developing solutions for the control of algae and aquatic weeds.

Recognized as a ground-breaking innovation in water technology, Zequanox is the industry's only EPA-approved, biological molluscicide for controlling zebra and quagga mussels (*Dreissena* species). Composed of killed cells from a ubiquitous soil microbe (*Pseudomonas fluorescens*), Zequanox is highly selective; and while lethal to zebra and quagga mussels, it poses no risk to humans, infrastructure, or the environment. Zequanox is nonpersistent and toxicology studies demonstrate that at concentration levels that produce mussel mortality of 76–100%, no product-induced mortality occurs in non-targets, including algae, fish, mollusks, or crustaceans. Zequanox can be used in a broad range of water conditions and temperatures, and has been proven effective for controlling adult mussels as well as reducing settlement. Trials are also underway to validate its effectiveness in controlling veligers (the planktonic life stage of mussels).

Zequanox was registered by the U.S. EPA in March 2012 for use in closed or semi-closed systems, such as service water and irrigation systems, and can now be used as a safer alternative to chlorine and quaternary ammonium compounds to control mussel populations. Unlike chemicals, Zequanox is safe for workers and has minimal use restrictions and permitting requirements. In addition, it is noncorrosive, so it won't harm equipment, and its use does not require detoxification upon discharge.

Ontario Federation of Anglers and Hunters
Invading Species Awareness Program
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The Ontario Federation of Anglers and Hunters (OFAH) was founded in 1928 due to concern over the future of Ontario's natural resources. It is Ontario's largest, nonprofit conservation based organization, representing 100,000 members, subscribers and supporters, and 710 affiliated conservation clubs. OFAH members enjoy various outdoor pursuits, but share a common interest in sustaining our natural resources and the quality of life that healthy resources make possible. As a result, for over eighty-five years, the OFAH has supported programs to conserve and restore fish and wildlife habitat and maintain the public's positive image of ethical resource users.

Recognizing the impacts of invasive species and the role of outdoor enthusiasts in their introduction and spread, the OFAH initiated the Invading Species Awareness Program (ISAP) in 1992 in partnership with the Ontario Ministry of Natural Resources (OMNR). Our objective is to raise public awareness of invasive species and to engage their support and participation in prevention, monitoring and control measures. The program is focused on the primary pathways of invasion and encourages citizen reporting of invasive species via the toll-free Invading Species Hotline and on-line reporting system (www.eddmaps.org/ontario). Through our partnership with the Government of Ontario delivering our province-wide program, the ISAP has become a leader in invasive species education and awareness in Ontario, and achieves enormous success in raising the profile of invasive species by working with industry leaders, government agencies, other ENGOS, universities, and a variety of community groups to reach our target audiences.

For more information on the OFAH/OMNR Invading Species Awareness Program, please visit www.invadingspecies.com, or call the Invading Species Hotline at 1-800-563-7711.

Ontario Ministry of Natural Resources

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The Ontario Ministry of Natural Resources (OMNR) works to promote healthy, sustainable ecosystems and conserve biodiversity. OMNR conducts scientific research and applies the findings to develop effective resource management policies. The OMNR is responsible for managing the fisheries of Ontario and works with partners and agencies to protect, restore and sustain Great Lakes and inland fish species and populations through planning, regulation, scientific study, stocking, and stewardship.

OMNR has the lead provincial role to prevent the introduction, establishment and spread of aquatic invasive species and the negative effects they have on Ontario's environment, economy and society. MNR's responsibilities include:

- leadership and coordination of inter-agency activities to prevent, detect, respond and manage the threat of aquatic invasive species,
- development and enforcement of legislation and policy,
- risk analysis,
- response planning,
- monitoring and science,
- development of management measures, and
- communications and outreach to the public.

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Ontario Power Generation produces about 60 per cent of the electricity used in Ontario. More than 95 per cent of OPG's generation is free of greenhouse gas causing emissions, making it an environmentally-friendly provider of power to Ontario's schools, hospitals, businesses and homes.

We operate 73 generating stations in communities across Ontario and employ about 11,000 people who are active members of the communities they live and work in.

OPG is committed to operating in a safe, efficient, open and environmentally-responsible manner.

Pacific States Marine Fisheries Commission

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Established in 1947 by consent of Congress, the Pacific States Marine Fisheries Commission (PSMFC) is an interstate compact agency that helps resource agencies and the fishing industry sustainably manage our valuable Pacific Ocean resources in a five-state region. Member states include California, Oregon, Washington, Idaho, and Alaska. Each represented by three Commissioners.

ST. LAWRENCE SEAWAY
VOIE MARITIME DU SAINT-LAURENT

The St. Lawrence Seaway Management Corporation
Corporation de Gestion de la Voie Maritime du Saint-Laurent

www.greatlakes-seaway.com

The Great Lakes St. Lawrence Seaway System is a deep draft waterway extending 3,700 km (2,340 miles) from the Atlantic Ocean to the head of the Great Lakes. It was built as a binational partnership between the U.S. and Canada, and operates as such. Since the Seaway is a gateway to the Great Lakes and thus, the heartland of North America, understanding and minimizing the impact of marine transportation on the environment is critical to the Seaway System. Administration of the system is shared by two entities.

The Saint Lawrence Seaway Development Corp. in the U.S., is a wholly owned government corporation within the U.S. Department of Transportation created by statute May 13, 1954, to construct, operate and maintain that part of the St. Lawrence Seaway between the Port of Montreal and Lake Erie, within the territorial limits of the United States.

The St. Lawrence Seaway Management Corporation in Canada, is a not-for-profit corporation (ownership of the Canadian portion of the Seaway remains with the Canadian federal government) responsible for the safe and efficient movement of marine traffic through the Canadian Seaway facilities, which consists of 13 of the 15 locks between Montreal and Lake Erie.

The two Seaway entities provide 24-hour, year-round coordination of operational activities, particularly with respect to rules and regulations, overall day-to-day operations, traffic management, navigation aids, safety, environmental programs, operating dates, and trade development programs. For more information, visit the binational web site at www.greatlakes-seaway.com.

University of Florida-IFAS Center for Aquatic and Invasive Plants

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The Center was established by the Florida legislature in 1978 and serves as a multi-disciplinary research, teaching, and extension unit directed to: develop environmentally sound techniques for the management of aquatic and natural area weed species; coordinate invasive aquatic plant research; and provide education and outreach about the impacts and management of invasive plants. Utilizing expertise from many departments within UF/IFAS and its Agricultural Research and Education Centers around the state, much of our outreach is disseminated through the following websites:

- http://plants.ifas.ufl.edu – CAIP's main website has been online since 1995 and includes news about aquatic plant management, links to special projects, educational publications, field guides, photographs and information on more than 500 plant species.
- http://plants.ifas.ufl.edu/manage – Provides a comprehensive overview of aquatic plant management in Florida freshwater environments, visitors gain an in-depth look at the many factors taken into account by plant managers who must keep invasive plants at low levels while also protecting Florida's unique aquatic habitats.
- http://plants.ifas.ufl.edu/education – Developed for educators, this website provides the resources needed to teach our next generation about the harmful impacts of invasive plants and issues related to natural resource management. The Center worked with dozens of teachers around the state to develop core presentations, hands-on lessons and activities, all of which correlate to the Florida Sunshine State Standards (and are soon to be correlated to national Common Core State Standards).*
- http://plants.ifas.ufl.edu/APIRS -- The Aquatic Plant Information Retrieval System is a (free) searchable bibliographic database with 80,000 annotated citations for scientific articles and reports on aquatic, wetland and inva¬sive plants and their management.
- http://plants.ifas.ufl.edu/assessment/ – In response to threats posed by invasive plant species, the UF/IFAS Invasive Plants Working Group developed the IFAS Assessment of Non-native Plants in Florida's Natural Areas to provide consistent recommendations concerning the use of non-native and potentially invasive plants in Florida.

**http://www.corestandards.org/*

Environmental Laboratory
US Army Engineer Research and Development Center

U.S. Army Engineer Research and Development Center, Environmental Laboratory

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The Environmental Laboratory at the U.S. Army Engineer Research and Development Center, Vicksburg, MS, is the problem solver for the U.S. Army Corps of Engineers and the Nation in environmental science and engineering. The laboratory supports the environmental missions of the U.S. Army, the Department of Defense, and the Nation through research, development, special studies, and technology transfer. The Environmental Laboratory conducts multi-disciplinary research in environmental quality and ecosystem restoration. Research activities include: evaluating and projecting the consequences of water resources development, navigation, and dredging on the environment; developing improved tools and metrics for environmental benefits analysis; assessing and restoring wetlands; evaluating and modeling inland and coastal water quality; guiding stewardship of natural resources; developing tools for cleanup of contaminated groundwater and soils; developing techniques to improve stream and riparian restoration; accelerating growth of desirable vegetation/habitat; implementing risk and decision frameworks in planning; forecasting potential impacts from climate change and sea level rise on coastal ecosystem restoration, identifying and applying biological, chemical, and physical control strategies for the management of nuisance and invasive aquatic plants and animals; applying risk-based contaminated sediment and soil toxicological assessment protocols; and performing upland disposal testing and assessment for dredged material.

Presenter Biosketches

Vinícius Abilhoa

Vinícius Abilhoa received his Ph.D. from the Federal University of Parana in 2004. He is the curator of the Fish Collection of the Capão da Imbuia Natural History Museum in Southern Brazil. His research includes taxonomy, inventory of fish species and aquatic ecosystem diversity. He is interested in ecology and management of invasive species.

Jennifer K. Adams

Jennifer graduated from the University of Toronto with a M.Sc. in physical geography in 2009. She has been working as an Aquatic Science Technician with Fisheries and Oceans Canada since October 2010. Her primary project since that time has been to determine the utility and efficiency of viability stains on microorganisms, for use in compliance testing of ballast water. Jennifer's areas of interest include freshwater ecology, aquatic invasive species, microscopic organisms, ballast water as a vector for NIS introduction, and environmental stressors on freshwater systems.

Jon Amberg

Jon Amberg holds a Doctoral degree in Animal Physiology for the University of Idaho and Master's degree in Fisheries from Michigan State University. At present, he works with development of new tools to monitor and control aquatic invasive species. His research activities combine the use of conventional methodologies with modern molecular techniques to better understand differences in biology and physiology of different species. His current projects include the development of species-specific controls for filter-feeding aquatic animals and the refinement of the use of environmental DNA as a monitoring tool for invasive fishes.

Lucy Anderson

Lucy Anderson is a second year Ph.D. student in the School of Biology at the University of Leeds, UK. In collaboration with CEFAS, her research focuses on the introduction and spread of freshwater pathogens by invasive species – in particular non-native crayfish – and humans. She is particularly interested in the role that recreational water users may be playing in the inadvertent spread of both aquatic invasive species and aquatic pathogens and is combining social research, fieldwork and laboratory experiments to explore this area. Prior to beginning her Ph.D., Lucy completed an M.Res. in Ecology and Environmental Management at the University of York, UK, and worked on research projects investigating chytrid disease in amphibians and bovine tuberculosis in wild boar.

Robert Baier

Robert Baier is a Ph.D. Biophysicist and Licensed/Certified Professional/Environmental Engineer, currently Professor and Director of the Biomaterials Graduate Program at SUNY Buffalo, U.S.A., where he specializes in development of nontoxic, nonpolluting coatings that must remain compatible with biological systems over the long term. As a 1966-68 Post-Doctoral Associate at the Surface Chemistry Branch of the U.S. Naval Research Laboratory, he was the first to identify the specific range of Critical Surface Tension that correlates with minimal bio-adhesion through least-denatured protein 'conditioning films'. He now advocates controlling the interior ship fouling of ballast water bio-films by using the same nontoxic principles that have been successful in minimizing bio-fouling by barnacles, tubeworms, mussels, and algae in waters of all salinities. ONR, NSF, and NOAA/Sea Grant have supported these studies.

Sarah Bailey

Dr. Sarah Bailey is a Research Scientist with Fisheries and Oceans Canada, recognized globally for her work on ship-mediated aquatic invasive species in the Great Lakes. Sarah is Chair of the ICES/IOC/IMO Working Group on Ballast and Other Ship Vectors, a Principal Investigator with the Canadian Aquatic Invasive Species Network, and an Adjunct Professor at the Great Lakes Institute for Environmental Research (Windsor) and the University of Toronto (Scarborough). Working mainly with ballast water and plankton, her research interests include identifying vectors and pathways of introduction, risk assessment and developing/evaluating strategies to prevent new invasions.

Elisabeth Bakker

Elisabeth Bakker obtained her M.Sc. degree at the University of Groningen and her Ph.D. at Wageningen University (both NL). She did postdocs at the University of Nebraska (U.S.A.), University of Alberta (Canada) and the Netherlands Institute of Ecology (NIOO-KNAW), where she currently holds a position as senior scientist. Her research focuses on the impact of herbivores on plant diversity and ecosystem functions. In freshwater systems she investigates the palatability and the ecosystem functions of exotic versus native macrophytes and the impact of exotic and native omnivores on macrophytes and water quality. She combines lab- and mesocosm work with field work and studies a diversity of herbivorous omnivores including snails, crayfish, fish, waterfowl and muskrats. Her work contributes both to fundamental science as well as management practice.

Nancy Balcom

Nancy Balcom is the Associate Director and Extension Program Leader for Connecticut Sea Grant, University of Connecticut. She has conducted outreach programming focused on aquatic invasive species since 1992. An appointed member of the Northeast ANS Panel of the ANS Task Force since its inception in 2001, she served as marine co-chair in 2011 and 2012. Balcom served on the federal Invasive Species Advisory Committee from 2008 to 2011. Balcom co-authored the State of Connecticut ANS Management Plan and serves on the Steering Committee overseeing its implementation. She also led the development of a draft interstate AIS management plan for Long Island Sound.

Daniel Barrios-O'Neill

Daniel Barrios-O'Neill previously worked for the Environment Agency in Northern Ireland, where he was a professional marine ecologist working on invasive species. Daniel is currently studying for a Ph.D. at Queen's University, Belfast. His research to date has focused on the impacts of invasive crustaceans from the Ponto-Caspian region, which continue to spread throughout Europe and North America. His work is part of an on-going collaborative effort between Queen's and the Universities of Windsor and McGill in Canada.

Martina Beck

Martina is a 2nd year Master's student in the School of Environmental Studies at the University of Victoria. Her research project is looking at the feeding and habitat preferences of non-native smallmouth bass in lakes throughout British Columbia. Martina did her B.Sc. in biology with a focus on marine biology and has work experience in the fields of fisheries monitoring and marine aquaculture. She has a strong passion for spending time outdoors and enjoys hiking, camping and SCUBA diving.

Jean-Nicolas Beisel

Jean-Nicolas is an associate professor (LIEC Laboratory) at the University of Lorraine (France) where he teaches population ecology, zoology and environmental parasitology. Aquatic ecologist with expertise in freshwater research and management, river restoration, biological invasion and ecotoxicology, he is responsible of a Master degree in Biodiversity, Conservation & Restoration. His research interests focus on the ecology of aquatic invasive species, specifically crustaceans and molluscs, the role of parasitism in ecological functioning, and the use of behavioural biomarkers to reveal a biotic or abiotic stress. Currently he is developing a project concerning the functional impact of invasive species on trophic food web.

Amy Benson

Amy Benson is a fishery biologist and GIS specialist with the U.S. Geological Survey where for the past twenty years she has been part of team maintaining a database on non-indigenous aquatic species for the entire United States. This involves data acquisition, storage and retrieval, and analysis. Her recent project involves looking for trends in population distributions of exotic fishes in the southeastern U.S. Amy received both Masters and Bachelors degrees from The Pennsylvania State University.

Boris Beric

Boris received his B.Sc. in General Science and in Biochemistry from the University of Windsor (2010). He is currently in his second year of the Environmental Science M.Sc. program at the Great Lakes Institute for Environmental Research (GLIER), University of Windsor, under the supervision of Dr. Hugh MacIsaac. Boris' research interest lies in biological invasions by aquatic invasive species (AIS). His project focuses on management of AIS around the world with an emphasis on key factors affecting rapid response programs.

Kiley Best

Kiley is a M.Sc. Candidate and fisheries technologist with the Center for Fisheries Ecosystems Research at the Marine Institute of Memorial University. She has a background in aquaculture and marine science and is the aquatic Invasive Species specialist for the Marin Institute campus. Her research focuses on green crab population life history and mussel aquaculture interactions in Newfoundland Canada.

Luiza Bielecka

Luiza Bielecka has obtained a Master's degree and a Doctorate degree in Earth Sciences (scientific discipline – oceanography) from the University of Gdańsk (Poland). In both cases she performed research on biology and ecology of marine zooplankton from the polar seas (Antarctica), especially planktonic crustaceans and chaetognaths. She is currently working as a researcher in the Department of Marine Plankton Research (Institute of Oceanography, University of Gdańsk). Her main scientific interests are:

- character of non-native species expansions to the Baltic Sea,
- role of alien species in Baltic waters,
- anthropogenic pressure on functioning and structure of pelagic fauna with special regard to health condition of dominating zooplankton species,
- zooplankton as an indicator of environmental changes in Baltic ecosystem,
- life strategy of mass occurrence polar zooplankton species in connection with global and local environmental changes.

April Blakeslee

Dr. April Blakeslee is an Assistant Professor in the Biology department at Long Island University-Post, and a Research Associate in the Marine Invasions lab at the Smithsonian Environmental Research (SERC). Dr. Blakeslee's research centers around global distribution patterns and processes in marine systems, including biodiversity, conservation biology, population genetics, parasite ecology, and biogeography – with an especial focus on the unique and integrative insight that can be gained from studying biological invasions. Dr. Blakeslee is currently working with the SERC Marine Invasions Lab on an Aquatic Invasive Species Sea Grant project exploring the Maine baitworm/wormweed vector, which transports species both nationally and globally; the project emphasizes the transport and sale of baitworms in the mid-Atlantic region.

Jonathan Blodgett

Jonathan Blodgett is the Aquatic Invasive Species Program Leader with the State of Hawaii's Division of Aquatic Resources. Many of Hawaii's coral reefs have been smothered by alien invasive algae and Jonathan oversees the program to help restore the reefs through mechanical removal and bio-control efforts with the use of native sea urchins.

Pieter Boets

Pieter Boets is a postdoctoral researcher at the department of Applied Ecology, Laboratory of Environmental Toxicology and Aquatic Ecology at Ghent University, Belgium. His research interest is related to the impact and spread of alien macro-invertebrates and fish in inland waters in Flanders (Belgium). Based on a combination of long term monitoring data, modelling techniques and laboratory experiments, he tries to gain insight into the complex ecology of invasive species.

Bill Bolen

Bill Bolen is currently a Senior Advisor with the U.S. Environmental Protection Agency (EPA). Mr. Bolen provides leadership, advice and consultation on Federal policy and program efforts involving the Great Lakes. Currently, Mr. Bolen represents EPA in the role as a Senior Executive on the interagency Asian Carp Regional Coordinating Committee. He also works directly with the Administration's Asian Carp team at the Council on Environmental Quality. This multi-million dollar effort is intended to prevent the Asian Carp from establishing a self-sustaining population in the Great Lakes. Mr. Bolen is responsible for the budgeting, planning, tracking, and operational implementation of various aspects of this effort. This includes coordination between senior-level Federal, Congressional, state, local and tribal officials as well as other stakeholders in industry and nongovernmental organizations. Through this work, Mr. Bolen has been able to apply innovative Emergency Response protocols and procedures in combating the introduction and spread of invasive species. Mr. Bolen has held a variety of senior management positions since joining the EPA in 1987 including Emergency Response Program Manager, Superfund Enforcement Coordinator, and Resource Conservation and Recovery Act Corrective Action Program Manager. Previously to joining the EPA, Mr. Bolen worked in the Gulf Coast in petroleum exploration and in Chicago with an international environmental consulting firm

Helene Bovy

Helene Bovy is a Ph.D. student at Queen's University Belfast (UK). She completed her B.Sc. at McGill University (Biology Major, Environment Minor) and a M.Sc. at University of Exeter (UK) in Biodiversity and Conservation; it was during her masters that she started her work in invasion ecology. Her current work focuses on the prediction of ecological impacts of invasive species; in particular, she is investigating the importance of intra- and inter-population predatory differences in invasive freshwater amphipods.

Margaret M. (Peg) Brady

Margaret M. (Peg) Brady is the NOAA Fisheries Strategic Planning Lead. In addition Peg is NOAA's senior policy liaison to the National Invasive Species Council and Aquatic Nuisance Species Task Force. As the Strategic Planning Lead, Peg ensures that NOAA Fisheries is to advance programs that implement NOAA's ecosystem-based management mission and vision. She oversees the planning, programming and budget formulation processes for the NOAA Fisheries' portfolio. Peg joined NOAA in 2003 and in 2006 was selected as candidate in NOAA's Leadership Competencies Development Program. She has served in leadership assignments at the NOAA NW Fisheries Science Center, serving as a liaison to the Puget Sound Partnership; and at the White House's Council on Environmental Quality (CEQ) as the coordinator to the U.S. Interagency Committee on Ocean Science and Resource Management Integration.

Johanna Bradie

Johanna Bradie holds a Masters degree in Environmental Science from the University of Windsor. Her masters work focused on evaluating the efficacy of NaCl brine as a treatment for ballast tanks non-compliant with ballast exchange. Johanna is presently a Ph.D. Candidate at McGill University under the supervision of Dr. Brian Leung. Her current work focuses on building models to predict the establishment of non-indigenous species using propagule pressure, habitat and life-history information.

Jeff Brinsmead

Jeff Brinsmead is currently a Senior Invasive Species Biologist with the Ontario Ministry of Natural Resources based in Peterborough, Ontario, Canada. This position includes coordinating policy and programs to prevent and manage the introduction and spread of invasive species within the province. Recent projects include monitoring the occurrence of non-target species in commercial wild harvested baitfish in Ontario, the development of a provincial rapid response framework, coordinating risk assessments, and prioritizing provincial AIS information needs. Jeff is currently the Ontario representative on the National Aquatic Invasive Species Committee, the Chair of the Ontario Introductions and Transfers Committee, an alternate member to the Great Lakes Panel on Aquatic Nuisance Species, and a member of the Management Board for the Canadian Aquatic Invasive Species Network. Jeff received a B.Sc. (1996) from McMaster University in Hamilton, Ontario and a M.Sc. (2000) from Trent University in Peterborough, Ontario.

Elizabeta Briski

Elizabeta Briski currently holds a Visiting Postdoctoral Fellowship at the Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada. Supervised by Dr. Sarah Bailey, she is conducting tests to evaluate the efficacy of different ballast water management systems on plankton. Her studies also include non-indigenous species diversity and empirical testing of the relationship between propagule and colonization pressure.

Mandy Bunke

Mandy Bunke holds a Masters degree in Marine and Fisheries Science from the University of Aberdeen, UK. She also holds a Masters through research degree in Mathematical modelling of the Marine Food Web from the University of York, UK. She performed research on the effects of human interactions on marine ecosystems. At present she is working as a researcher on a joint Ph.D. project with University of Leeds and Queens University Belfast. Her research activities include a broad spectrum of topics concerning non-native species including assessing predatory impacts, impact of parasites on feeding rates and behaviour and modelling of effects of parasite infection at the population and community levels. Currently she is involved in the evaluation of the predatory impacts of the invasive amphipod *Dikerogammarus villosus* on the native *Gammarus pulex* and how this is affected by parasites.

Lyubov Burlakova

Dr. Lyubov Burlakova is a Research Scientist in the Great Lakes Center at Buffalo State College (NY) since September 2007. She received her undergraduate degree in Biophysics and Ph.D. in Hydrobiology from Belarusian State University. Her research interests and areas of expertise include ecology, biology, patterns of spread of aquatic invasive species and their role in freshwater ecosystems, and ecology, diversity and conservation of benthic communities. Her research has been funded by federal and state agencies including U.S. Fish and Wildlife Service, U.S. Department of Agriculture, and U.S. Environmental Protection Agency. She has published 61 peer-reviewed papers, and made over 66 presentations at scientific meetings.

Joseph M. Caffrey

Joe Caffrey is a Senior Research Officer with Inland Fisheries Ireland (IFI), a statutory body whose primary function is the protection and conservation of the inland fisheries resource. He was awarded his Doctorate in Aquatic Botany from University College Dublin, Ireland, in 1990. He has been employed with IFI and its predecessor organisations since 1976. His principal research interests over this time period have focused on the biology, ecology and management of aquatic macrophytes and non-salmonid freshwater fish species in natural and artificial aquatic habitats. In more recent years his research has brought him into contact with freshwater invasive species and he is currently heading up the Invasive Species Section within IFI. This work involves researching the biology and ecology of freshwater invasive species (whether macrophyte, macroinvertebrate or fish) that are present or are likely to be introduced to Ireland and developing new and innovative methods to control or manage them. He offers advice to the Government in relation to his primary research responsibilities and provides support in the development of national policy and legislation in these areas.

Marnie Campbell

Professor Marnie Campbell is a Chair in Ecological Security in the School of Medical and Applied Sciences at the Central Queensland University. Prior to this role she was an Associated Professor and Head of Department at the University of Tasmania. Her research interests focus on elucidating human mediated impacts on biodiversity in the marine environment and developing remediation and management options. This extends to all aspects of the process, including identifying risks, determining how impacts occur in space and time, measuring, and mitigating impacts. Specifically, her research focuses on fields of marine ecosystem restoration and marine bio-invasions, which are fundamentally linked by processes of community assembly. Her career has maintained a balance between active science research and the interface with management/policy.

Mônica Campos

Dr. Campos is a biologist, with a Ph.D. in Crustal Evolution and Natural Resources from Federal University of Ouro Preto (UFOP). She is currently a researcher at Fundação Centro Tecnológico de Minas Gerais (CETEC) and Centro de Bioengenharia de Espécies Invasoras de Hidrelétricas (CBEIH). She has experience in ecology, with emphasis on Ecology of Aquatic Macroinvertebrates.

Matthew Cannister

Matt Cannister holds a Master of Biology from Valdosta State University. At present he is working for the United States Geological Survey at their Southeastern Ecological Science Center located in Gainesville, Florida. He is a technician for the Non-indigenous Aquatic Species (NAS) Program, which serves as a central repository for spatially referenced bio-geographic accounts of introduced aquatic species in the United States.

Oscar Casas-Monroy

Oscar's research topics are freshwater and marine biological and ecological invasions and AIS introductions via ballast water/sediments. Additionally, he is also interested in design, development and implementation of rapid detection tools, principally for non-indigenous/harmful/toxic marine algae (i.e., dinoflagellate cysts and motile cells). His current work focuses on risk analysis of plankton non-indigenous species to Canadian marine ecosystems. This national risk assessment evaluates relative risks of different shipping pathways (International vs. Coastal vs. Domestic) in order to identify and prioritize research needs, resource allocation and policy decisions.

Rowshyra Castaneda

Rowshyra recently completed her Master's thesis at McGill University, which focused on examining the distribution, abundance and condition of the Asian clam *Corbicula fluminea* in the discharge plume of a nuclear power plant (Gentilly-2) in the St. Lawrence River. Her undergraduate research (McGill) included field and lab work in the Neotropics and East Africa.

W. Lindsay Chadderton

Lindsay Chadderton is the Aquatic Invasive Species Director for The Nature Conservancy's Great Lakes Project. He manages the development of the conservancy's aquatic invasive species program for the Great Lakes region. Lindsay is part of the four person team that developed the environmental DNA surveillance methods used to track the invasion of Asian carp in the Chicago Area Waterway System and the Great Lakes. Lindsay earned a BS and MS in Zoology from Canterbury University in Christchurch New Zealand, majoring in limnology.

Paul Champion

Paul Champion is a Principal Scientist at the National Institute of Water and Atmospheric Research (NIWA) in Hamilton, New Zealand, where he has been a part of the aquatic plant management research team since 1988, with over 25 years' experience in the field of plant ecology. His current research mostly concerns proactive management strategies for aquatic weeds including evaluating and managing introduction pathways both internationally and internally, working in conjunction with government policy and management agencies. Other research includes optimizing surveillance programs and incursion response to new invasions. He is a graduate of the University of Leicester, UK (B.Sc. Hons.) and University of Waikato, New Zealand (M.Sc.).

Samuel Chan

Sam Chan is an Assistant Professor at Oregon State University with academic appointments in Fisheries and Wildlife, Marine Resources Management and Applied Economics. He serves as the statewide aquatic invasive species and watershed health specialist for the Sea Grant College Program and Extension Service and is the Broader Impacts Team Leader for the National Science Foundation's Water Sustainability and Climate Change Project. Sam studied for his B.S., M.S. and Ph.D. programs at the University of California at Berkeley and Oregon State University. Sam's work focuses on understanding the mechanisms of bio-invason pathways, the impacts of invasive species, human behaviors that lead to spread and prevention to aid in the design of outreach and education approaches to facilitate prevention as well as early detection and rapid response. Prior to joining Oregon State University, Sam served as a Research Plant Physiologist with the U.S. Department of Agriculture Forest Service studying riparian microclimates, modeling and field testing restoration of riparian forests, streamsides and wetlands dominated by invasive species.

Farrah Chan

Farrah Chan is a Ph.D. candidate at the Great Lakes Institute for Environmental Research at the University of Windsor, under the supervision of Dr. Hugh MacIsaac from the University of Windsor and Dr. Sarah Bailey from Fisheries and Oceans Canada. Her research examines the risk of aquatic non-indigenous species introductions in the Canadian Arctic via ballast water discharge and hull fouling. She is an HQP of the Canadian Aquatic Invasive Species Network (CAISN).

Duane Chapman

Duane Chapman is a fisheries biologist with the U.S. Geological Survey, Columbia Environmental Research Center. His first contact with Asian carps was in aquaculture while an undergraduate summer helper for the Iowa Conservation Commission in 1978. His first scientific journal publication was on grass carp in 1988 while working on his M.S. at the University of Wyoming. He has been working on Asian carps almost exclusively since 2002, and has co-authored two books and several articles on these invasive fishes.

Patrice Charlebois

Pat has been conducting AIS outreach for Illinois-Indiana Sea Grant and the Illinois Natural History Survey since 1996. In that capacity, she and her staff have developed comprehensive outreach programming for both Illinois and Indiana that focuses on invasion pathways including recreational water use, water gardening, and classroom use of live specimens. Pat also serves on several regional committees involved with invasive species issues including the Great Lakes ANS Panel, the Mississippi River Basin ANS Panel, and the Asian carp technical and policy workgroup. Pat earned her undergraduate and graduate degrees from the University of Notre Dame and is currently housed at the Chicago Botanic Garden.

Anindita Chatterjee

Anindita Chatterjee is a Senior Research Fellow of Indian Statistical Institute, pursuing her Ph.D. in the area of aquatic ecology and biological invasion, with special emphasis on the adaptation potential and phenotypic plasticity of the invasive plant *Alternanthera philoxeroides*. She has a double Masters' degree (M.Sc. and M.Phil.) in Environmental Science and her work experiences include the ecological assessment of river, lake and pond ecosystems and biodiversity study of aquatic macrophytes and planktons. She also completed an internship program with the University of Illinois, U.S.A. and the National Great Rivers Research and Education Center (NGRREC), in association with the Nature Conservancy, U.S.A. She has been thoroughly trained in submerged aquatic vegetation monitoring techniques of the Long-Term Resource Monitoring Program (LTRMP), an element of the Upper Mississippi River Restoration – Environmental Management Program, U.S.A.

Wei Chen

Wei Chen holds a joint master degree "European Master in Applied Ecology" from Erasmus Mundus Master Programme. He spent two and half years on studying population and evolutionary biology, applied ecology, environmental sciences at University of Poitiers, France, University of East Anglia, UK, University of Coimbra, Portugal and University of Kiel, Germany. Currently, he is serving as a scientific researcher, and also as a Ph.D. student at Department of Ecology and Evolution, Frankfurt University and Biodiversity and Climate Research Centre (BiK-F), Frankfurt am Main, Germany. His studies involve broad topics in freshwater ecology and crustacean invasions in the Rhine system. His up-to-date project is to illustrate ecology and evolutionary strategies of native and invasive amphipods in the Rhine.

Corey Chivers

Corey Chivers is a Ph.D. candidate studying numerical ecology at McGill University. His thesis focuses on the development of forecasting, risk, and impact assessment models of non-native species. By combining computational simulations with

both biological and sociological data, his research aims to provide decision support to resource managers and policy makers. With an emphasis on uncertainty quantification through the construction of Bayesian models, Corey analyses the implications of various human and biological factors on the spread of fresh water invasive species, including: 1) environmental and demographic stochasticity, 2) dispersal network structure, and 3) human behavioural feedbacks to policy decisions. Together, this research provides novel insights into both ecological processes and environmental policy.

Renata Claudi

Renata Claudi is an environmental scientist with over 30 years of diverse business and technical experience. She is the president of RNT Consulting Inc., a company which focuses on various aspects of aquatic alien species invasions. This includes work on economic impacts, selection and installation of appropriate control options, custom research and vulnerability assessments for various facilities. Most of her work in the last five years has involved the impact of quagga mussels on the various facilities in western United States and custom research on innovative control options. In 2010 Ms. Claudi co-authored a book titled Monitoring and Control of Macrofouling Mollusks in Fresh Water Systems issued by CRC Press, the latest in series of publications. She has been one of the organizers of the International Conferences on Aquatic Nuisance Species since its launch.

David Bruce Conn

David Bruce Conn is Professor of Biology and Dean of the School of Mathematical and Natural Sciences at Berry College, Associate of Invertebrate Zoology at the Museum of Comparative Zoology at Harvard University, and Jefferson Science Fellow in the Office of International Health and Biodefense at the U.S. Department of State. He sits on editorial boards of several journals, and is past president of three scientific societies. His current research centers on the parasites and pathogens associated with aquatic invasive species. Bruce and his wife, Denise Andriot Conn, along with collaborators from many institutions, have conducted research for more than 30 years on invasive species, parasites, and other biota in freshwater and marine ecosystems around the globe.

Alison Coulter

Alison Coulter holds a B.S. from Michigan State University in zoology and completed her M.S. at Central Michigan University examining movements and assemblages of fishes in small streams. She is currently a Ph.D. student with Reuben Goforth at Purdue University in the ecological sciences and engineering interdisciplinary graduate program (ESE-IGP) where her work is focused on bigheaded carps. The current scope of her work includes spawning and spawning cues, hybridization in adults and eggs, movements and movement cues and the dietary niches of these invasive fish.

Kim Cuddington

Kim Cuddington is an Assistant Professor at University of Waterloo. Her research on invasive species includes risk assessment based on probability theory and stage-structured population models (e.g., Asian carp in the Great Lakes), estimates of spread rates and probable range produced by combining niche-based and integro-difference models (e.g., Giant Hogweed), and comparing calculations of final range maps produced by niche-based models and physiological models (e.g., Emerald Ash Borer) She has also worked on appropriate representations of environmental stochasticity and the impact of such descriptions on invasion risk, as well as the effect of habitat modification by ecosystem engineers. In 2011, she organized a symposium at the Ecological Society of America that dealt with invasive species which cross the U.S.-Canada border, and she remains interested in the management of border crossing species.

Becky Cudmore

Becky Cudmore is a Senior Science Advisor on Aquatic Invasive Species for the federal Department of Fisheries and Oceans Canada based out of Burlington, Ontario. She also manages the department's national Centre of Expertise for Aquatic Risk Assessment and the new Canadian Asian Carp Program. Ms. Cudmore studied invasion ecology during her undergraduate at Trent University in Peterborough, moving to invasion patterns of fishes in the Great Lakes for her graduate program at the University of Toronto. She worked and studied at the Royal Ontario Museum prior to moving to Fisheries and Oceans Canada. After two decades of study and work on aquatic invasive species, Ms. Cudmore was awarded a Queen's Diamond Jubilee Medal for her efforts to protect the Great Lakes from aquatic invasive species.

Alisha Dahlstrom

Alisha Dahlstrom received her Ph.D. from the University of Tasmania (Australia). Her research focused on risk assessment for aquatic non-indigenous species. She is currently a Cooperative Institute for Limnology and Ecosystems Research (CILER) post-doctorate fellow at Wayne State University (Michigan). She is continuing her work on risk assessment, with a focus on the Great Lakes, through a Great Lakes Restoration Initiative (GLRI) project assessing cumulative risk across vectors and species. She is also working in Toledo Harbor (Lake Erie) on a project comparing detection efficiencies for various sampling gears and habitats.

Yves de Lafontaine

Yves de Lafontaine holds a Ph.D. degree in Ecology from McGill University, Montreal, Canada, and is currently working as research scientist at Centre Saint-Laurent, Environment Canada, in Montreal. His research activities focus on the study of stressors on large river ecosystems, including the ecology and control of non-native species, the hydroclimatic variation on river fish diversity and the impacts of contaminants on aquatic organisms. His current work deals with the distribution and feeding ecology of the new invader, the bloody-red shrimp (*Hemimysis anomala*), in the Great Lakes-St. Lawrence River basin. He is also a member of the board of directors of the St. Lawrence Action Plan director committee, a 5-year program dedicated to research studies in the St. Lawrence River.

Isabelle Desjardins

Isabelle Desjardins has been the invasive fauna species coordinator for the Ministère du Développement Durable, de l'Environnement, de la Faune et des Parc du Québec since June 2012. She is a biologist and has a M.Sc. in Maritime resources management. She is developing an early detection program, a monitoring network, a provincial strategy, as well as several educational and awareness programs and activities on exotic invasive fauna for the province.

Anjana Dewanji

Anjana Dewanji obtained her Ph.D. from Calcutta University, India. Her fields of interest include factors (like eutrophication) influencing the ecology of aquatic plants and their temporal patterns, and the study of two invasive wetland plants namely, *Alternanthera philoxeroides* and *Mikania micarantha* – their morphometric traits as well as their growth potential in this region.

Yury Dgebuadze

Yury Dgebuadze graduated from the Moscow State University, got a Ph.D. (Biology) degree from Russian Academy of Sciences (RAS) and Doctor of sciences (Biology) degree from Moscow State University. He developed research on the invasion dynamics, effects and vulnerability of aboriginal ecosystems. Main objects of his studies are fish, beaver and zooplankton. He is head of the Laboratory of Water Communities and Invasion Ecology in A.N.Severtsov Institute of Ecology & Evolution, RAS. At present in field of biological invasion he is working as one of the leader of IUBS Scientific Program "Biological consequences of Global Change" and Project of Russian Foundation of Basic Research. He is Editor-in-Chief of the Russian Journal of Biological Invasion. The English version of this Journal is distributed by Springer.

Jaimie T.A. Dick

Jaimie Dick is Professor of Invasion Ecology at Queen's University Belfast, N. Ireland, where he is also a Senior Investigator in the Quercus Biodiversity Centre and on the Invasive Species Ireland contract, dealing with invaders throughout Ireland. Jaimie also researches invasive species impacts in Great Britain, Europe, N. America and South Africa. While Jaimie has projects on diverse invaders, including deer and squirrels, his passion is experimental approaches to understanding and predicting invasive aquatic species impacts, particularly high profile crustacean invaders such as 'killer shrimp'.

Andrew Drake

Andrew received his Ph.D. from the University of Toronto in 2010. Following the completion of his degree, he joined Fisheries and Oceans Canada's Great Lakes Laboratory for Fisheries and Aquatic Sciences in Burlington, Ontario, where he is currently an NSERC visiting fellow. His research generally involves applied ecology of fishes, quantitative risk assessment, and understanding the influence of human activities on aquatic ecosystems. Current projects include quantitative harvest models, and estimating human-mediated invasions associated with baitfish activity, commercial shipping, and recreational boating within Canada.

Lisa Drake

Lisa Drake is a Physical Scientist at the U.S. Naval Research Laboratory (NRL) in Key West, Florida and holds M.S. and Ph.D. degrees in Oceanography (Old Dominion University, Norfolk, Virginia). Currently, she leads the NRL Ballast Water Science and Technology Program, an interdisciplinary team of biologists, engineers, and a statistician developing procedures and methods used in testing ballast water management systems. Dr. Drake has been active in national and international policy by, for example, participating in the Environmental Protection Agency's Environmental Technology Verification technical panel meetings to develop the Generic Protocol for the Verification of Ballast Water Treatment Technology and serving as a member of the U.S. Delegation to the United Nation's International Maritime Organization Subcommittee on Bulk Liquids and Gases.

Elizabeth Edgerton

Elizabeth is a first year graduate student at Texas A&M University in College Station, TX, and is currently working on her Masters of Science in Wildlife and Fisheries Sciences. Elizabeth is also a research assistant at Texas Water Resources Institute, a division of Texas A&M Agrilife Research. Her focus is aquatic invasive species, specifically developing an Aquatic Weed Risk Assessment Model for the state of Texas. Elizabeth earned her Bachelor of Arts degree in Environmental Studies from Baylor University in 2010.

Paul Edwards

Paul Edwards is a Ph.D. candidate at McGill University. His research interests are in the effective monitoring and management of aquatic invasive species. He builds statistical and mechanistic models of real case examples to capture the generalities of dispersal and its implications for effective management and feasibility of eradication.

Kristina Enciso

After obtaining her B.Sc. in Biology at Queen's University, Kristina worked at Fisheries and Oceans Canada's Great Lakes Laboratory for Fisheries and Aquatic Sciences where her interest in freshwater and invasion ecology flourished. She is currently a Master's student at McGill University with her research focusing on the use of species distribution models and development of new techniques to examine community dynamics between non-invasive species (NIS) and native species in an effort to provide more robust predictions of current and future distributions.

Marilyn Ennis

Marilyn graduated with a B.Sc. (Hons.) in Zoology and a PGCE in education from Queen's University Belfast. She completed her Masters at the University of Ulster and has worked extensively in environmental education. She currently lectures in Environmental monitoring at the College of Agriculture, Food and Rural Enterprise (Greenmount campus) Northern Ireland, and has returned to academic research as a part time Ph.D. student. Her current research is focused on the ecophysiology of freshwater invasive species in Ireland and is primarily concerned with how parasitism and the consequent host immune response, affects the dietary protein and energy needs of the invasive amphipod host (*Gammarus pulex*), and how this may affect community structure through predator prey choice and feeding behaviour.

Kevin Erickson

Kevin Erickson is currently an Endeavour Postgraduate Award Ph.D. Scholar at Central Queensland University in Gladstone, Australia, studying and analyzing the marine ornamental biosecurity procedures and risks within Australia.

He recently earned his Master's degree in Aquatic Pathobiology from the Institute of Aquaculture at the University of Stirling, Scotland. His work experiences include positions as the Marine Science Director for the Pennington Marine Science Center, California,a Curator/Location Director for Issham Aquatics, and Tropical Tank Keeper at Oregon State University's Hatfield Marine Science Center.

He obtained his Ethical Fish Keeping Certificate from the University of Prince Edward Island, Canada in 2009, his Professional Certificate in Aquarium Science from the Oregon Coast Community College in 2008 and his Bachelor of Science in Marine Biology from the Florida Institute of Technology in 2007.

Personally he has kept many marine fish tanks as well as reef tanks. He enjoys designing and building his own aquarium filters and is actively looking for additional DIY projects. He currently serves on the Board of Directors for the Marine Aquarium Societies of North America (MASNA) as the Vice President and is the host of MASNA's podcast, MASNA Live.

Emilie Etoundi

Emilie's Ph.D. thesis, started in October 2011, aims to understand the link between successful invasion and reproductive mode in the clam genus *Corbicula*, in which individuals could be either sexual or asexual. However, despite the overwhelming predominance of sexuality among animals and its incontestable advantages, only asexuals are very successful invaders. Hence she investigates how asexuality can be maintained is this genus and how it could favour invasion through genetic, cytological and histological studies.

Amanda Eyraud

Amanda Eyraud received her B.Sc. in Biological Science, with a focus on animal agriculture, from the University of Guelph. She is currently a Master's candidate under the supervision of Dr. Hugh MacIsaac at the Great Lakes Institute for Environmental Research, University of Windsor, studying the distribution and survival tactics of invasive macrophytes in the Great Lakes. She is also Highly Qualified Personnel for the Canadian Aquatic Invasive Species Network.

Irina Y. Feniova

Irina obtained her Ph.D. in Biological Sciences at M.V. Lomonosov Moscow State University. She is a Senior Scientific Researcher at the A.N. Severtsov Institute of Ecology and Evolution, of the Russian Academy of Sciences. Her scientific interests include aquatic ecology, zooplankton, computer simulations of cladoceran dynamics, laboratory experiments with zooplankton species at different levels of food renewal and predator pressure, invasion processes.

Maureen Ferry

Maureen Ferry is researching zebra mussel habitat preference, growth, and mortality as a graduate research assistant with the Wisconsin Cooperative Fishery Research Unit at the University of Wisconsin-Stevens Point. Her research will provide framework for early detection zebra mussel monitoring protocols and offer guidance on expected zebra mussel growth and mortality following establishment. Previously Maureen was the Lake Superior Basin Aquatic Invasive Species Specialist with the Wisconsin Department of Natural Resources. Earlier she was the Invasive Species Program Manager for Florence County, Wisconsin where she served as chair of the Wild Rivers Invasive Species Coalition and was instrumental in the development of a regional zebra mussel education, planning, and research project which is now her graduate research. In her free time, Maureen enjoys botanizing, birding, hockey and roller derby.

Matthew First

Dr. Matt First received a Master of Science degree from the University of Akron and a Ph.D. in Marine Sciences from the University of Georgia. He specializes in microbial ecology, marine microbiology, and protist physiology. Dr. First was awarded a postdoctoral scholarship from Woods Hole Oceanographic Institution. Currently, he is a contractor at the Naval Research Laboratory in Key West, Florida.

Amy Fowler

Amy Fowler received her B.S. in biology from the University of New Hampshire and her Ph.D. in marine science from the University of Auckland, New Zealand on a J. William Fulbright fellowship. Her dissertation examined the impacts of a newly established Asian swimming crab, *Charybdis japonica*, on New Zealand's native benthic fauna. She then worked as a post-doctoral researcher at the Smithsonian Environmental Research Center's Marine Invasions Lab, concentrating on studying the interactions between a native crab (*Rhithropanopeus harrisii*) and its non-native castrating parasite and the many introduced populations of *R. harrisii* around the world. Collaborating with others at Maryland Sea Grant and UC Davis while still at SERC, she also investigated the role of the live bait trade of polychaete worms from Maine as a vector for introducing other marine organisms hitch-hiking on the algae which is used to pack the worms. Currently, she is a post-doctoral teaching fellow in the Biology Department at Villanova University in Pennsylvania teaching marine biology and non-majors biology.

Michael Fox

Michael Fox is a professor in Environmental Science and Biology at Trent University in Ontario, Canada. His research is focused on fish population ecology and the application of life history theory to invasion biology and climate change. Most recently, his research has been conducted on two invasive species on two continents: the round goby in North America and the pumpkinseed sunfish in Europe. He has been a member of a NATO collaborative linkage network studying non-native fishes in Europe since 2001.

Nicholas Friedenberg

Nicholas Friedenberg received his Ph.D. in evolutionary ecology from Dartmouth College, where he experimentally tested theories on the evolution of dispersal rates in relation to habitat stability. He currently works as a senior scientist at Applied Biomathematics in Setuaket, NY, where he leads projects in ecological risk analysis and software development. His research deals generally in population and community dynamics in the context of heterogeneous environments, with applications for endangered and invasive species, pest management, and microbial evolution. He has recently been involved with research conducted by the Army Corps of Engineers Environmental Research and Development Center on sturgeon, paddlefish, and Asian carp in the Mississippi River.

Pam Fuller

Pam Fuller obtained her Master's degree in Zoology from the University of Florida. She began working for the U.S. Fish and Wildlife Service's National Fisheries Research Center located in Gainesville, Florida while she was working on her degree. She conducted mussel surveys in southeastern rivers for the first few summers and then joined the Non-indigenous Aquatic Species Database program. She is now the manager of that program for the U.S. Geological Survey, where she has been for more than 20 years. The NAS database tracks the distribution of introduced aquatic species nationwide. She very much enjoys her position because every day is a new learning experience. She is continually learning recent developments in information management, new computer skills, taxonomy, geography and zoogeography. Ms. Fuller has been involved in many efforts to network databases both nationally and internationally. She is also the author of "Nonindigenous Fishes Introduced into Inland Waters of the United States" - a book published by the American Fisheries Society.

Lyn A. Gettys

Lynn received her B.S. in Horticulture from the University of Florida, her M.S. in Plant Breeding from North Carolina State University and her Ph.D. in Plant Genetics from the University of Florida. She has been conducting research on aquatic plants since 1996 and has been working with invasive aquatic weeds since 2005. Lynn is an Assistant Professor at the University of Florida IFAS Ft. Lauderdale REC and is affiliated with the UF IFAS Center for Aquatic and Invasive Plants in Gainesville. Her appointment is 60% research and 40% extension and her area of specialization is aquatic and wetland plant science, which includes propagation and culture of native species and control of invasive weeds.

Sara Ghabooli

Sara Ghabooli is currently working towards her Ph.D. 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. She is mainly interested in molecular ecology, population genetics and evolutionary genetics of aquatic invasive species.

Laure Giamberini

Laure Giamberini is a professor in aquatic ecotoxicology at the University of Lorraine, France (UMR CNRS 7360). Her research addresses (i) the development and validation of cellular and individual biomarkers in different freshwater invertebrate species (ii) the metal (ionic and nanoparticles) metabolism in bivalves and (iii) the interactions in host (zebra mussel) -parasite systems in relationship with pollution. She is a regular expert for Belgium FNRS and French ANR and ANSES (French Agency for Food Environmental and Occupational Health and Safety). Currently she is involved in two national and international programmes (with GDRi iCEINT, Duke University) studying ecotoxicology of several metallic nanoparticles in bivalves and gammarids. She is also involved in a French-Canadian research project concerning the interactions between pollution and climate changes. It aims at the development of improved monitoring strategy using blue and zebra mussel biological responses.

Reuben Goforth

Reuben Goforth holds a Masters degree in Aquaculture, Fisheries and Wildlife from Clemson University, Clemson, SC, and a Ph.D. in Natural Resources from Cornell University, Ithaca, NY. He has worked in a wide range of freshwater ecosystems, from tropical rainforest streams of Costa Rica to nearshore areas of four of the five Laurentian Great Lakes. Much of the current work in his lab at Purdue University, West Lafayette, IN, focuses on the biology and ecology of bigheaded carps (*Hypophthalmichthys* spp.), and he has evolving research in controlling invasive red lionfish (*Pterois volitans*) in the western Atlantic Ocean and Caribbean Sea.

Jesica Goldsmit

Jesica Goldsmit holds an M.Sc. in Biology from the Universidad Nacional de Córdoba, Argentina. She performed research on the nutrition of Crustaceans and physiological effects on mussels and isopods due to water contamination in Ushuaia, Tierra del Fuego, Argentina. At present she is a Ph.D. student at the Institut de Sciences de la Mer (ISMER), Rimouski, Québec, Canada. Her thesis work is focused on the identification, biodiversity and relationships with global warming and shipping activity of benthic non-indigenous species (NIS) in ports of the Canadian Arctic. The general objectives of her project are to characterize existing native and non-native benthic invertebrates in coastal areas of the Canadian Arctic where the risk for introduction of NIS is the highest and to evaluate the overall risk for future NIS incursions with changes related to global warming and shipping activity.

Stephan Gollasch

Stephan Gollasch took his first ballast water sample in 1992 and since then has been involved in many ballast water sampling studies. As a member of the German Delegation at IMO he supports the development of the IMO ballast water sampling guidance. He is currently involved in two European Union projects which address ballast water management aspects, namely in the projects VECTORS and Ballast Water Opportunity.

John Goss

John Goss serves as the principal advisor to The White House Council on Environmental Quality (CEQ) Chair Nancy Sutley on Asian carp issues, and oversees the coordination of Federal, state, and local efforts to keep Asian carp from establishing in the Great Lakes ecosystems. This continues the Obama Administration's proactive response to the threat that Asian carp pose to the Great Lakes.

Goss is chair of the Asian Carp Regional Coordinating Committee (ACRCC), which is a team of Federal, state and local agencies working together to prevent Asian carp from establishing populations in the Great Lakes. The Asian Carp Control Strategy Framework, released in February, 2010 and updated in December 2010 unifies Federal, state and local action in an unparalleled effort to combat invasive species.

Goss joins CEQ from the Indiana Wildlife Federation, the Indiana State affiliate of the National Wildlife Federation, where he served for four years as the Executive Director. In his role at the Wildlife Federation, he worked with conservation, business and industry groups to support the Great Lakes Compact. Goss previously served as Director of the Indiana Department of Natural Resources and as Vice Chair of the Great Lakes Commission.

Prior to his position at the Indiana Department of Natural Resources, Goss was Director of Tourism for the State of Indiana and chaired the Great Lakes International Marketing Initiative for the Great Lakes Governors Association. Goss served as Chief of Staff for Lt. Governor Frank O'Bannon, District Director for Congressman Frank McCloskey and Deputy Mayor for the City of Bloomington, Indiana. Goss received his Masters of Public Affairs and his B.A. in Economics from Indiana University.

Jonathan F. Grant

Jonathan F. Grant is responsible for development of test methods and protocols for the testing of ballast water management systems (BWMS) at the U.S. Naval Research Laboratory. He has been involved with NRL's Ballast Water Treatment Test Facility (BWTTF) facility since its inception in 2003, where he was responsible for design and implementation of the instrumentation, system control and data acquisition facilities. Mr. Grant served as Test Director during the first full scale Pilot Test to the ETV draft protocol is a participant in the ETV Ballast Water Technical Panel. 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 U.S. Government and their contractors.

Sara Grisé
Sara Grisé is a Senior Coastal Outreach Specialist with Pennsylvania Sea Grant. She has a B.S. degree in Biology from Penn State Erie, the Behrend College, and a M.S. degree in Biology from Shippensburg University where she conducted her thesis research on the impacts of climate change on non-native species distribution and establishment potential. Sara's focus areas include aquatic invasive species education, outreach, and management, and climate change impacts and adaptation.

Bart Grutters
Bart Grutters received his Masters degree in Biology from the Radboud University Nijmegen. He performed a comparative study on invasive dreissenids concerning their tolerance to temperature, salinity and depth, investigated processes involved in peat degradation and tested methods to restore degraded shallow lakes in peatlands. Currently he is employed by the Netherlands Institute of Ecology (NIOO-KNAW) as a Ph.D. candidate. His research revolves around comparing the ecosystem functions of native and non-native aquatic plants, including species identity or traits to better understand the impact of exotic species.

Danielle Haak
Danielle Haak earned a Bachelors degree in Wildlife Ecology from the University of Wisconsin-Madison and a Masters degree in Biological Sciences from Michigan Technological University. She is currently working on a Ph.D. in Applied Ecology at the University of Nebraska-Lincoln as an Integrative Graduate Education and Research (IGERT) trainee, where she is developing bioenergetics and habitat suitability models for the invasive Chinese mystery snail (*Bellamya chinensis*). Her other research interests include fisheries ecology, resilience, and ecosystem ecology.

William Haller
William Haller is the Acting Director of the University of Florida Center for Aquatic and Invasive Plants and has been active in the use of pesticides for the control of aquatic invasive species, particularly the use of herbicides for the control of aquatic weeds. In the past decade he has also conducted work on the control of the island apple snail and screened compounds which might be effective against this aquatic pest. The limited number of products registered by the U.S. EPA for mollusk control forced control projects of both zebra mussels (Nebraska) and Island apple snails (Florida) with copper sulfate, both projects resulting in failure. The high cost of pesticide registration combined with limited markets and general lack of selectivity of pesticides used to control aquatic invasive species makes any significant progress on eradication and control unlikely in the near future.

Kayla Hamelin
Kayla Hamelin holds a Bachelor of Science with Combined Honours in Marine Biology and Oceanography from Dalhousie University. She was previously involved in wildlife telemetry research with the Canadian Sea Turtle Network. At present, she is working on a M.Sc. under the supervision of Dr. Anthony Ricciardi at McGill University in Montreal. Her research involves evaluating the effects of thermal effluent from the Gentilly-2 Nuclear Power Plant on the diversity and distribution of benthic invertebrates in the St. Lawrence River. She is particularly interested in the role of invasive species, such as the Asian clam *Corbicula fluminea*, in this community response to temperature.

Ahdia Hassan
Ahdia is currently completing her M.Sc. degree at McGill University in a lab that specializes in aquatic invasions. Her thesis explores factors that lead to variation in impacts of introduced animals. Extending across multiple taxa, she is evaluating the negative ecological and economic impacts of established non-native species in order to identify factors useful for risk assessment. Her research also examines whether a species' pest status is independent of its bio-geographic origin.

Tim Haxton
Tim Haxton has worked as a biologist with the Ontario Ministry of Natural Resources since 1987 and is currently a Fisheries Specialist with the Aquatic Science Unit based out of Peterborough, a position he has held since 2000. Tim holds a Ph.D. from the University of Ottawa and has focused his research on the effects of water power management on fish communities, more specifically lake sturgeon. He has a strong statistical background and relishes tackling large databases or mentoring staff on different analytical techniques. More recently, he has lead a project to review the affects Aquatic Invasive Species have on inland freshwater fish communities and is currently assisting with risk assessments of species introductions.

Cari-Ann Hayer
Cari-Ann received her Master's degree from Auburn University in Alabama and she is currently pursuing a Ph.D. at South Dakota State University. Her research focus is trophic and invasion ecology. She is specifically interested in the food web dynamics among native riverine fishes and the potential alterations that may occur to the intricate and dynamic food web when an invasive species such as Asian carps colonize and/or overrun a new ecosystem.

Colin Henein
Dr. Colin Henein is a Policy Advisor with Transport Canada Marine Policy, working toward uniform implementation of practicable and protective ballast water requirements. Taking into account scientific, legal, technical and policy perspectives, Colin leads development of Canadian regulatory options for ballast water management, represents Canada in ballast water discussions at the International Maritime Organization and leads federal interdepartmental efforts towards compatibility of Canadian, U.S. and international ballast water requirements.

Chad Hewitt
Chad is currently the Pro Vice-Chancellor (Research) at Central Queensland University, responsible for the University's research and research training objectives. He has previously held positions as Director of the National Centre for Marine Conservation and Resource Sustainability at University of Tasmania; Chief Technical Officer – Marine Biosecurity for the New Zealand Government; and Invasion Biologist at the CSIRO Centre for Research on Introduced Marine Pests as Leader of the Invasion Processes Group. Chad currently serves by Ministerial appointment on the Australian "Eminent Scientists Group" providing advice and comment on Import Risk Assessments. His personal research portfolio revolves around the role humans play in changing the natural world and how natural science can influence management and policy, specifically related to marine invasions. Chad developed the Australian National Port Baseline Survey program in 1995 to elucidate the scale and scope of marine invasions in Australia, including the establishment of survey protocols that have now been implemented globally. In addition, he has participated in capacity building activities for governance and biosecurity frameworks with small island states and other developing countries throughout the Pacific and Indian Oceans.

Jaclyn Hill
Dr. Jaclyn Hill is a stable isotope ecologist with an interest in marine and freshwater trophic and ecosystem functioning. She completed her undergraduate studies at the University of Guelph, Canada and her Ph.D. at Rhodes University, South Africa. Currently a postdoctoral fellow at Rhodes University, working on sewage plume mapping in invaded ecosystems, she has begun collaborating with the Rhodes University Biological Control Unit and the Centre for Invasion Biology at the South African Institute for Aquatic Biodiversity (SAIAB).

Collin Hinz
Collin Hinz is a large river ecologist working for the Illinois Natural History Survey at the Illinois River Biological Station (IRBS). Collin's background is in fisheries, limnology, and riverine zooplankton. Currently, his ongoing, long-term, study focuses on nutrient dynamics in the Illinois River and zooplankton community composition in response to Asian carp presence. Collin has presented findings from his studies to various groups ranging from university audiences to Asian carp technical and policy workgroups.

Greg Hitzroth
Greg Hitzroth is an aquatic invasive species specialist with the Illinois Natural History Survey and Illinois-Indiana Sea Grant's Aquatic Invasive Species team. He is currently involved with the design and implementation of public outreach programs and resources designed to increase awareness of the spread of invasive species through the organisms in trade pathway. Greg holds a M.S. in Biology from Northern Arizona University.

Michael H. Hoff
Michael Hoff is the Invasive Species Program Coordinator for the U.S. Fish and Wildlife Service (USFWS) in the Midwest Region. He began working on invasive species issues in 1975, and has focused primarily on invasive species activities since

2001. He played a lead role in drafting Aquatic Invasive Species Action Plans for the Great Lakes Regional Collaboration and for the Mississippi Interstate Cooperative Resource Association. Mr. Hoff is leading efforts to use risk assessment products for regulatory and non-regulatory decision-making, and is helping to lead early detection and response planning for the USFWS in the Great Lakes region.

Joel Hoffman

Joel Hoffman is a Research Biologist with the U.S. Environmental Protection Agency's National Health and Environmental Effects Research Laboratory in Duluth, Minnesota. He earned his Ph.D. in Marine Science from the College of William and Mary at the Virginia Institute of Marine Science. His research activities are directed toward the early life history of estuarine and Great Lakes coastal wetland fishes, with an emphasis of how human alterations to ecosystem functions influence habitat use and fish population dynamics. Currently, he is part of a U.S. EPA research team that is developing guidance on scientifically sound and cost effective early detection technologies and sampling strategies to support the development of a Great Lakes-wide aquatic invasive species early detection network.

Jan Jeffrey Hoover

Jan Jeffrey Hoover began work as a Research Fisheries Biologist at the U.S. Army Engineer Research and Development Center in 1989. He evaluates impacts and benefits of civil works projects on aquatic communities of wetlands, streams, rivers, and estuaries. As part of this work, Jan conducts field and laboratory studies of imperiled and invasive species including sturgeon, paddlefish, Asian carp, suckermouth armored catfishes, and Japanese mystery snail. His special interests in these organisms are swimming performance and population dynamics. During the 1970s, when he was a high school student in Florida, Jan managed a tropical fish store and collected exotic fishes from local waters for his home aquaria thereby gaining early hands-on experience in pathways of introduction and harvest-based management of invasive fishes.

Denise M. Hosler

Denise Hosler is with the Ecological Research and Investigations, Invasive Species Team with the Bureau of Reclamation. She is a graduate of the University of Colorado and has an extensive background in chemistry and herbaceous plant science. Prior to the Bureau of Reclamation, she worked for 21 years on environmental issues with private industry bridging chemistry, biology, and environmental compliance. During this time she developed technical specialization in bioremediation and organic chemistry as applied to natural systems. In the last 15 years, working for Ecological Applications and Research Group, she helped to develop an Integrated Pest Management Manual (IPM) and participated in IPM research efforts to control several aquatic nuisance species such as giant salvinia, salt cedar, and dreissenid mussels. Since 2006, she has worked on the early detection and potential control methods for dreissenid mussels in the western U.S. In addition to extensive field work of integrated pest management and invasive species control, she has continued laboratory work with microorganisms. Denise has been working with molecular biologists, microbiologists, engineers, and environmental scientists in government and private industry on numerous projects to resolve biofouling and identify key species using taxonomic and molecular methods.

Kimberly Howland

Kimberly Howland holds a Ph.D. in Environmental Ecology from the University of Alberta. Her thesis research focused on the ecology, life history and evolutionary biology of anadromous and freshwater salmonids in the Canadian Arctic. At present she is working as research scientist with the Arctic Research Division of Fisheries and Oceans Canada (DFO), Winnipeg and as an adjunct professor with the University of Alberta. Although she continues to conduct research related to various aspects of northern salmonid ecology and evolution, she has more recently been responsible for the development of a new research program for aquatic invasive species (AIS) in the Canadian Arctic. Through DFO and as part of the Canadian Aquatic Invasive Species Network (CAISN), she has been involved in the development of an Arctic AIS port monitoring program designed to allow for early detection and response to AIS and establish a reliable baseline for further monitoring, and she is involved in the modeling of AIS risks associated with climate change and shipping activity in the Canadian Arctic. She has also been working cooperatively with Transport Canada and other DFO researchers to provide ecological assessments of alternate ballast water exchange zones in the Canadian Arctic and examine ecological risks of AIS introductions associated with alternate ballast water exchange and shipping activities.

Josephine Iacarella

Josie has a Masters in Marine Science and is currently in the Ph.D. program at McGill University, studying in an invasive species ecology lab. As a part of her Ph.D., she is working with collaborators from Queen's University (Belfast, UK) to develop predictive tools of aquatic invasive species impact, testing them in both Canada and Ireland.

Kelvin Ka Lok Ip

Kelvin Ka Lok Ip holds a Bachelor degree in Environmental Life Science from the University of Hong Kong. He performed his final year project on the phenology of seed resources and ecology of farmland birds in freshwater farmland. At present he is a Master degree candidate at Department of Biology, Hong Kong Baptist University. His current research effort focuses on exploring the potential of black carp *Mylopharygodon piceus* as a control agent for the invasive apple snail *Pomacea canaliculata* in freshwater wetlands of Hong Kong.

Kevin Irons

Mr. Kevin Irons is the Aquatic Nuisance Species Program Manager and Aquaculture Program Manager with the Illinois Department of Natural Resources and works out of the IDNR Headquarters in Springfield, Illinois. Mr. Irons represents Illinois on the Great Lakes and Mississippi River Basin Panels on Aquatic Nuisance species working with federal, state, and local partners to develop, coordinate, and implement policy for comprehensive management of aquatic nuisance species in the state and region. A large part of those duties currently is the implementation of the Asian Carp Management Framework to prevent Asian carp from establishing populations in the Chicago Area Waterway System and Lake Michigan. Prior to the IDNR, Mr. Irons has worked as a large river ecologist for 19 years at the Illinois Natural History Survey's Illinois River Biological Station where he was the fish component leader for the Long Term Resource Monitoring Program. His research has focused on the strengths of the LTRMP to answer research questions as well topics of invasive species in the Illinois River. These invasives include: white perch *Morone americana*, round goby *Neogobius melanostomus*, and Asian carp species (bighead carp *Hypophthalmichthys nobilis*, silver carp *Hypophthalmichthys molitrix*, and grass carp *Ctenopharyngodon idella*). In addition to the day to day monitoring on large rivers, his research has focused on largemouth bass population dynamics, winter habitat preference, and age and growth of several riverine species.

Kevin is a past chair of the Upper Mississippi River Conservation Committee - Fish Technical Section and member of the American Fisheries Society, as well as serving on the Executive Committee of the Introduced Fish Section - AFS.

Andrew Jamieson

Andrew Jamieson holds a Master of Science degree from the University of McGill and is a Senior Irrigation and Drainage Engineer with Agriculture and Agri-Food Canada. Andrew has 10 years of experience working as an agricultural engineer, developing and delivering technical information related to water management (drainage, irrigation, and water supplies). He leads a team of engineers focused on developing practical, sustainable irrigation and drainage practices that will assist farmers in managing risks associated with severe weather events. Andrew currently assisting the Leamington Area Drip grower group in developing cost effective controls for dreissenid mussels and algae biofouling.

Douglas A. Jensen

For nearly two decades, Doug Jensen has coordinated the University of Minnesota Sea Grant's aquatic invasive species (AIS) program. He specializes in strategic public outreach, planning, and evaluation aimed at preventing the spread of AIS through behavior intervention. Doug's efforts support two national campaigns, *Habitattitude*™ and *Stop Aquatic Hitchhikers!*™. He has published scientific papers, fact sheets, and the popular AIS WATCH ID cards. He serves on the ANS Task Force's Prevention Committee, Recreational Activities Committee (co-chair), the Great Lakes Panel on ANS, Information and Education Committee (chair), the Minnesota DNR Statewide AIS Advisory Committee (Ex-officio), and the Minnesota Invasive Species Advisory Committee. He co-chaired the 2008 Minnesota Invasive Species Conference and helped plan the 2010 Minnesota-Wisconsin Invasive Species Conference and the 2012 Upper Midwest Invasive Species Conference, which drew over 500 attendees from a dozen states. In 2012, Doug was honored with the national Outstanding Invasive Species Outreach and Education Award in Washington, DC. Doug earned an M.S. in Education and a B.S. in Biology from the University of Minnesota Duluth.

Erika Jensen

Erika Jensen is a project manager at the Great Lakes Commission where she manages and provides support to several Commission initiatives related to aquatic invasive species and policy. She currently coordinates the Great Lakes Panel on Aquatic Nuisance Species and is involved in the Commission's work on advancing options for separating the Mississippi River and Great Lakes watersheds to prevent the transfer of AIS. She has a Master's degree from the Nicholas School of the Environment at Duke University and B.S. from Michigan State University.

Łukasz Jermacz

Łukasz Jermacz is a Ph.D. student in the Department of Invertebrate Zoology at the Nicolaus Copernicus University in Torun, Poland. His scientific interests focus on biology and ecology of Ponto-Caspian invasive species, especially on their interactions with native and alien species. His current research areas include habitat preferences of an amphipod *Pontogammarus robustoides* in relation to bottom type and macrophyte coverage, as well as its interactions with *Dikerogammarus villosus* and predatory fish.

Tim Johnson

Tim Johnson is a Great Lakes Research Scientist with the Ontario Ministry of Natural Resources, based at the Glenora Fisheries Station in eastern Lake Ontario. Tim holds a Ph.D. in Zoology with a minor in Limnology and Oceanography from the University of Wisconsin-Madison. Tim's research focus is the structure and efficiency of aquatic food webs, including the effects of aquatic invasive species, climate change, and habitat alteration on growth and production of fishes and other aquatic organisms. Tim is a former president of the International Association for Great Lakes Research, Canadian government lead on the Lake Ontario node of the Great Lakes Regional Research Information Network, and a former member of the Great Lakes Fishery Commission's Board of Technical Experts.

Lisa Jones

Lisa Jones just completed her Ph.D. in the Department of Biology at McGill University under the supervision of Dr. Anthony Ricciardi. Her doctoral research explored the role of life history differences and abiotic tolerances in explaining outcomes of interactions between closely related exotic species, with a particular focus on the exotic species replacement occurring between the zebra and quagga mussel in the St. Lawrence River. This last year Lisa has worked on various invasive species initiatives for both Environment Canada and Fisheries and Oceans Canada.

Alexander Karatayev

Alexander Karatayev became the Director of the Great Lakes Center in Buffalo State College in 2007. He earned his M.S. degree in Biology from the Belarusian State University in 1976. He earned his Ph.D. degree in Hydrobiology in 1983 and the Doctor of Science degree in Hydrobiology in 1992 from the Institute of Zoology of Belarusian Academy of Science. For over 10 years (1986-1996), he supervised research on *Dreissena* in the Soviet Union, and later in the Union of Independent States and the Baltic Region, as part of the project "Species and its Productivity" of the UNESCO program "Man & Biosphere". In 2000, after being Chair of the General Ecology Department at the Belarusian State University, Alexander Karatayev relocated to the U.S., and in 2006 became a full Professor of Biology at the Stephen F. Austin State University in Texas. Since 1988, most of his research, teaching, and outreach activity have been conducted in collaboration with his wife and research partner Dr. Lyubov Burlakova, currently a Research Scientist in the Great Lakes Center. In 2005, Dr. Alexander Karatayev was recognized with the Stephen F. Austin State University Faculty Achievement Award in Research. He has taught 12 graduate and undergraduate courses, including Global Ecology, General Ecology, Aquatic Ecology, Introductory Zoology, Limnology, Marine Biology, and Pollution of Aquatic Environments. He has also supervised 17 graduate students, who have established successful careers in ecological and biomedical research, environmental companies, state and federal agencies, and high schools in the U.S. and Europe. His current research focuses on three areas: (1) biodiversity, conservation and management of freshwater ecosystems; (2) ecology, biology, and patterns of spread of exotic species, as well as their role in aquatic ecosystems; and (3) parasites and symbionts of invasive species. He has worked in a broad range of habitats on a wide range of invertebrate systems, and thus has extensive experience in field and laboratory techniques, including studies of various freshwater communities, identification of aquatic invertebrates, parasitology, radioecology, and field and laboratory manipulation experiments. The geography of his research activity includes Europe, Asia, and North and South Americas. Dr. Alexander Karatayev has published over 100 papers, presented over 100 talks at various meetings, and received over 30 research grants as principal investigator and/or co-investigator.

John R. (Jack) Kelly

Jack Kelly is an ecologist with the U.S. Environmental Protection Agency's Office of Research and Development in Duluth MN. He holds a B.A. (Zoology, University of New Hampshire) and Ph.D. (Oceanography, University of Rhode Island). He currently holds Adjunct positions as Professor of Biology (Integrated Biosciences faculty, University of Minnesota Duluth) and Senior Research Associate (Natural Resources Research Institute, University of Minnesota Duluth). Dr. Kelly has conducted studies on a wide variety of marine and freshwater ecosystems, focusing on contemporary environmental problems and ecological approaches to assess and manage them. Current research focuses on the Great Lakes waters and watersheds, and includes efforts providing a technical foundation for an invasive species detection network.

Anita Kelly

Anita Kelly holds a Doctorate degree in Zoology from Southern Illinois University, Carbondale, Illinois. She has published on the history and spread of the Asian carp throughout the United States. She currently is a Fish Health Specialist with the University of Arkansas Pine Bluff. In this position, she conducts routine fish health checks, fish health exams for Fish Health Certificates and samples ponds for aquatic nuisance species. These inspections enable producers to ship fish nationally and internationally. She is actively involved in the "Safe Bait" program in Arkansas. This program was an industry driven initiative to improve their product and eliminate introductions of unwanted species into other states.

Åsa Kestrup

Åsa Kestrup received her Ph.D. in invasive species ecology from McGill University in Montreal in 2010, and was a student within the Canadian Aquatic Invasive Species Network (CAISN). Since the completion of her degree, Dr. Kestrup has been working with invasive species issues at the interface between science and policy at three departments of the federal government of Canada: Fisheries and Oceans Canada, Environment Canada, and Natural Resources Canada - Canadian Forest Service. She is currently working for the Canadian Wildlife Federation, where she is in charge of a project with the objective to assess the Status of Aquatic Invasive Species in Canada.

Jay Kilian

Jay Kilian is a biologist with the Maryland Department of Natural Resources. He has worked as part of the Maryland Biological Stream Survey for 18 years. His research focuses on rare species, invasive species, and the ecology of freshwater streams. He is also actively involved in the prevention and management of aquatic invasive species in Maryland. He holds a Bachelor of Science in Biology from Salisbury University, a Bachelor of Science in Environmental Marine Science from the University of Maryland Eastern Shore, and a Masters of Science in Wildlife and Fisheries Biology from Frostburg State University.

Jaewoo Kim

Dr. Jaewoo Kim is a Visiting Fellow with Fisheries and Oceans Canada (DFO) and is based in Burlington, Ontario, Canada. His current research focuses on evaluating the risk of direct movement of fishes through the Welland Canal and St. Mary's River using acoustic telemetry. He recently worked as a postdoctoral fellow at University of Toronto, examining the regional heterogeneity of lake morphology in relation to geology and its influence on fish communities in Ontario lakes. He received his Ph.D., M.Sc., and B.Sc. degrees in Biology at Concordia University, Montreal, Canada. His doctoral work examined the ecological and behavioural implications of predation risk in wild juvenile Atlantic salmon.

Ronald Kinnunen

Ron Kinnunen has degrees in Fisheries Biology and Management. He has helped develop training materials on aquatic invasive species-hazard analysis critical control points which he uses in his training workshops on aquaculture biosecurity. Ron works closely with the baitfish and aquaculture industries as well as state, federal, and tribal fisheries management agencies to help ensure that their products are free of aquatic invasive species.

Marte Kitson

Marte Kitson is an outreach specialist and National Park Service liaison in the University of Minnesota Sea Grant Program. She began working with aquatic invasive species 10 years ago and earned her MS on the backs of *Bythotrephes*. She currently serves on the on the Minnesota Invasive Species Advisory Committee, and she served on the Upper Midwest Invasive Species program committee. Projects she is involved in raise awareness about AIS and what to do to prevent their spread, foster scientific literacy in youth, and connect scientists and teachers.

Daniel Kluza

Daniel Kluza is a Senior Adviser with the New Zealand Ministry for Primary Industries (MPI). As a member of the Biosecurity Risk Analysis group, Daniel provides risk assessment advice on freshwater and marine biosecurity issues to groups and teams across MPI, covering issues ranging from aquarium trade imports to biosecurity clearance of submersible oil rigs. Biofouling and ballast water risks are Daniel's primary focus, with an increasing emphasis on managing aquaculture disease pathways.

Katy Klymus

Katy Klymus holds a Ph.D. in Evolutionary Biology and Ecology from the University of Missouri, where she studied intraspecific phylogenetic and behavioral differentiation of the canyon tree frog. Currently she is working as a post-doctoral researcher for the Missouri Cooperative Fish and Wildlife Unit of the University of Missouri. Her current project evaluates the use of environmental DNA (eDNA) techniques as a tool for the detection of invasive Asian Carp. Her research is part of a larger, collaborative project with the U.S. Army Corps of Engineers, U.S. Geological Survey, and U.S Fish and Wildlife Service.

Jaroslaw Kobak

Jaroslaw Kobak has worked at the Nicolaus Copernicus University (Torun, Poland) in the Department of Invertebrate Zoology since receiving his Ph.D. in hydrobiology in 2001. His current scientific interests focus on the biology of Ponto-Caspian invaders in Europe, such as zebra mussels, amphipods and gobies. He is studying interactions between these organisms, their habitat preferences, behaviour and impact on native biota. For more information, visit: http://www.umk.pl/~jkob73/english/index_en.html

Victoria Kurtz

Ms. Victoria Kurtz is Manager of Invasive Species and Algae Technologies in the aquatics department at Fluid Imaging Technologies of Yarmouth, Maine, U.S.A. She has worked in fields of algae technologies, biofuels and invasive species, focused primarily on new technologies used to detect and monitor algae, contaminants, invasive species and other microscopic particulates in fluid mediums. Ms. Kurtz has been a presenter on these and other subjects for the American and European Algae Biomass Organizations, the National Algae Association, Algae World Mena and more recently at the Phycology Society of America.

Robert (Bob) Lambe

Bob Lambe was appointed Executive Director of the Canada-Ontario Invasive Species Centre in January 2012. Previously, he held the position of Regional Director General of Central and Arctic Region at the Canadian federal Department of Fisheries and Oceans. Bob is currently Vice Chair of the Great Lakes Fishery Commission and one of four Canadian commissioners appointed by the Governor in Council.

Throughout his federal public service career, Bob held various management and professional positions in Transport Canada and Industry Canada prior to moving to Fisheries and Oceans. He also worked in the telecommunications and industrial electronics industries within the private sector.

Bob holds a Masters of Business Administration degree from the Ivey School of Business at University of Western Ontario and is an electronic engineering technology graduate from the Cabot Institute of Applied Arts and Technology in St. John's, Newfoundland and Labrador.

Rob S.E.W. Leuven

Rob Leuven studied biology (aquatic ecology, animal physiology, fisheries & aquaculture). His Ph.D. thesis concerned the impacts of acidification on the biodiversity and functioning of aquatic ecosystems. He was project leader of several large research projects commissioned by the World Bank, European Commission, The Netherlands Organization for Scientific Research, several governmental organizations and non-governmental organizations. He successfully supervised 12 Ph.D.-projects and (co)authored more than 200 papers (among which 98 ISI-WOS articles), 18 scientific books and 50 professional reports. His main research interest is understanding the impact of multiple stressors on biodiversity and functioning of aquatic ecosystems (rivers, floodplains, moorland pools, peat bogs and urban waters). Research activities particularly focus on effects of aquatic invasive species on river ecosystems. Special attention is paid to the invasion process (including dispersal patterns, causes of establishment success, physiological tolerances and biological traits of invaders), risk assessment of aquatic invasions, effects of climate change on global redistribution of species, ecological and socio-economical impacts and invasion management.

Sarah LeSage

Sarah LeSage is the Aquatic Invasive Species Program Coordinator for the state of Michigan Department of Environmental Quality. Sarah has served in this capacity since 2010 where she organizes statewide interdepartmental efforts to prevent and control aquatic invasive species. She is currently coordinating efforts to update and implement Michigan's Aquatic Invasive Species State Management Plan.

David A. Lieb

David Lieb is an invertebrate zoologist with the Pennsylvania Fish & Boat Commission and Western Pennsylvania Conservancy and is responsible for the development and implementation of conservation, management, and regulatory initiatives that target Pennsylvania's aquatic invertebrates. Recent initiatives have focused on developing ways to slow the spread of Pennsylvania's exotic crayfish species, which have had substantial negative impacts on the state's aquatic resources. His recent published works have focused on the ecology, distribution, conservation, management, and genetics of Pennsylvania's crayfish fauna and have included management recommendations that target the live bait trade. David holds a Ph.D. in Ecology with a minor in Statistics from The Pennsylvania State University and was previously employed by the Stroud Water Research Center and the Academy of Natural Sciences of Philadelphia.

Carolyn Link

Carolyn Link obtained an M.S. from the University of Nevada, Las Vegas, in water resources management, focusing her studies on quagga mussel ecology with a graduate assistantship from the Desert Research Institute. Ms. Link's past experience includes work in aquatic animal husbandry and life support engineering, which allowed her to swim with sharks and work with komodo dragons. At MBI, Ms. Link leads the product development and field studies team for the company's microbial-based molluscicide, Zequanox®.

Robert D. Linley

Robert Dallas Linley holds a Masters degree in Biology from Laurentian University, Sudbury ON, Canada. Currently he is working on field testing the effectiveness of a mechanical filter to reduce or eliminate aquatic species entering the ballast tanks of commercial vessels. He is presently working with the Canadian Department of Fisheries and Oceans, in Burlington Ontario under the direction of Dr. Sarah Bailey. Prior to this he was at the Dorset Environmental Science Center investigating the effects multiple ecological stressors, including the effects of NIS, on lake ecosystems. His current activities include regional and national environmental risk assessments, sampling ballast water entering the North American Great Lakes, operating a towed sensor array, working with a Laser Optical Plankton Counter and a FlowCam® as well as providing technical and mechanical expertise to field projects.

Frances Lucy

Dr. Frances Lucy is a lecturer and researcher at the Institute of Technology, Sligo in Ireland, where she co-ordinates an on-line degree in Environmental Management. She is a member of the Board of Inland Fisheries Ireland. Actively involved in zebra mussel and Asian clam research, she is fortunate to work with a range of international scientists, many of whom she met at this ICAIS conference series.

Hugh MacIsaac

Hugh MacIsaac is a professor at the Great Lakes Institute for Environmental Research at the University of Windsor, who studies pathways and vectors of species introduction. Hugh has worked on alien invasive species for 23 years and currently directs the Canadian Aquatic Invasive Species Network, a consortium of 31 professors from across Canada. His current interests include non-ship pathways of AIS introduction, and use of molecular tools for early detection programs in ports and harbours.

Gerald L. Mackie

Gerry Mackie has been working with freshwater molluscs for >40 years. He has authored or co-authored six books, 15 chapters in books, over 150 peer-reviewed journal articles, numerous conference proceedings, and technical and government publications. He is Co-Chair of the Mollusc Species Specialist Subcommittee. In 2009 Dr. Mackie was awarded a life-time achievement award by the Freshwater Mollusk Conservation Society recognizing his long-term contributions that have advanced the conservation and science of freshwater mollusks at the national and international levels.

Calum MacNeil

Dr. Calum MacNeil is the Freshwater Biologist and Environmental Protection Officer (Controlled Waters) with the Isle of Man Government. He has worked on freshwater community/pollution ecology and the impacts of aquatic invasive species for universities/government agencies in Scotland, Northern Ireland, England, The Netherlands, New Zealand and Alaska. Calum has spent over a decade concentrating on the impacts of invasive freshwater amphipod 'shrimps', latterly focussing on the recent invasion of the British Isles by the 'killer shrimp' *Dikerogammarus villous*. In his spare time he is a one man environmental protection agency for the freshwaters, estuaries and beaches of a small British (but non-U.K.) island, the Isle of Man.

Andrew R. Mahon

Dr. Andrew Mahon is Assistant Professor of Molecular Ecology at Central Michigan University, Department of Biology, Institute for Great Lakes Research. He holds a Ph.D. in Ecological Sciences from Old Dominion University. He has post-doctoral experiences at Auburn University and the University of Notre Dame. Dr. Mahon previously held the position of Research Assistant Professor at the University of Notre Dame. His research interests are best summarized in the fields of evolutionary biology, molecular ecology, and conservation genetics. More specifically, his work uses molecular tools to investigate invasive species ecology and the phylogeography and population genetics of organisms in aquatic and marine systems. Currently, a portion of his research program uses molecular genetic surveillance to detect rare species in aquatic systems (e.g., invasive, non-native, threatened or endangered). Additionally, his work stresses communication between scientists and management organizations on the use of genetic surveillance tools and error in their use to ensure the proper use and interpretation of these tools.

Nicholas E. Mandrak

Dr. 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. He is also a member of the NSERC network, Canadian Aquatic Invasive Species Network. Dr. Mandrak has over 150 published papers, book chapters, and reports and three books on the biodiversity and conservation of Canadian freshwater fishes.

Jonathan Marescaux

Jonathan Marescaux studied biology (2005 – 2010) at the University of Namur (Belgium) and specialized in biodiversity. The aim of his Master thesis was to contribute to the phylogeographical study of the invasive basket clam Corbicula. This work investigated the morphology, the phylogeny and the reproduction of the Asiatic clams in French rivers. Then he made a Master Internship in China to study the behaviour (ethogram and respiratory pattern) of the Indo-Pacific bottlenose dolphin in captivity. He graduated in 2010 and obtained the "Jacques Kets Award" and the "Adrien Bauchau Award" for the best Master Thesis. In October 2010 he began a Ph.D. grant (National Fund for Scientific Research) to do research at the University of Namur on the invasion of Western Europe by the quagga mussel (*Dreissena rostriformis bugensis*). His thesis activities include a broad spectrum of research concerning *Dreissena* invasion: (1) to take stock of its invasion in the Belgian waterways; (2) to elucidate the invasion pathway and vectors of the species in Western Europe in order to establish a phylogeography study; (3) to assess the impacts of the quagga mussel by determining densities, native mussel perturbation, filtration rate and population dynamics.

Grant Martin

Grant Martin recently finished his Ph.D. in the Department of Zoology and Entomology at Rhodes University, Grahamstown, South Africa. He has conducted research on potential biological control agents for the control of *Lagaropsiphon major* in Ireland, fresh water aquatic plant invasion risks posed by the aquarium trade, aquarists and the internet trade in South Africa and the susceptibility of South African fresh water systems to aquatic plant invasions. Other research interests include understanding both abiotic and biotic drivers of aquatic plant invasions. He is currently part of a research team managing aquatic invasive plant species through the use of insect biological control agents in South Africa.

Sara Meehan

Sara is a research student at the Institute of Technology, Sligo, Ireland where she is undertaking a Ph.D. on 'Assessment and utilization of Zequanox® for zebra mussel (*Dreissena polymorpha*) control in Irish waters. She has a Bachelor of Science in Applied Freshwater and Marine Biology (GMIT Galway, Ireland) and previously worked for the Irish Marine Institute on a graduate programme in Marine Environment & Food Safety Services.

Cassandra Mellish

Cassandra Mellish is an undergraduate science student at the University of Prince Edward Island. She is in her fourth and final year of studies with a major in Biology, a minor in Environmental Studies, and is doing her Honours. For the past two summers she has enjoyed doing research on invasive green crabs in Prince Edward Island estuaries.

Margaret D. Modley

Ms. Modley is the Aquatic Nuisance Species Manager Coordinator at the Lake Champlain Basin Program in Grand Isle, VT where she has worked since 2003. She has a Bachelor of Arts Degree in Environmental Studies and Geology from the University of Vermont and a Masters Degree in Public Administration from the University of Vermont. Her work has focused on invasive species rapid response planning in the states of New York and Vermont and the province of Quebec. She is a member of the National Aquatic Nuisance Species Task Force and is the current Treasurer of the Northeast Aquatic Nuisance Species Panel. Modley supervises the Lake Champlain Boat Launch Steward Program on Lake Champlain, coordinates an invasive species grant program in the basin, and enjoys assisting partners with field management control and rapid response efforts.

Daniel P. Molloy

Dan's international research activities have resulted in over 80 publications focusing on the diseases of aquatic invertebrates and environmentally-safe methods for control of pest species, including dreissenids. He recently left his position as Director of the NYS Museum's Field Research Laboratory to join the Department of Biological Sciences at the State University of New York at Albany and to found Molloy & Associates, LLC – a consulting firm specializing in the transfer of scientific information on the biology, ecology, and control of dreissenids. He is the patent inventor of the dreissenid biocontrol method now being commercialized under the product name Zequanox®.

Sophie Monfette

Sophie Monfette is a graduate of Laurentian University's Law and Justice Program and Sir Sandford Fleming College's Fish and Wildlife Technician Program. She is the Coordinator for *Ontario's Invading Species Awareness Program*, a joint initiative of the Ontario Federation of Anglers and Hunters and the Ontario Ministry of Natural Resources. She extensive experience in communicating the problem of invasive species to the public, and has established and maintains partnerships with hundreds of organizations to deliver one of the most comprehensive invasive species awareness programs in the country.

She is an invited Member-At-Large of the U.S. Great Lakes Panel on Aquatic Invasive Species and serves on the Information and Education Committee to assist in the coordination of outreach efforts across the Great Lakes basin. She also serves as the OFAH representative on the Board of Directors for the Canadian Aquatic Invasive Species Network and the Biodiversity Education and Awareness Network.

Cameron Moser

Cameron Moser holds a degree in Mechanical Engineering from the University of Florida. He has five years of experience working with and designing fluid power and automation systems for industrial facilities. He is currently providing engineering support for the Aquatic Nuisance Species Program at the Naval Research Laboratory in Key West, Florida, by consulting in the design of experiments and managing the site's full scale ballast water test system.

Fredrika Moser

Dr. Fredrika Moser received a Ph.D. in 1997 from Rutgers University where she studied at the Institute for Marine and Coastal Sciences. She held a post-doctoral appointment at the Bermuda Biological Station for Research focusing on biodiversity and ocean and human health issues. From 1999 – 2001, Dr. Moser represented the U.S. Department of State on the Aquatic Nuisance Species Task Force and was a member of the U.S. Delegation to the International Maritime Organization where she helped negotiate an international agreement on ballast water management. In 2001, Dr. Moser joined Maryland Sea Grant as the Assistant Director for Research. Her efforts at Sea Grant on aquatic invasive species involved organizing, facilitating and producing reports for two workshops and developing a template "Rapid Response Plan for Aquatic Invasive Species" (2009) to assist states within and beyond the mid-Atlantic region in developing their own rapid response plans. In addition, she is the past chair of the Mid-Atlantic Regional Panel on Aquatic Invasive Species. Most recently, Dr. Moser is the PI on a multi-institutional grant to investigate vector management using live bait as a model vector. Dr. Moser is currently Director of Maryland Sea Grant.

Philip B. Moy

Phil started working for with the University of Wisconsin Sea Grant Institute in 1999. In June of 2011, Phil was appointed as the Assistant Director for Research and Outreach. Prior to that, he was the Fisheries and Non-indigenous Species Specialist. Phil holds a doctorate in zoology from Southern Illinois University at Carbondale. He is president elect of the North Central Division of the American Fisheries Society. He is past chair of the Great Lakes Aquatic Nuisance Species Panel and is Chair of the Technical and Policy Workgroup and the Barrier Safety Workgroup of the Asian Carp Regional Coordinating Committee (ACRCC). He is also a member of the Monitoring and Rapid Response Work Group of the ACRCC. His interests include AIS prevention, canals, barrier technologies and Great Lakes fisheries. His current project involves working with tournament anglers and organizers in the Midwest to prevent the spread of AIS.

Arnaldo Nakamura

Arnaldo Nakamura holds a Masters degree in Materials Engineering from the Universidade Federal de Ouro Preto. He performed research on the microstructure investigation using electron microscopy for invasive species. At present he is working as a researcher on a joined Ph.D. project of the Bioengineering Center of Invasive Species - CBEIh.org. His research activities include a broad spectrum of topics concerning electron microscopy (SEM and TEM) and microstructure characterizations of the shell, foot and byssus of the Golden Mussel, focused on new control methods. Currently he is involved in the characterization of the Golden Mussel's foot cells using Transmission Electron Microscopy with the objective identification of the proteins involved on the process of byssus formation and adhesive properties.

Lucas Nathan

Lucas Nathan received a Bachelor's degree in Fisheries from the University of Wisconsin-Stevens Point. Currently he is in pursuit of a Master's degree in Conservation Biology at Central Michigan University. His Master's research is part of a collaborative project between Central Michigan University's Institute of Great Lakes Research and the University of Notre Dame's Environmental Change Initiative. His current work focuses on the utilization of environmental DNA (eDNA) to detect the presence of invasive species in the Great Lakes commercial bait trade.

Matthew Neilson

Matthew Neilson is an ichthyologist with research interests in population genetics, systematics, ecology, and evolutionary biology, and is interested in understanding the patterns and processes that shape diversity in native and invasive fish faunas. He received an MS degree in Biology from California State University-Long Beach, and earned a Ph.D. in Biology from the University of Toledo, both centered on the population genetics and systematics of introduced gobiid fishes in the United States. He is currently a biological scientist with Cherokee Nation Technology Solutions, on contract with the U.S. Geological Survey's Non-indigenous Aquatic Species Program

Michael Netherland

Dr. Michael Netherland holds a Ph.D. in Agronomy from the University of Florida. He has conducted extensive research linking aquatic plant biology and physiology to the impacts of herbicide treatments on both invasive and native aquatic plants. The ability to link invasive plant biology to management efforts can help in development of new use patterns that minimize use and maximize both cost-effectiveness and selectivity. At present, Dr. Netherland is stationed at the University of Florida Center for Aquatic and Invasive Plants and the majority of his research projects continue to focus on invasive submersed species such as hydrilla and Eurasian watermilfoil. Dr. Netherland has been involved in developing data for newly registered herbicides as well as developing new use patterns for older products. He has worked extensively on issues surrounding herbicide resistance in aquatics. Recent research has emphasized the feedback loop that exists between extensive and consistent field sampling and improved study design at the laboratory and mesocosm scale.

Jordan Ouellette-Plante

Jordan Ouellette-Plante is completing a M.Sc. degree in biology at McGill University under the supervision of Professor Anthony Ricciardi and co-supervisor Professor Ladd Johnson from Université Laval. His research concerns spatial and temporal adaptations of zebra and quagga mussels in different turbidity environments along the St. Lawrence River.

Katherine Pagnucco

Katie Pagnucco holds a Masters degree in Science from the University of Alberta in Edmonton. She performed research on the effectiveness of newly-constructed tunnels at reducing road mortality of an endangered amphibian population, as well as the threat of an introduced fish population on the early life stages of this amphibian. Currently, she is a Ph.D. student at McGill University in Montreal, where she aims to identify predictable patterns of impact of non-native fishes in freshwater communities. This will be achieved through large-scale field surveys, local-scale experimentation, and meta-analyses of existing literature documenting the impacts of non-native fish worldwide. Field surveys and mesocosm experiments focus on impacts of the round goby (*Neogobius melanostomus*), and explore both direct, and indirect impacts of invaders via trophic cascades.

Adelaida L. Palma

Adelaida Palma holds a Doctorate degree in Fisheries from the Iloilo State College of Fisheries. She is currently the Chief of the Bureau of Fisheries and Aquatic Resources-National Inland Fisheries Technology Center. Her works covered the wide area of research and development on the propagation and restoration of indigenous species; risk assessment of species being introduced for aquaculture; and the evaluation of the impacts of invasive exotic species particularly knifefish to the fisheries and livelihood of fisherfolks in Laguna de Bay. Her works had lead to collaboration between the local government units, the municipal fisheries and aquatic resources management council, the Laguna Lake Development Authority and the Bureau of Fisheries and Aquatic Resources to jointly implement measures for the containment and control of the invasive species. She is also actively engaged in tri-media information and education campaign to create public awareness and abate future invasive species introductions or escapement in natural bodies of inland waters.

Vrushalee Palsule

Vrushalee Palsule is working in Dr. Carol Stepien's Great Lakes Genetics/Genomics Laboratory at the University of Toledo's Lake Erie Center on the VHS (viral hemorrhagic septicemia) virus. Vrushalee previously received a Master of Science Degree in Cell and Molecular Biology from Louisiana Tech University. The Great Lakes Genetics/Genomics

Laboratory of Dr. Stepien has worked on invasion genetics in the Great Lakes for two decades, including much of the pioneering work on dreissenid mussels, the Eurasian ruffe, the Ponto Caspian round and tuberose gobies, and VHSv. VHSv outbreaks first appeared in the Great Lakes in 2005 and 2006, and the Stepien lab has traced its invasional history to an origin in the North Atlantic Ocean, published as Pierce and Stepien 2012 in Molecular Ecology. Vrushalee is presenting results from a new diagnostic test developed that accurately quantifies and diagnoses VHSv. She has partnered in this work with Lindsey Pierce, Dr. Stepien's Ph.D. student, and Dr. James Willey from the University of Toledo's Health Science campus.

Esteban M. Paolucci

Esteban M. Paolucci is a postdoctoral fellow in ecology of aquatic invasive species at the Great Lakes Institute for Environmental Research, University of Windsor. He specializes in aquatic invasive species in South America. His research includes the study of the impact non-native mollusc species in trophic webs and predator-preys interactions. Currently he is involved in the evaluation of ballast water treatment systems on board of commercials vessels in order to reduce the magnitude of ballast water as a vector for the introduction of non-indigenous species.

Susan Park

Susan Park received her B.A. and M.A. in biology from the University of Pennsylvania and her Ph.D. in oceanography from the University of Delaware. Her dissertation focused on the range expansion of the nonnative Asian shore crab *Hemigrapsus sanguineus*. Since then, she has spent her career working at the interface of marine science and policy. She is currently the Assistant Director for Research at Virginia Sea Grant, where she oversees the program's research and fellowship portfolio. She is also a Research Assistant Professor at the Virginia Institute of Marine Science. Prior to Virginia Sea Grant, Susan was Senior Program Officer for the Ocean Studies Board at the National Academies, where she worked on a range of ocean policy issues, including marine debris and tsunami warnings and preparedness. Susan also spent time working on aquatic invasive species management with the Massachusetts Office of Coastal Zone Management and the Northeast Aquatic Nuisance Species Panel as a NOAA Coastal Management Fellow.

Aaron D. Parker

Aaron Parker holds a Master's degree in biology with a fisheries/limnology emphasis from Grand Valley State University, Allendale, MI, U.S.A. He performed research evaluating phenotypic and genetic differences in yellow perch (*Perca flavescens*) populations within coastal wetland and pelagic environments of Lakes Michigan and Huron. While working on his graduate research at the Annis Water Resources Institute - GVSU, Muskegon, MI, U.S.A, he assisted on several monitoring projects and experiments involving round goby (*Neogobius melanostomus*) and *Driessena* mussels within coastal areas of Lakes Michigan and Huron. After receiving his Master's degree from GVSU, he worked in an aquatic ecology laboratory at Florida International University (FIU) in Miami, FL, U.S.A. His work at FIU involved intensive sampling of aquatic fauna, particularly small fish, throughout the entire Everglades ecosystem, which has endured numerous biological invasions. The intensive monitoring assisted various managers and government agencies in keeping track of invasive fish populations. Currently, he is employed by the U.S. Fish and Wildlife Service at the Carterville Fish and Wildlife Conservation Office. Almost all of his work currently focuses on the threat of Asian carp and the various strategies that have been employed to prevent their dispersal into Lake Michigan. Specifically, most of his time is spent monitoring fish or performing experiments within an electric dispersal barrier near Chicago, Illinois, U.S.A. that is designed to prevent upstream fish passage to Lake Michigan.

Rachel Paterson

Dr. Rachel Paterson is a postdoctoral research fellow in the School of Biological Sciences at Queen's University Belfast (UK). For the past 18 months she has been investigating the influence of parasitism in freshwater communities with Prof. Jaimie Dick (QUB), and Drs. Alison Dunn and Melanie Hatcher (University of Leeds, UK). Her currently research focuses on how parasites mediate the impacts of exotic gammarids in native communities through predatory functional response and stable isotope approaches. Rachel's previous research used a multi-scale approach of field surveys, experimental infections and dynamic population modelling to investigate the influence of exotic salmonids on native host-parasite dynamics in New Zealand and Argentina (Ph.D. 2011, University of Otago, New Zealand).

Debrupa Pathak

Debrupa currently works for the Biodiversity Policy Section as a Biodiversity Conservation Biologist for the Ontario Ministry of Natural Resources. In this section she assists with policy development on the conservation of biodiversity, wetlands and on the prevention and management of invasive species. She has a Bachelor of Science from the University of Toronto and has recently graduated from the Ecosystem Management Program at Sir Sandford Fleming College. Debrupa also demonstrates her passion for conservation by volunteering as a board member of the Kawartha Turtle Trauma Centre and conducting conservation projects in other countries such as Costa Rica and South Africa.

Stephen Phillips

Stephen Phillips is a senior program manager at the Pacific States Marine Fisheries Commission (located in Portland Oregon) where he has worked for over 20 years. For the last 13 years his main responsibility has been management of PSMFC's Aquatic Nuisance Species Project. Prior to the ANS project, Mr. Phillips worked as a habitat biologist for the PSMFC. Mr. Phillips received his Bachelor's in Biology from Baldwin Wallace College (Berea, Ohio) in 1979 and a Master's of Fisheries Science from Oregon State University in 1987.

Stanley Pickles

Stan Pickles joined Ontario Hydro at the Bruce Nuclear Generating Station in 1989. Mussels were new and he was new to the site so it seemed in many respects the best fit. Stan worked for about 10 years implementing methods to address the effects of zebra mussels that others worked to develop. He also learned a lot about people, science and engineering along the way. He then moved on to another engineering program, Flow Accelerated Corrosion, facing similar development needs in 1999. It seems that an area of expertise is never really relinquished and mussel mitigation is back on his plate again. While technical issues may be different there are many common aspects associated with the work that can be learned to help smooth the way.

Erik Pilgrim

Erik Pilgrim holds a Ph.D. in Biology from Utah State University in Logan, UT. He has performed molecular genetic research on various marine and freshwater invasive aquatic invertebrates for the U.S. Environmental Protection Agency since 2006. This molecular work has had several goals including using genetic diversity within invasive populations to determine number of invasions and to pinpoint the native populations that gave rise to invasion. His current research has expanded into next-generation DNA sequencing as a method for detecting invasive species from bulk environmental samples.

John Polglaze

John is a marine scientist with particular expertise in the environmental management of ports and ships following a seagoing career in the Royal Australian Navy. His involvement in ship-mediated invasive marine species management, both biofouling and ballast water, spans over 12 years, advising the shipping and maritime industries, port operators and developers, and policy and regulatory agencies including the IMO, and he developed a number of the Australian national biofouling management guidelines. He has conducted around 200 individual ship biofouling inspections and risk appraisals, encompassing a broad diversity of vessels, ranging from oil rigs to barges, and including general cargo ships, submarines, pipe layers, an array of dredger types and other specialised vessels.

Katherine Prescott

Katherine Prescott has a multidisciplinary background in science, engineering, and education. She has over 20 years of experience in field and laboratory research, ecosystem and water quality modeling, and science and engineering education. In addition to participating in research and monitoring projects for dreissenid mussels in North America, Katherine has technical experience in limnology, hydrodynamic and water quality modelling, and environmental science. As an Associate with RNT Consulting Inc., Katherine's recent projects have focused on developing tools for determining environmental suitability for dreissenid mussels in North American lakes and water distribution networks.

Carson Prichard

Carson Prichard is a Ph.D. student in the Great Lakes Genetics/Genomics Laboratory at the University of Toledo's Lake Erie Center, working with Dr. Carol Stepien. He received his Masters degree in Fisheries and Wildlife from Michigan State University where he developed statistical models to estimate sea lamprey wounding rates on lake trout in the Laurentian Great Lakes. Such estimates are a key informant in estimating lake trout abundances and setting harvest regulations. His current Ph.D. research efforts are in developing a rapid and inexpensive next generation sequencing test to identify, discriminate, and quantify invasive and native fish species using environmental DNA from water samples. Funded by the U.S. EPA Great Lakes Restoration Initiative, the test includes all fish species identified as likely to invade the Great Lakes, all fish species that already have invaded, and native species. Carson also is investigating the population genetics of invasive Asian carp species, comparing populations at Great Lakes invasion fronts to longer established populations in North America.

Pedro Quijon

Pedro Quijon holds a Ph.D. degree in marine biology from Memorial University (St. John's, Newfoundland) and B.Sc. and M.Sc. degrees in Biology and Zoology, respectively, from the Universidad Austral de Chile (Valdivia, Chile). His research focuses on coastal ecology and involves marine invasive species, particularly green crab, benthic biodiversity, species interactions, meroplankton communities and animal-sediment relationships. Currently he holds an Associate professor of Biology position at the University of Prince Edward Island (Charlottetown, PE), and conducts most of his research on coastal habitats of the southern Gulf of St. Lawrence, Atlantic Canada.

Sanjeevi Rajagopal

Sanjeevi Rajagopal earned a Ph.D. (Doctor of Philosophy) degree from University of Madras, India in 1991 and a D.Sc. (Doctor of Science) degree from Radboud University Nijmegen, Netherlands in 1997. He has extensively worked on the several aspects of biofouling and invasive species in tropical, subtropical and temperate environments. He joined the Department of Animal Ecology and Ecophysiology, Radboud University Nijmegen, Netherlands in June 1994. He is presently involved in the development of novel (CO_2), environmentally sound (heat treatment), chemical (chlorination) and non-chemical technologies (biological control) for the control of macro-fouling in raw water systems. In March 1994, he was a recipient of the Young Scientist award from Rotary International (District 3000), Illinois, U.S.A. and visited Argentina, Paraguay and Brazil as a Rotary International Ambassador (GSE member) of goodwill and understanding. 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.

Dr. Jeffrey Ram earned his Ph.D. from Caltech, did post-doctoral work at the University of California, Santa Cruz, and is currently a professor at Wayne State University. Since the invasion of zebra mussels into North America, the Ram laboratory has focused on the biology and molecular analysis of aquatic invaders and microorganisms. This research is currently funded by three grants: development of molecular and microscopic methods for verifying ballast water treatment, investigation of early detection methods for non-native species in Toledo Harbor, and the design and implementation of automated systems for monitoring live versus dead organisms in ballast water.

Jeffrey Ram

Dr. Jeffrey Ram earned his Ph.D. from Caltech, did post-doctoral work at the University of California, Santa Cruz, and is currently a professor at Wayne State University. Since the invasion of zebra mussels into North America, the Ram laboratory has focused on the biology and molecular analysis of aquatic invaders and microorganisms. This research is currently funded by three grants: development of molecular and microscopic methods for verifying ballast water treatment, investigation of early detection methods for non-native species in Toledo Harbor, and the design and implementation of automated systems for monitoring live versus dead organisms in ballast water.

Anthony Ricciardi

Dr. Anthony Ricciardi is an Associate Professor in the Faculty of Science at McGill University and the Associate Director of Research in the McGill School of Environment. For the past 20 years, his research has examined the causes and consequences of biological invasions. He serves on the editorial boards of the journal *Biological Invasions* and the journal Diversity and Distributions. He also serves on the scientific committee of the Canadian Aquatic Invasive Species Network an NSERC research group that assesses the risks and mechanisms of invasion in Canada's lakes, rivers and coastal waters. For more information about Dr. Ricciardi's research, visit: http://redpath-staff.mcgill.ca/ricciardi/index.html

Paula Rosewarne

Paula Rosewarne is currently a Ph.D. student at the University of Leeds, UK. In conjunction with project partners Tarmac she has conducted research assessing the suitability of restored quarries as potential recipient sites for conservation translocations of White-clawed crayfish in the UK, an endangered species across its range. More recently, her research activities have focused on the spread and likely impacts of the invasive signal crayfish and Chinese mitten crab. She employed a range of methods to assess the trophic interactions of these invasive decapods where they increasingly co-occur, and has addressed movement rates in relation to riverine barriers using telemetry.

Edward Rutherford

Dr. Edward Rutherford is a Research Fishery Biologist at NOAA's Great Lakes Environmental Research Laboratory in Ann Arbor, MI. He obtained a B.S. in biology from Tufts University, a M.S. in Marine Science from University of Miami, and a Ph.D. in Marine Environmental Estuarine Science from the University of Maryland. Dr. Rutherford's research interests include population dynamics, early life history and habitat of Great Lakes and marine fishes. His current research projects include forecasting the impacts of invasive species on Great Lakes food webs and fisheries, and developing maps, databases and decision support tools to facilitate prediction of invasive species distributions and relative abundances.

Scott Sanders

Scott Sanders holds Bachelors degrees in Aquatic Biology, Chemistry, and Broad Field Science from the University of Wisconsin - Superior. He has worked for the U.S. Fish and Wildlife Service for nine years across the country. His work has focused on everything from sea lamprey assessments in Michigan to juvenile salmonid telemetry in Washington State. Currently he works on assessing risk of species that have invaded or have the potential to invade the United States. A component of the assessments is determining a climate niche for various species and developing a program to predict them.

Victor Santucci

Vic Santucci currently is the Lake Michigan Program Manager with the Illinois Department of Natural Resources and formerly was the Department's Asian Carp Project Specialist working in the Chicago area. As project specialist, Vic worked with federal, state, and local partners to develop, coordinate, and implement a monitoring and rapid response plan to prevent Asian carp from establishing populations in the Chicago Area Waterway System and Lake Michigan. Vic has worked as a fisheries biologist for the past 27 years and is certified as a Fisheries Professional by the American Fisheries Society.

Mariusz Sapota

Mariusz Sapota is an assistant professor with the University of Gdańsk, Institute of Oceanography, Poland. His main field of interest is biology and ecology of shallow water fishes. His main work area is the Gulf of Gdańsk and adjacent waters of the Baltic Sea. The main efforts on invasive species have focused on the round goby influence on the functioning of the Gulf of Gdańsk biocenosis and various aspects of biology of invasive aquatic organisms helping them to conquered new territories.

Don C. Schmitz

Mr. Schmitz is the Research Program Manager at the Florida Fish and Wildlife Conservation Commission in Tallahassee, Florida. He has co-edited a book, "Strangers in Paradise: Impact and Management of Nonindigenous Species in Florida (with D. Simberloff and T. C. Brown)," coauthored several publications concerning national policy towards invasive species, and coauthored numerous publications and book chapters about the ecological impact of invasive non-native plant species in Florida. He initiated and organized the process that led to a U.S. Presidential Executive Order creating the country's first National Invasive Species Management Plan and National Invasive Species Council, was a member of the U.S. Congress's Office of Technology Assessment Panel on Harmful Nonindigneous Species, is a former chair of the Florida Exotic Pest Plant Council and former Co-Chair of the Florida Invasive Animal Task Team. Mr. Schmitz is a member of the Gulf and South Atlantic Regional Panel on Aquatic Invasive Species and served as a staff member to Florida's Invasive Species Working Group. In 2010, Mr. Schmitz initiated and organized workshops that resulted in the establishment of the North American Invasive Species Network (NAISN), an international non-profit organization. In 2011 he was appointed the Managing Director of NAISN. He currently manages ~25 university and/or government research and outreach projects a year for the Invasive Plant Management Section at the Florida Fish and Wildlife Conservation Commission and holds a Master's Degree in Biological Science from the University of Central Florida.

Natasha Serrao

Natasha recently completed her undergraduate degree in Molecular Biology and Genetics at the University of Guelph. She worked in a DNA barcoding lab for two years where she then did her honours thesis on DNA barcoding of snakeheads.

Rory Sheehan

Rory is a Ph.D. student studying the Asian clam in Ireland. He holds a B.Sc. in marine and freshwater biology and a post-graduate qualification in environmental toxicology and pollution monitoring. His previous varied research includes rare fish environmental impact assessment, fish population research, angling promotion and market research. http://ie.linkedin.com/pub/rory-sheehan/43/4b7/57b.

Anouk Simard

Anouk Simard has worked as a biologist for the Direction of Biodiversity and Wildlife Disease of *Ministère des ressources naturelles et de la faune* (*Direction de la biodiversité et des maladies de la faune du, MRNF/secteur faune*) since 2009. She recently completed a Master and Ph.D. in the Department of Biology at Laval University, and she holds a B.Sc. degree in Environmental Science from McGill University. For her master and doctoral research, Anouk studied with the Centre for Northern Studies (*Centre d'études nordiques, CEN*) the effect of environmental variation on the demography and life history of white-tailed deer on Anticosti Island. Ms. Simard has participated in several studies including diet composition of birds of prey in Saskatchewan (McGill), reproductive success of waterfowl (Ducks Unlimited), biodiversity monitoring in agricultural areas of Indiana (Purdue University), and bird diversity in riparian habitats of Oregon and Wyoming (Wildlife Conservation Society). She was also involved in environmental impact assessment during an internship in Burkina Faso. Currently, Anouk's work focuses on invasive alien species, climate change, biodiversity monitoring and species at risk conservation. She is involved in several research projects, including bat habitat selection and conservation, Asian clam population dynamic, methodological research for biodiversity monitoring. Her research interests include wildlife management, conservation, population ecology, and tropic interactions.

Isabelle Simard

Isabelle Simard has been the invasive plant species coordinator for the Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs du Québec since 2006. She is a biologist and has a Ph.D. in environmental studies. She is developing early detection and monitoring networks on exotic invasive plants for the province.

Paul Skawinski

Paul Skawinski is finishing a Master's degree program in May 2013 at the University of Wisconsin-Stevens Point College of Natural Resources. He is studying in-lake and shoreland variables and their impact on Eurasian watermilfoil (*Myriophyllum spicatum* L.) and milfoil weevils (*Euhrychiopsis lecontei* Dietz). Paul is also transitioning back to full-time status as Regional Aquatic Invasive Species Education Specialist for a five-county area in Central Wisconsin. He is the author and photographer of the popular field guide Aquatic Plants of the Upper Midwest, and is currently collaborating with Dr. Ken Karol, Assistant Curator at the New York Botanical Garden, on assessing the diversity and abundance of the macro-algal family Characeae in Wisconsin lakes. Paul also serves as the Vice President of the Botanical Club of Wisconsin.

Matt Smith

Matt Smith graduated from Fleming College as a Fish and Wildlife Technician and attended Lethbridge College in the Conservation Law Enforcement degree program. As an avid angler, hunter, and camper, Matt understands the responsibility outdoor recreational enthusiasts have to protect natural resources. As the *Aquatic Invasive Species Outreach Liaison* with the Ontario Federation of Anglers and Hunters, Invading Species Awareness Program, Matt promotes public outreach to the various pathways that spread aquatic invasive species (AIS), and provides advice to the various recourse users on how to mitigate the spread of AIS. Matt sits as an alternate Member-At-Large of the U.S. Great Lakes Panel on Aquatic Invasive Species and serves on the Information and Education Committee to assist in the coordination of outreach efforts across the Great Lakes basin.

Andrea Sneekes

Andrea Sneekes is an expert in the field of testing ballast water treatment systems to minimize the introduction of new invasive alien species. Since 2011, she is a member of ICES Working Group on Ballast and Other Ship Vectors (WGBOSV). Andrea contributes actively in discussions of several international groups like Global TestNet. As a senior analyst at the ecotoxicological laboratory she supports and trains junior researchers, research assistants and analysts. She has broad experiences with a suite of ecological experiments and is the project manager for many of these national and international studies.

Peter Sorensen

Peter Sorensen is a professor in Fisheries, Wildlife and Conservation Biology at the University of Minnesota where he also serves as the director of the Minnesota Aquatic Invasive Species Research Center. His interests lie in the field of fish behavior and pheromones. He has published on sea lamprey and the common carp.

Saulius Stakėnas

Saulius Stake·nas had Marie Curie Intra-European scholarship during period of 2004-2006 years in CEFAS, Lowestoft Laboratory, UK as postdoctoral research. During this period Saulius Stake·nas worked on project "Assessing the risk and understanding the processes of invasion by non-native fish species within and between river catchment" and mainly performed fish telemetry studies to examine movements, migration and dispersal of non-native species in fresh and brackish water systems. Currently he is leading scientist in project "Dispersion, impact and abundance mitigation study of round goby and Amur sleeper in Lithuania", funded by Research Council of Lithuania. Main objectives of project are direct (competition for habitat, predator-prey) and indirect (competition for food, accumulation and transportation of hazardous materials and transfer to higher trophic level) impact of invasive fish species on native aquatic communities.

Paul Stebbing

Dr. Paul Stebbing works for the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) in the UK. He is the co-ordinator for non-native species research and technical advice at Cefas, Weymouth laboratory. The main focus of his work is providing customers with evidence based advice on the management and control of invasive non-native species in both freshwater and marine environments. Examples of current projects include: management and control of invasive crayfish, development of biosecurity measures to prevent the spread of aquatic invasive species, development of a management programme for marine non-native species under the Marine Strategy Framework Directive.

Grant Stentiford

Grant Stentiford holds a BSc from the University of Nottingham UK and a Ph.D. from the University of Glasgow, UK. He is a policy-oriented research scientist with a strong track record in delivering government-funded scientific programmes. He is Team Leader for the Pathology and Molecular Systematics Team at CEFAS and Director of the European Union Reference Laboratory for Crustacean Diseases on behalf of the European Commission. His main interests are the pathology and taxonomy of significant invertebrate pathogens and their regulating role in cultured and wild animal populations.

Carol Stepien

Dr. Carol Stepien is Distinguished University Professor of Ecology and Director of the Lake Erie Research Center at the University of Toledo in Toledo, Ohio. She has over 80 publications in top peer-reviewed scientific journals and has been researching invasion genetics in the Great Lakes for the past 20 years. She has done much of the pioneering genetic work on the Great Lakes invasions by dreissenid mussels, Eurasian ruffe, Ponto-Caspian gobies, and the VHS fish virus. Her Ph.D. degree is from the University of Southern California, and she then wrote and was awarded her own postdoctoral fellowships from the NSF and the Sloan Foundation, which she conducted at Scripps Institution of Oceanography and the University of Texas, Austin, respectively. Her Great Lakes Genetics/Genomics Laboratory also researches conservation genetics and genomics of native fishes, in addition to their work on invasions. Dr. Stepien has made a number of research collection trips to the Black Sea, Caspian Sea, and Baltic Sea and just returned from work in the United Arab Emerites, Poland, and Australia this spring. Her first ICAIS conference was in 1993, from which ideas she wrote and received a large grant award from the National Sea Grant program to begin her seminal work on the genetics of the zebra mussel invasion.

Tom Stewart

Dr. Tom Stewart has worked for over 25 years Great Lakes science and management issues and is currently working for the Ontario Ministry of Natural Resources as a Program Advisor – Great Lakes Ecosystems. His research interests include food web ecology and modeling and forecasting the ecological consequences of novel species additions.

Iris Stiers

Iris Stiers holds a Masters degree in Biology from the Free University of Brussels. At present she is working on a Ph.D. at the Free University of Brussels that focuses on disentangling the patterns of ecological impact of aquatic invasive plants on freshwater ecosystems and the role of environmental stressors in these systems. She studies the community-level impacts of aquatic invasive weeds on different functional groups such as native plants, macroinvertebrates, phytoplankton, zooplankton and pollinators. Currently, she is also involved in the Alien Alert project that aims to develop, calibrate and validate a quick screening tool to identify the most harmful non-native organisms that may be introduced in Belgium and neighbouring areas in the coming years.

Rochelle Sturtevant

Rochelle Sturtevant holds a Ph.D. in systems ecology from Kent State University. Currently, she is working as the Regional Sea Grant Specialist for Outreach at the NOAA Great Lakes Environmental Research Laboratory where she serves as manager for the NOAA GLANSIS database. Dr. Sturtevant also serves as Sea Grant's Extension Representative to the Great Lakes Panel of the Aquatic Nuisance Species Task Force.

Yajun Sun

Yajun Sun is a Ph.D. student in the Department of Geography, University of Toronto under the supervision of Dr. Mathew Wells. His doctoral research focuses on the influences of physical mixing on aquatic invasions in Lake Huron-Lake Erie corridor, an invasional hotspot in the Great Lakes. In the last three years, they conducted trials of ballast water discharge in the St. Clair River to investigate the extent of dilution of discharge due to physical mixing and they measured zooplankton abundance in Lake St. Clair to understand the ecological characteristics in the recipient water. These findings will be incorporated into modeling of population dynamics to assess the invasion risks introduced by ballast water discharge, taking into account both physical mixing and ecological heterogeneities.

Francisco Sylvester

Francisco Sylvester graduated in Biological Sciences at the Universidad Autónoma de Madrid (1998) and holds a Ph.D. from the Universidad de Buenos Aires (2006). He performed research on hull-fouling as a vector for the introduction of aquatic invasive species to Canada as a postdoctoral fellow at the University of Windsor, ON. Outside of the academic world, he worked on protected areas management with the Argentine National Environmental Agency and National Park Service. Currently, he works as an assistant researcher with the Argentine CONICET and teacher assistant at Universidad de Buenos Aires. His research interest include the role of hull fouling and ballast water for aquatic introductions and the ecology of the freshwater invasive bivalve mussel *Limnoperna fortunei* in South America. Lately, he has also been involved collaboration projects concerning terrestrial invaders such as the Argentine ant.

Carolina Taraborelli

Carolina holds a M.Sc. degree in Aquatic Ecology from Trent University (Ontario, Canada) and a B.Sc. degree in Zoology from La Plata University (Buenos Aires, Argentina). She has spent her last 12 years working on different projects focused on aquatic invasive species (golden mussel, Dreissenid mussels, round goby and Hemimysis) looking at their distribution, abundance, diet, reproduction, impacts, role in food webs and control tools. As part of her work she has conducted extensive field surveys, laboratory tests and has trained personnel on sample collection/process methods and taxa identification. Carolina is currently holding a biologist position at the Ontario Ministry of Natural Resources (ARDS) working with Dr. Tim Johnson and she is an associate biologist at RNT Consulting Inc.

John Teem

John Teem earned his Ph.D. in Biology at Brandeis University in 1984 working on yeast molecular biology with Dr. Michael Rosbash. As the invasive species coordinator for the Florida Department of Agriculture and Consumer Services / Division of Aquaculture, he is involved with regulation of the ornamental fish industry and also aquatic invasive species research. His present research seeks to apply molecular biology and genetics to eradicate aquatic invasive species. He is the originator of the Trojan Y Chromosome eradication strategy for invasive fish and is currently developing genetic biocontrol methods for invasive snails in Florida.

Todd Tietjen

Dr. Tietjen joined the Southern Nevada Water Authority in 2008 to work as their in-house limnologist examining water quality issues in Lake Mead. Prior to this he was an Assistant Professor of Aquatic Resources at Mississippi State University. Todd received his Ph.D. in Aquatic Ecology from the University of Alabama. Todd is currently an associated editor for the North American Lake Management Society journal, Lake and Reservoir Management, and is the co-chair for the NALMS 2013 conference in San Diego.

David Tordonato

David Tordonato is a materials engineer with the U.S. Bureau of Reclamation. He works in the Technical Service Center's Materials Engineering and Research Laboratory. He is a registered professional engineer in the state of Colorado and holds B.S. and M.S. degrees in Mechanical Engineering from Virginia Tech as well as a Ph.D. in Materials and Metallurgical Engineering from the Colorado School of Mines. He is currently involved in research to identify and evaluate the coating products to prevent the attachment of fouling organisms such as zebra and quagga mussels on hydraulic infrastructure. His research consists of field and laboratory testing to determine coating effectiveness and expected service life. He holds a current SPRAT certification and frequently performs engineering assessments and other work on inaccessible features of Reclamation Dams and equipment using Rope Access methods.

Jeremy Trombley

Jeremy Trombley is a Ph.D. student in anthropology at the University of Maryland College Park. He has a Master's in Applied Anthropology from the same institution and has worked on a number of projects at the confluence of environmental and social concerns. These include research on the controversy surrounding coal-fired power in Western Kansas, Traditional Cultural Properties in northern Nevada, and the role of computational modeling and participatory methods in understanding and addressing water quality issues on the Chesapeake Bay. Most recently, he has worked on a collaborative team with researchers from the Smithsonian Environmental Research Center (SERC) to investigate vector management as a method of halting or mitigating the introduction of aquatic invasive species to the Mid-Atlantic region.

Paula Tummon Flynn

Paula Tummon Flynn is a Biology honours student at the University of Prince Edward Island. She spent the summer and fall of 2012 working on interactions among coastal decapods under the supervision of Dr. Pedro Quijon. Her honours project concentrated on how the impact of the invasive green crab on native species is modified by injury.

Megan van der Bank

Megan van der Bank holds a Masters degree in Biodiversity and Conservation Biology from the University of the Western Cape, Bellville, Cape Town, South Africa. Her Masters research involved studying the integrated diet of pelagic gobies in the Northern Benguela ecosystem using trophic markers such as stable isotopes and fatty acids. She is presently employed by CapeNature, a public institution in the Western Cape, as part of their Invasive Alien Fauna Unit (IAF). The activities of the IAF include managing and coordinating dedicated projects which aim to mitigate the effects of invasive alien fauna on biodiversity. Presently the focus of the unit is on the eradication of alien fish and rehabilitation of priority river systems

Johannes Adriaan van der Walt

Riaan van der Walt holds a B.Tech. degree in Nature Conservation from the Cape Peninsula University of Technology, Cape Town, South Africa. He has worked for CapeNature for more than 20 years and was recently appointed as Technical Coordinator for invasive alien fauna projects within CapeNature. CapeNature is a public institution with the statutory responsibility for biodiversity conservation in the Western Cape, South Africa. He is currently also busy with his master's degree looking at the management of invasive alien fish in the Western Cape, South Africa. Projects currently under his supervision include: feral pig eradication, rotenone and manual eradication of invasive alien fish and aquatic weeds.

Karine Van Doninck

Karine Van Doninck is a Professor at the University of Namur in Belgium. For more then ten years she has been tackling one of the most fundamental questions in evolutionary biology: 'why do most organisms reproduce sexually?' She addresses this question by studying those rare animal groups that abandoned sex. The model systems in the laboratory are the bdelloid rotifers and the *Corbicula* clams, employing two different modes of asexual reproduction.

Hein van Kleef

Hein van Kleef is senior researcher at the Bargerveen Foundation. He performs applies research on the possibilities of preserving and restoring native aquatic biodiversity. His work on non-native species focuses on the ecology of invasive fish and invertebrates that impede recovery of degraded ecosystems. A recent project aimed at identifying natural determinants of dominance of the invasive pumpkinseed sunfish. Findings of the study have resulted in multiple control programs for this species in the Netherlands. Current and future species of research are Dreissenidae and Anseriformes.

Tony Van Oostrom

Tony Van Oostrom graduated from the University of Waterloo with a Bachelor of Environmental Studies Degree in 1985. He has been working with Ontario Power Generation for 27 years in a number of environment and production related capacities.

Since 1998, Tony has been working in the Niagara Plant Group located in Niagara Falls, Ontario. He has held roles as Senior Environmental Advisor, Section Manger – Environmental Compliance, and most recently as First Line Manager – Production Overseeing Services, which includes Operation and Maintenance of the International Control Dam.

Niagara Plant Group operates five hydroelectric generating stations that produce about 10% of the power in the Province of Ontario. One of Tony's roles has involved overseeing management of the Zebra and Quagga Mussel Treatment to protect cooling water systems in the hydroelectric generating stations.

Since Tony's arrival, the Niagara Plant Group has re-built their Zebra and Quagga Mussel Treatment System using a state-of-the-art design. With that new design, sodium hypochlorite usage was reduced by over 80%.

In 2008 trials were initiated using Zequanox® at the DeCew Generating Station in partnership with Marrone Bioinnovations. In 2012, after four years of trials, a mortality effectiveness rate of 94% was achieved for a full plant treatment.

Mariëlle van Riel

Mariëlle van Riel is a researcher at the department of Fresh Water Ecology at Alterra, Wageningen Research Centre in The Netherlands. Mariëlle completed her Ph.D. at the Radboud University in Nijmegen, where she studied the ecology and impact of invasive species in aquatic systems. Her scope of interest involves aquatic and marine ecology food web dynamics, with an emphasis on ecological response of ecosystems to anthropogenic stressors.

Cees van Slooten

From 2003 to 2010 Cees van Slooten studied Marine Biology at the university of Groningen. Since 2010 he has been involved in ballast water research as a Ph.D. student. His research focuses on two main topics, namely the consequences of toxic chemicals in ballast water treatment, and developing quick and reliable tools to check the quality of ballast water onboard ships.

Jake Vander Zanden

Jake Vander Zanden's research interests include limnology, food webs, invasive species, benthic ecology, and conservation biology. While most of his research is on inland lakes of North America, and Wisconsin in particular, he has also worked in interesting places such as Mongolia, Iceland, and Mexico. He received bachelor's and doctorate degrees from McGill University in Montreal, Canada. Jake is a Professor at the Center for Limnology, University of Wisconsin - Madison. In addition to his research, he maintains an active outreach program, and teaches popular courses in 'Limnology' and 'Ecology of Fishes' at University of Wisconsin - Madison.

María Fernanda Ávila Velandia

María Fernanda Ávila Velandia graduated in Biological Sciences at the Universidad Pedagógica Nacional de Colombia in 2006. During high school, she engaged in work-study programs at several Colombian universities to study the ecology of mountain lakes. She is currently pursuing a Master's degree at the University of Buenos Aires where she works on ballast-water risk assessment in South American ports. She also conducts environmental consulting work.

Laura Verbrugge

Laura Verbrugge holds a Masters degree in Environmental Sciences from the Radboud University Nijmegen. She performed research on the effects of climate change on native and non-native mollusc species in riverine ecosystems, as well as a comparative study on risk assessment protocols for invasive species. At present she is working as a researcher on a joined Ph.D. project of the Institute for Science, Innovation and Society (ISIS) and the Institute of Water and Wetland Research (IWWR), both stationed at the Radboud University. Her research activities include a broad spectrum of topics concerning non-native species including (ecological) risks, public perception and preventive measures and communication campaigns. Currently she is involved in the evaluation of the Dutch code of conduct for invasive aquatic plants, a voluntary agreement between the government and horticulture sector with the objective prevent further introductions of invasive species by increasing public awareness.

Hugo Verreycken

Hugo is a senior scientist at the Biodiversity and Natural Environment Department of the Flemish Research Institute for Nature and Forest (INBO). His research focuses on the study of non-native freshwater fish in Flanders, the northern part of Belgium. The occurrence and distribution of non-native fish and the evolution of these populations over time are closely monitored. Beside this, Hugo is responsible for the online freshwater fish database of INBO: the 'Fish Information System (VIS)'.

Lifei Wang

Lifei Wang is a Ph.D. candidate at the Department of Ecology and Evolutionary Biology, University of Toronto. She is interested in predicting the ecological impacts of environmental stressors such as biological invasions and the potential distributions of invasive species by using statistical models. She is also interested in examining the effects of data quality on model performance using simulations and improving the performance of modeling approaches used to generate predictions.

Megan Weber

Megan Weber holds an M.S. from San Jose State University (SJSU) in environmental studies and a B.S. from the University of California, Santa Cruz in marine biology. While studying at SJSU, Ms. Weber helped develop an invasive mussel monitoring program and rapid response plan at the Santa Clara Valley Water District. Currently, Ms. Weber works at Marrone Bio Innovations where she works towards the development of Zequanox, a biopesticide for invasive mussel control, focusing on use in open water environments.

Terri Wells

Terri Wells is the lead Research Technician and Data Manager for the Department of Fisheries and Oceans Aquatic Invasive Species Research Program in Newfoundland. She has assisted in the development and management of Newfoundland's AIS survey and monitoring program since 2006. She has assisted in the development and implementation of experimental mitigation studies for established populations of European green crab, violet tunicate and golden star tunicate in Newfoundland. She is also involved in the collection and analysis of international and domestic shipping traffic data and it's relation to the introduction and spread of marine invasive species.

Philip Weyl

Philip is a Ph.D. student working with the biological control programme against weeds at Rhodes University. He has always been interested in water related sciences and aquatic weeds, especially submerged aquatic weeds. His work on *Myriophyllum spicatum* is especially important for South Africa because origins have to be determined before a biological control programme can be initiated.

Timothy Wier

Tim is a Mechanical engineer employed by Excet Incorporated to work for the Naval Research Laboratory Aquatic Nuisance Species team. Throughout the last six years, he has participated on several large scale land-based ballast water treatment system experiments as well as conducted research related to sampling of ballast water.

Christopher J. Wiley

Chris straddles two Canadian Federal government departments. He is currently the Manager of Technical Services for Transport Canada Ontario Region and advises Fisheries and Oceans Canada, Central and Arctic Region, as Aquatic Invasive Species Coordinator. He spent fifteen years as a Chief Engineer on icebreakers, product tankers, passenger ships, supply vessels and mega yachts. He joined the Canadian Federal government in 1993 and has been involved in the ballast water file since 1994, leading Canada's response to the discharge of aquatic invasive species from ships into the Great Lakes. He is currently Chair of the Ballast Water Working and Review Groups at the International Maritime Organization.

Leonard Willett

Leonard Willett has a degree in Business Management and specializes in Water & Wastewater Treatment Process. His current position is with the Bureau of Reclamation (BOR) at Hoover Dam as the Compliance Manager and Quagga Mussel Coordinator. 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 related to bio fouling, coordinating research efforts related to control mussels, and installing control barriers to combat the western invasion of the quagga mussel. Leonard is certified in several states as a Water & Wastewater Treatment Operators.

Chris Wilson

Chris Wilson is a research scientist with the Ontario Ministry of Natural Resources, and runs the province's Aquatic Biodiversity and Conservation research unit at Trent University. He oversees the Ontario Ministry of Natural Resources' Fisheries Genetics lab at Trent, as well as the provincial research hatchery. Members of his lab work on a number of conservation issues in exploited and endangered fish and invertebrate species in Ontario. His research primarily focuses on the spatial genetic structure and biodiversity of exploited and endangered aquatic species, and using this information to help inform their sustainable management. His research also involves a number of issues relating to non-native species in North America and Europe, most recently including using environmental DNA screening to search for Asian carp in Ontario waters of the Great Lakes as part of Ontario's surveillance efforts.

David Wong

David Wong is a current a faculty in the Biology Department of State University of New York at Oneonta and an adjunct faculty in Department of Environmental and Occupational Health, University of Nevada Las Vegas. He has studied ecology and physiology of bivalve mollusks and other shellfish for 21 years. He is especially interested in invasive mussels such as the green mussel *Perna viridis*, the quagga mussel *Dreissena rostriformis bugensis*, and the zebra mussel Dreissena polymorpha. His current focus is on biology, control, and management of invasive zebra/quagga mussels in the Lower Colorado River Basin and lakes in North America. Working with his colleagues and students, he has 48 peer-reviewed publications and 87 presentations.

Stan Yavno

Stan Yavno holds an undergraduate and Masters degree in Biological Sciences from the University of Windsor. His thesis examined the behavioural responses of the invasive round goby to signals from conspecifics. This research led to first laboratory description of reproductive behaviours exhibited by male and female round goby. Stan has continued to pursue his interests in invasive fishes, and is presently conducting his Ph.D. research at Trent University. His thesis examines the ecological traits that contribute to the range expansion of invasive (Iberian) pumpkinseed sunfish. This work is done in collaboration with researchers at the University of Girona, and is supervised by Dr. Michael Fox (Trent).

Robert Young

Rob Young is a Ph.D. student at the University of Guelph working on a marine barcoding project funded through the Canadian Aquatic Invasive Species Network and co-sponsored through the University of Guelph and the Department of Fisheries and Oceans. He completed his Masters work at the University of Waterloo investigating the biogeography and phylogeography of Canadian *Fucus* species. In both his current and past work he has utilized molecular phylogenetics within marine taxa to investigate questions of geographical distributions and speciation. His current work includes investigating Canadian plankton biodiversity and evaluating the presence and distribution of invasive plankton species.

Sarah Zack

Sarah Zack is an aquatic invasive species (AIS) specialist for Illinois-Indiana Sea Grant and the Illinois Natural History Survey, and is responsible for implementing public outreach to all recreational water users. Prior to joining IISG's AIS team in 2011, Ms. Zack was an ecology instructor at Loyola University Chicago and a wildlife and fisheries biologist for Wisconsin Department of Natural Resources. She holds a M.S. in biology with an emphasis on aquatic ecology from Loyola University Chicago and a B.S. in zoology and biological conservation from the University of Wisconsin-Madison.

Author Index

Abbott, Cathryn 47
Abilhoa, Vinícius 65
Abramovich, Yariv 173
Adamowicz, Sarah 47
Adams, Jennifer 21, 40, 42
Aldridge, David C.. . . . . 30, 201
Alexander, Mhairi 9, 10, 30, 49, 78
Allan, Craig 83
Allen, Jenny 206
Allinger, Lisa 39
Almada, Pablo 66
Alves de Andrade, André Felipe. 182, 183, 184
Amberg, Jon J.. . . . . 16, 36, 59
Anderson, Karl. 17
Anderson, Lucy 238
Araujo, João 185
Archambault, Philippe. 82
Arnott, Shelley. 11
Ávila Velandia, María Fernanda 66
Avlijas, Sunica 30
Azmi, Fauziah 135
Bacela-Spychalska, Karolina 242
Bacon, Rémi 204
Baier, Robert 67
Bailey, Elizabeth. 36
Bailey, Sarah 16, 19, 21, 39, 40, 42, 63
Bajer, Przemek. 232
Bakker, Elisabeth S.. . . . . 219, 243
Balcer, Mary 39
Balcom, Nancy. 121, 205
Banerjee, Achyut K.. 199
Banno, Fady 26
Barbosa, Norma 79
Barrios-O'Neill, Daniel 10
Bateman, Kelly S. 242
Beahan, E.. 57
Beck, Martina 128
Beisel, Jean-Nicolas. 241
Beletsky, Dmitry. 48
Benson, Amy J.. . . . . 68, 74
Beric, Boris 69
Bertrand, Katie. 37
Best, Kiley. 54
Bielecka, Luiza Agnieszka. 70
bij de Vaate, Abraham 29, 132
Blakeslee, April 208, 209
Blan, Jacob 129
Blaschik, Noreen 205
Blodgett, Jonathan. 229
Blonska, Dagmara 125
Bloom, Kevin. 153
Boets, Pieter 31
Bojko, Jamie 242
Bolen, William 3
Boltovskoy, Demetrio 20, 66
Boon, J. 225
Borelli, Jonathan 58
Bossenbroek, Jonathan M 48
Bovy, Helene C. 10, 71
Bradie, Johanna 116
Brady, Margaret (Peg) 159
Breck, J. 35
Brinsmead, Jeff 169
Briski, Elizabeta 19, 39, 40, 42, 63, 81
Brisson-Bonenfant, Catherine 170
Bronnenhuber, Jennifer. 46
Brothers, Elizabeth 17
Browne, David. 159
Bryant, Dominic E.P. 164
Budny, Michelle 221
Bunke, Mandy 49
Burlakova, Lyubov 112, 130
Caffrey, Joseph M.. . . . . 104, 143, 202
Calfee, Robin D. 57
Campbell, Linda. 11
Campbell, Marnie. 2, 119, 135, 164
Cangelosi, Allegra 39
Canning-Clode, Joao. 208, 209
Cannister, Matthew J. 74
Carreon, Lucia 11
Casas-Monroy, Oscar. 21
Castaneda, Rowshyra 203, 204
Chadderton, W. Lindsay 45, 48
Chaine, Noelle M.. 83
Champion, Paul 178
Chan, Farrah 21, 63
Chan, Samuel 160, 234
Chapman, Duane 17, 222
Charlebois, Patrice 141, 161, 163
Chatterjee, Anindita 198, 199
Chen, Wei 32
Chivers, Corey 138
Choudhury, Anindo 240
Claudi, Renata 151, 152, 173, 192, 194
Clayton, John 178
Coetzee, Julie 90, 91, 179, 217
Cole, Rebecca 240
Coley, Henry 224
Collas, Frank P.L.. . . . . 132, 174
Collin, Samuel 27
Conn, David Bruce 156
Cooke, R. 35
Copp, Gordon H. 88, 125, 148
Copplestone, David 169
Correa, Nancy 20
Correia, Thalisson 101
Cotter, Sheena. 78
Coulter, Alison 16, 36
Couturier, Cyr 54
Crawford, Erin 223
Cristescu, Melania 81
Crunkilton, Ronald 220
Cuddington, Kim 15
Cudmore, Becky. 15, 34
Dahlstrom, Alisha. 75
David, Matej 61
De Bruyn, Luc 109
De Carvalho, Marcela David de . 72, 73, 100, 101,182, 183, 184, 185
De Carvalho Resende, Vinicius 72
de Cássia Souza Campos, Mônica72, 73, 100, 101, 182, 183, 184
de Lafontaine, Yves. 8
Decker, Karie 83
Deibel, Dan. 224
Devin, Simon. 149
Dewanji, Anjana. 198, 199
Dgebuadze, Yury Yu 52, 118
Dick, Jaimie T.A. 7, 9, 10, 30, 49, 50, 71, 78
Dilks, David. 124
Diniz Galvão, Danielle 182, 184
Dmochowska, Barbara 76
Dodd, Jennifer. 30
Dorazio, Robert 68
Dorenbosch, Martijn 243
Drake, Andrew. 167, 168, 169
Drake, Lisa 93, 244, 245, 246, 247
Dunkley, Tal 155
Dunn, Alison 49, 50, 51, 238, 242
Dyson, Eric C.. 121
Dzialowski, Andrew 52
Eder, Tim 235
Edgerton, Elizabeth 77
Edwards, Paul 27
Emmerson, Mark 10, 71
Enciso, Kristina 136
Ennis, Marilyn 50, 78
Erickson, Kevin 119
Escaravage, Stephen 193
Etoundi, Emilie 200, 201
Ewart, John. 206
Eyraud, Amanda. 218
Fanberg, Lana 39
Farley, Mark 163
Feniova, Irina. 52
Ferreira, Maria Beatriz 79
Ferry, Maureen 80
Finney, Samuel 237
Finnoff, David C 35
First, Matthew R. 244, 245, 246
Flint, Nicole. 119
Forbes, Valery E.. 83
Forsberg, Robert L.. 67
Fowler, Amy 166, 208, 209
Fox, Michael G.. . . . . 147, 148
Friedenberg, Nicholas 58,
Fuller, Pamela 53, 68, 74, 106
Fusaro, Abigal 75, 162
Gaikowski, Mark P. 59
Gala, Richard. 26
Gallagher, Kevin. 30
Garkowski, Jeff 124
Gauthier, K.. 80
Gerstenberger, Shawn. 214
Gettys, Lyn 177, 196
Ghabooli, Sara. 81
Giamberini, Laure. 113, 149
Ginnett, Tim 80
Gismondi, Eric 241
Gittenberger, A. 225
Gizicki, Jason P. 26
Glover, David C. 56
Goethals, Peter L.M. 31
Goettel, Robin 144
Goforth, Reuben 16, 36
Goldberg, Jason. 95
Goldsmit, Jesica 82
Gollasch, Stephan 61
Gomes Kunzmann, Bárbara 182, 184

Gontijo, Newton 100, 101
Goss, John 12
Grabowska, Joanna 125
Graeb, Brian 37
Grant, Jonathan F.. . . . . 93, 244, 247
Greer, Michael 216
Gregory, Lucas. 77
Griffin, Kathryn 240
Grisé, Sara 154
Grocock, Christopher 51
Gruber, Bridget 211, 212
Grutters, Bart M.C. 219
Guerold, Francois 149
Gunderson, Jeffrey L.. 186
Gutierrez, Juan 231
Haak, Danielle M. 83
Hahn, Nicky 60
Haller, William T.. . . . . 177, 196
Hamelin, Kayla. 84, 204
Hannah, Charles. 22
Hanner, Robert 146
Hardwick, Terrie 98
Hartman, Leslie 53
Haska, Christina 205
Hassan, Ahdia 85
Hatcher, Melanie 49, 50
Haxton, Tim 155
Hayer, Cari-Ann 37
Henein, Colin 38
Herborg, Leif-Matthias. 128
Hernandez, Marco 64
Hewitt, Chad L. 2, 119, 135, 164
Higdon, Jeff 22
Hilibrich, Danielle. 163
Hill, Jaclyn 127
Hill, Martin 90, 91, 127
Hinz, Collin 33
Hitzroth, Greg 161, 163
Hoff, Michael H. 24, 99
Hoffman, Joel C.. . . . . 25, 43, 44
Hoover, Jan Jeffrey 58, 60
Hosler, Denise 153
Howell, Allison. 190
Howland, Kimberly 22, 82
Hubert, Terrance 59
Huyse, Tine 109
Iacarella, Josephine 9
Ip, Kelvin K. L.. . . . . 228, 56
Jackson, Donald A. 137
Jamieson, Andrew 195
Janik, Jeffrey 151, 192
Jansen, Jeroen M.. . . . . 225, 233
Jensen, Douglas. 120, 144
Jensen, Erika 86, 140, 235
Jerde, Christopher L. 48, 221
Jermacz, Lukasz 87, 88, 125
Johnson, Fred 68
Johnson, Ladd E. 27, 134
Johnson, Tim. 11, 35
Jones, Lisa A.. 133
Jones, Roy 127
Jongejans, Eelke 126
Kaag, N.H.B.M. 225
Kakareko, Tomasz. 88, 111, 125
Kalarus, Marcin 70
Karatayev, Alexander. 110, 112, 130
Kashian, Donna 26, 75
Katzenmeyer, Alan 60
Keller, Douglas. 16, 36
Keller, Reuben P.. 163
Kelly, Anita 187
Kelly, John R.. . . . . 15, 43, 44
Kestrup, Åsa 159
Kilian, Jay 189
Kim, Jaewoo 236
King, Meagan 11
Kingsley-Smith, Peter 53
Kinnunen, Ronald. 186
Kirschner, Robert 163
Kitson, Marte. 144
Klauda, Ronald J. 189
Klaus, Sebastian. 32
Kluza, Daniel A. 117
Klymus, Katy 222
Knott, David 53
Kobak, Jaroslaw 87, 88, 111, 125
Koenig, Brenda 169
Koopman, Remon (K.R.) 132, 174
Koops, Marten A. 15
Kraemer, George 205
Kurtz, Victoria 153
Kyle, Christopher 46
Laybourn, Adam 58
LeSage, Sarah 5
Leung, Brian 27, 116, 136, 138
Leuven, Rob S.E.W. 132, 174, 180

Lew, Julia 172
Lewis, Trevor 224
Lieb, David 188
Light, Theo 154
Lin, Senjie. 205
Link, Carolyn 150, 152, 212
Linley, R. Dallas 21, 40
Little, Edward E. 57
Lock, Koen 31
Lodge, David M.. . . . . 35, 48
Lopes, Roberto 100, 101
Lowen, Ben. 224
Lucey, Michael. 17
Lucy, Frances. 89, 112, 202, 211
Luoma, James A. 59
MacIsaac, Hugh 63, 64, 69, 81, 218, 226
Mackie, Gerald L. 181
MacMillan, Mitchell 98
MacNeil, Calum 28, 30
Mahon, Andrew. 45, 48, 221
Malyshev, Andrey. 55
Mancini, Frank. 229
Mandrak, Nicholas E.. . . . . 14, 105, 167, 168, 169, 236
Marescaux, Jonathan 131, 201
Markee, Thomas. 39
Martin, Grant. 90, 92, 179
Martinson, John. 44
Marty, Jérôme 8
Mason, D. 35
Massagounder, Karthik 17
Masser, Michael 77
Masson, G. 148
Mastitsky, Sergey E.. . . . . 132, 174
Mays, Nicole 39
McDonald, Kent. 11
McKenzie, Cynthia 54, 224
McNiven, Mary 92
Meatyard, James 242
Meehan, Sara 211
Mellish, Cassandra 55, 92, 102
Meloni, Marco 20
Merten, Bobbi Jo 210
Metcalfe, Brent 11
Meyer, Anne E.. 67
Mick, James 56
Miller, A. Whitman 208
Minguez, Laëtitia 149
Mirabilio, Sara 206
Mitchell, Darryl 169
Modley, Margaret. 23, 239
Molloy, Daniel P.. . . . . 113, 149, 171
Mombaerts, Merlijn 109
Monfette, Sophie 124
Morris, James A.. 53
Mortimer, Robert 51
Moser, Cameron. 93, 244, 247
Moser, Fredrika 206, 208, 209
Moy, Philip B.. 142
Mudrak-Cejiolka, Stella 70
Murray, Kelly 212
Nakamura, Arnaldo Filho 185
Nathan, Lucas 221
Neilson, Matthew. 74, 106
Nelson, Harry 153
Nelson, William 121
Netherland, Michael D. 216
Nico, Leo G.. 240
Nienhuis, Sarah 155
Norcutt, Laura 140
Nudds, Shannon 22
O'Donnell, Robert 224
O'Flaherty, Mark. 224
O'Meara, Scott. 192
Ostermeyer, Jan 109
Ouellette-Plante, Jordan 134
Padilla, Dianna. 130
Pagnucco, Katherine 108
Palash, Anna 52
Palma, Adelaida 94
Palsule, Vrushalee. 223
Panov, Vadim 89
Paolucci, Esteban Marcelo 64
Paquet, Annie 204
Park, Susan 166, 206
Parker, Aaron. 237
Parson, Evan 246
Pasko, Susan 95, 159
Pasternak, Lainey 141
Paterson, Rachel 50, 78, 96
Pathak, Debrupa 123
Paukert, Craig 222
Pearce, Fiona. 158
Peeler, Edmund 158
Peperzak, Louis 41
Perry, Andrew 224
Peterson, Gregory 25, 43, 44

Philippart, K. 225
Phillips, Stephen 175
Pickering, Tyler 55, 102
Pickles, Stanley B. 191
Pierce, Lindsey. 129, 223
Pigneur, Lise-Marie 200, 201
Pilgrim, Brooks 224
Pilgrim, Erik. 25, 43, 44
Pimentel, Patricia 73
Pitombo, Fábio 20
Plante, Sophie 204
Plath, Martin 32
Polglaze, John F. 62
Polkinghorne, Christine 39
Pope, Kevin. 83
Potapov, Alexei 64
Poulin, Robert 96
Poupin, Pascal 149
Pozna-ska, Malgorzata. 88, 111, 125
Prescott, Katherine 151
Prescott, Thomas 173, 194
Prichard, Carson. 97
Prihoda, Kelsey 39
Przybylski, Miroslaw 125
Puglis, H. 57
Quijon, Pedro 55, 92, 98, 102
Rackl, Sarahann 212
Rajagopal, Sanjeevi 225, 233
Rakauskas, Vytautas 145
Ram, Jeffrey L. 26
Razlutskki, Vladimir. 52
Reavie, Euan 39
Regan, Deanna 39
Regina Mota, Hellen 72, 73, 100, 101, 182, 183, 184, 185
Reid, Donald M. 39
Ricciardi, Anthony . . 1, 9, 10, 30, 84, 85, 108, 133, 134, 203, 204
Richter, Cathy 222
Riley, Scott 244, 245, 246
Robbins-Walmsley, Stephanie 244, 245, 246
Roberts, Dave 213
Rodrigues Diniz, Vinicius Sergio. 73
Roefer, Peggy 172
Rogers, P. Bradley 237
Rolla, Maria Edith 79
Rooke, A. 147
Rosenberg, Ytzhak 173
Rosewarne, Paula 51
Rothlisberger, J. 35
Rowe, Peter. 206
Ruiz, Gregory 208, 209
Rutherford, Edward S. 35, 162
Saillard, Heidi 39
Sanders, Scott 99, 139
Santucci, Victor 56
Sapota, Mariusz R. 107
Sass, Gregory 80
Schaefer, Heidi. 39
Schmitz, Don C. 176
Schwerdt, Tyler 39
Seekamp, Erin 141, 161
Serrao, Natasha 146
Shaw, Bret 190
Sheehan, Rory 202
Shestakov, Vladimir. 89
Shiganova, Tamara 81
Shoval, Benzi. 173
Sieracki, Jennifer 48
Siferd, Tim 22
Sigler, Von 97
Silva, Fabiano Alcísioe 72, 100, 101, 182, 183, 184
Simard, Anouk. 203, 204
Simard, Isabelle 6
Simmonds, Jr., Robert 237
Simões, Daniel. 79
Skaja, Allen 210
Skawinski, Paul M. 220
Skóra, Felipe 65
Smith, Caleigh 46
Smith, Matt. 122
Sneekes, Andrea 225
Sohm-Rederstorff, Bénédicte 113
Sorensen, Peter W. 57, 232
Sornom, Pascal 241
Southern, Larry 60
Spaulding, Benjamin. 153
St. Hilaire, Sophie 92
Stak-nas, Saulius. 145
Stebbing, Paul 158, 238, 242
Stefanavage, Tom. 16
Steinke, Dirk 146
Stentiford, Grant 238, 242
Stephen, Bruce J. 83
Stepien, Carol 97, 114, 129, 223
Stepon-nas, Andriuis 145
Stewart, Bruce 22
Stewart, Jeffrey 237

Stewart, Robert 22
Stewart, Tom. 34
Stiers, Iris 197
Stokes, Nancy 113
Stone, Nathan 187
Streit, Bruno 32
Sturtevant, Rochelle 162
Sun, Yajun 157
Sylvester, Francisco. 20, 66
Sysova, Elena. 52
Szaniawska, Anna. 76
Tangora, Sue 5
Taraborelli, Carolina 152, 192
Teem, John 230, 231
TenEyck, Matthew 39
Therriault, Thomas W. 47
Tietjen, Todd 172
Tompkins, Daniel M. 96
Tordonato, David 210
Townsend, Colin 96
Trebel, Margaret 22
Trebitz, Anett 25, 43, 44
Triest, Ludwig 197
Trombley, Jeremy. 207
Tucker, Andrew 45, 48
Tucker, Ann Marie. 224
Tulumello, Brianne 112
Tummon Flynn, Paula S.. . . . . 55, 92, 102
Tunowski, Jacek. 52
Turtora, Michaael 68
Uden, Daniel 83
Ullrich, Dave 235
Valadão Cardoso, Antônio . 72, 73, 100, 101, 182, 183, 184, 185
Valente, E.. 148
van den Born, Riyan 180
van der Bank, Megan 103
van der Velde, Gerard 29, 132, 174, 233
van der Walt, Johannes Adriaan. 103, 227
van der Weidde, B. 225
Van Doninck, Karine 131, 200, 201
van Kleef, Hein. 126
Van Oostrom, Anthony 212
Van Pelt, H. 225
van Riel, Mariëlle 29
van Slooten, Cees. 41
van Staden, Ben. 227
Vander Zanden, Jake. 165
Veldhuizen, Tanya. 151, 192
Vellinger, Céline 241
Verbrugge, Laura 180
Verreycken, Hugo. 109
Virbickas, Tomas 145
Vitule, Jean Ricardo Simões 65
Volpe, John. 128
Wallace, John R. 188
Wang, Lifei 137
Watters, Ashlie. 214
Weber, Megan 213
Weisz, Erika. 124
Wells, Mathew 157
Wells, Terri 224
Wen, Qiu Jian 228
Wert, Eric 172
Weyl, Olaf 127
Weyl, Philip. 217
Wheeler, Tyler 98
White, Piran 238
Whitlatch, Robert. 205
Whitman Miller, A. 209
Whitney, Sarah 206
Wier, Timothy 93, 244, 247
Wijers, Tom 41
Wiley, Christopher J. 18, 19, 22, 39
Willett, Leonard 215
Willey, James. 223
Wilson, Chris 11, 46
Wilson, Kathryn 196
Wing, Chris 51
Wittmann, Marion 35, 48
Wolfgang, Johann 32
Wong, David W.H.. 214
Wozney, Kristyne 46
Yarish, Charles 205
Yasuda, Nina 201
Yavno, Stan. 147
Yeo, Jiyoun 223
Young, Robert 47
Yuille, Mike 11
Zack, Sarah 141
Zambon, Joseph 67
Zanatta, David. 112
Zhan, Aibin. 81
Zhang, Hongyan 34, 35
Zhang, Huang 205
Zu, Xinhua 35

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