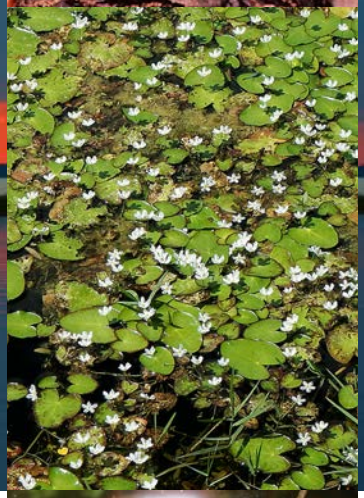
FINAL PROGRAM

Global Action Against Aquatic Invasive Species

October 22-26, 2017
Marriott Coral Springs
Fort Lauderdale, Florida



ICAIS

20th International Conference on Aquatic Invasive Species

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Conference at a Glance

Sunday, October 22, 2017

3:00 PM to 6:00 PM
Conference Registration
Speaker PowerPoint Submission

Monday, October 23, 2017

7:00 AM to 5:00 PM
Conference Registration
Speaker PowerPoint Submission

8:30 AM to 9:50 AM
Opening Plenary Session

9:50 AM to 10:20 AM
Networking Break

10:20 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

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

6:50 to 7:00 PM
Mussel Dog Demonstration

7:20 to 7:30 PM
Mussel Dog Demonstration

Tuesday, October 24, 2017

7:00 AM to 5:00 PM
Conference Registration
Speaker PowerPoint Submission

8:45 AM to 9:50 AM
Plenary Session

9:50 AM to 10:20 AM
Networking Break

10:20 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, October 25, 2017

7:00 AM to 5:00 PM
Conference Registration
Speaker PowerPoint Submission

8:45 AM to 9:50 AM
Plenary Session

9:50 AM to 10:20 AM
Networking Break

10:20 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 5:20 PM
Concurrent Sessions

Evening Free

Thursday, October 26, 2017

7:00 AM to 11:40 AM
Conference Registration
Speaker PowerPoint Submission

8:45 AM to 9:50 AM
Plenary Session

9:50 AM to 10:20 AM
Networking Break

10:20 AM to 12:00 PM
Concurrent Sessions

11:40 PM
Conference Adjourns

Twitter Guidelines

The organizers of ICAIS encourage live tweeting throughout the conference under the hashtag **#ICAIS2017**. The conference organizers thank all tweeters for respecting the wishes of speakers and poster presenters who do not want live tweeting about their presentations.

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Monday, October 23, 2017

Opening Plenary

8:30 AM
Welcoming Remarks
Tracey Cooke, Executive Director, Invasive Species Centre

Jay Ferrell, Director, University of Florida, IFAS Center for Aquatic and Invasive Plants

Lyn Gettys, ICAIS 2017 Technical Program Chair, University of Florida, IFAS

9:00 AM
Invited Keynote Presentation
Session Chair: Tracey Cooke, Invasive Species Centre

Unravelling the Ecology of Non-native Species to Inform European Strategy
Helen Roy, Head of Zoology, Biological Records Centre, Centre for Ecology and Hydrology, UK

9:50 AM
Networking Break

Session 1A

Response and Control I
Session Chair: Renata Claudi, RNT Consulting Inc.

10:20 AM
Zebra Mussel Control – 16 Years of Ozone Treatment at Lennox G.S.
Mike Farrell, Ontario Power Generation

10:40 AM
Chemical Free Disinfection for Macro / Micro Biofouling (AIS) to Protect Cooling Water Systems of Hydroelectric Facilities
Ytzhak Rozenberg, Atlantium Technologies

11:00 AM
Influence of Water Temperature on the Toxicity of Molluscicides to Zebra Mussels (*Dreissna polymorpha*)
James A. Luoma, U.S. Geological Survey

11:20 AM
The Use of Potassium Chloride to Control Zebra Mussels: Semi-Static Systems
Dan Butts, ASI Group Ltd.

11:40 AM
Environmentally Sustainable Management of Invasive Dreissenid Mussels using Zequanox
Seth Donrovich, Marrone Bio Innovations

12:00 PM
Luncheon

Session 2A

Early Detection I
Session Chair: Jeff Brinsmead, Ontario Ministry of Natural Resources and Forestry

10:20 AM
Biodiversity Entering United States Ports via Ballast Water Discharge: An Analysis using High Throughput Sequencing
John Darling, U.S. Environmental Protection Agency

10:40 AM
Identifying 'Risky' Sites in the Laurentian Great Lakes: Development of a Spatially Explicit Method for Selecting Sites for AIS Surveillance
W. Lindsay Chadderton, The Nature Conservancy

11:00 AM
Enhanced Aquatic Connectivity through Regional Coordination and Selective Fish Passage Solutions
Lisa Walter, Great Lakes Fishery Commission

11:20 AM
Asian Carp Early Detection Surveillance in the Canadian Waters of the Great Lakes
David Marson, Fisheries and Oceans Canada

11:40 AM
Early Detection of a Highly Invasive Bivalve Based on Environmental DNA (eDNA)
Zhiqiang Xia, University of Windsor

12:00 PM
Luncheon

Session 3A

Engagement I
Session Chair: Tracey Cooke, Invasive Species Centre

10:20 AM
INVASIVESNET Initiative: Towards the Development of the International Association for Open Knowledge on Invasive Alien Species
Frances E. Lucy, Institute of Technology, Sligo and Inland Fisheries Ireland

10:40 AM
Invasive Mussel Collaborative: Developing Tools and a Strategy for Managing Zebra and Quagga Mussels in the Great Lakes
Erika Jensen, Great Lakes Commission

11:00 AM
LINVEXO: A New Tool for Invasive Species Education in The Netherlands
Annerie Rutenfrans, Adviesbureau Beleef en Weet

11:20 AM
Underpinning Invasive Species Outreach with an Effective Communications Plan
Eithne Davis, Institute of Technology Sligo

11:40 AM
A Redesigned Volunteer AIS Monitoring Program in Wisconsin, USA
Paul Skawinski, University of Wisconsin - Extension Lakes Program, Stevens Point

12:00 PM
Luncheon

Monday, October 23, 2017

Session 1B

Response and Control II

Session Chair: Dan Butts, ASI Group Ltd.

1:30 PM
Evaluation of Carbon Dioxide as a Dreissenid Mussel Control Tool
Diane Waller, U.S. Geological Survey

1:50 PM
Taking No Prisoners, Beating Back Invasive Species – Bureau of Reclamation
Leonard Willett, Bureau of Reclamation

2:10 PM
Temperature and Dose Response of Invasive Quagga Mussels to Various Molluscicides in High Conductivity Water
Michael Booth, United Water Conservation District

2:30 PM
Control of Zebra and Quagga Mussels with a More Rational Use of Copper
David Hammond, Earth Science Labs, Inc.

2:50 PM
Field Evaluation of the Service Life of Foul-release Coatings in the Columbia River, Oregon and Washington, USA
Withdrawn
Steve Wells, Portland State University

3:10 PM
Networking Break

Session 2B

Biotic Drivers I

Session Chair: David Nisbet, Invasive Species Centre

1:30 PM
Pollution – A Gateway for Freshwater Amphipod Invaders to Cause Ecosystem Change?
Calum MacNeil, Isle of Man Government

1:50 PM
Comparative Assessment of Gammarids under Stressful Conditions
Isabel Casties, GEOMAR

2:10 PM
Are Ponto-Caspian Species Inherently Predisposed to Cross Salinity Boundaries? Experimental Selection of a Ponto-Caspian Gammarid
Nora-Charlotte Pauli, GEOMAR

2:30 PM
Experimental Assessment of Emerging Invasion Threat: A Host-Parasite Coevolutionary Association Modulating Invasional Meltdown
Martin Reichard, Academy of Sciences of the Czech Republic

2:50 PM
Experimental Evaluation of Microhabitat Preferences of Ponto-Caspian Gammarids
Jaroslaw Kobak, Nicolaus Copernicus University

3:10 PM
Networking Break

Session 3B

Engagement II

Session Chair: Deborah Sparks, Invasive Species Centre

1:30 PM
Sticky Habits: Insights into Behaviors by Recreational Boaters
Douglas A. Jensen, University of Minnesota Sea Grant Program

1:50 PM
Invading Species Hit Squad: Community Based Education and Outreach
Sophie Monfette, Ontario Federation of Anglers and Hunters

2:10 PM
Asian Carp Exhibit at the Toronto Zoo
Lauren Tonelli, Invasive Species Centre

2:30 PM
A Perfect Match: Increasing Impact in Invasive Species Outreach through Extension and Cooperative Invasive Species Management Area Collaboration
Shannon Carnevale, University of Florida - IFAS

2:50 PM
Illinois Aquatic Pet Surrender Events, Rehoming and Care Networks
Greg Hitzroth, Illinois-Indiana Sea Grant and Illinois Natural History Survey

3:10 PM
Networking Break

Monday, October 23, 2017

Session 1C

Response and Control III

Session Chair: Jill Wingfield, Great Lakes Fishery Commission

3:40 PM
Management Review of AIS in Ontario
Lauren Tonelli, Invasive Species Centre

4:00 PM
Evolving Strategies for AIS Response: Lessons Learned from 10Years of Research in Newfoundland, Canada
Cynthia H. McKenzie, Fisheries and Oceans Canada

4:20 PM
Development of a Selective, Environmentally Safe and Low Cost Carp Pesticide
Maurice Sadowsky, MJSTI Corp.

Session 2C

Biotic Drivers II

Session Chair: Frank Collas, Radboud University Nijmegen

3:40 PM
Do Ecological Interactions Explain Dominance Shift between Ponto-Caspian Bivalves *Dreissena polymorpha* and *Dreissena rostriformis bugensis* in their Introduced Range
Anouk D'Hont, GiMaRIS

4:00 PM
Managing Invasive Plants and Animals Amidst Endangered Species
Withdrawn
Mike Bodle, South Florida Water Management District

4:20 PM
Invasional Genetic Patterns Across Time and Space in North American *Dreissena* Mussels
Nathaniel T. Marshall, University of Toledo

4:40 PM
Introducing the Quagga Mussel as a Method for Water Quality Improvement: Assessed Risks and Permit Criteria
Lisette de Hoop, Radboud University Nijmegen

5:00 PM
What Really Scares Zebra Mussels? A Few Words about the Impact of Biotic Factors on Valve Movement Reactions of the Zebra Mussel *Dreissena polymorpha*
Anna Dzierżyńska-Białończyk, Nicolaus Copernicus University

5:20 PM
Does the Invasional Meltdown Exist? The Case of the Ponto-Caspian Community
Jaroslaw Kobak, Nicolaus Copernicus University

Session 3C

Tools I

Session Chair: Sarah Bailey, Fisheries and Oceans Canada

3:40 PM
Methods for Quantifying Biofouling: An Initial Examination of Optical and Acoustic Approaches
Scott Riley, Excet, Inc.

4:00 PM
Performance Evaluations of Instruments Designed for Rapid, Shipboard Detection of Living Microorganisms in Ballast Water
Matthew R. First, Naval Research Laboratory

4:20 PM
Assessment of Ballast Water Management Systems: Science in Support of Policy
Hugh MacIntyre, Dalhousie University

4:40 PM
Advances in Validating MPN and Stain-Motility Methods for Assessing Phytoplankton for Ballast Water Treatment
Brian Petri, Trojan Technologies

5:00 PM
Implementing DNA Metabarcoding as Cost-effective Tool to Provide Biological Data for Port Baseline Survey
Anaïs Rey, AZTI, Marine Research Division

5:20 PM
Optimization and Performance Testing of a Sequence Processing Pipeline Applied to Early Detection of Nonindigenous Species
Ryan Scott, University of Windsor

Monday, October 23, 2017

Poster Session 6:00 PM – 7:30 PM

An Exotic Fish, Bullseye Snakehead (*Channa marulius* [Hamilton, 1822]), in the Canal System of Southern Florida, USA
Amy J. Benson, U.S. Geological Survey

Dry Ice - A Novel Control and Eradication Method for Invasive Asian Clam Corbicula fluminea?
Neil Coughlan, Queen's University Belfast

Multiple Introductory Events Shape the Phylogeographic Structure of a Globally Invasive Marine Mussel
Andrew David, Clarkson University

Do Ecological Interactions Explain Dominance Shift between Ponto-Caspian Bivalves Dreissena polymorpha and Dreissena rostriformis bugensis in their Introduced Range
Anouk D'Hont, GiMaRIS

Addressing AIS introductions from Aquariums and Water Gardens using Outreach and Retailer Inquiry in Michigan
Paige Filice, Michigan State University

Contrasting Patterns of *Pomacea maculata* Establishment and Dispersal in the Everglades vs a Central Florida Lake System
Silvia Millan Gutierre, University of West Florida

How the Burrowing Activity of the North American Crayfish *Procambarus clarkii* Alters the Seepage Process in River Levees
Phillip J. Haubrock, University of Florence

Microbial Communities Associated With Aquatic Invasive Species Using High-Throughput Sequencing Approaches
Prince Mathai, University of Minnesota - St. Paul

The Status of the Native *Myriophyllum sibiricum* in New England: Evidence of Drastic Decline in Presence and Genetic Structure of Extant Populations
Anastasia Mozharova, University of Massachusetts, Boston

Potential Dispersal of Grass Carps in the St. Lawrence River Network (Québec, Canada) based on Habitat and Barrier Mapping
Olivier Morissette, Ministère des Forêts, de la Faune et des Parcs

***Phragmites australis* Management in Florida Under a Changing Climate**
Candice M. Prince, University of Florida

Herbicide Resistance and Microbiomes in Michigan (US) Lakes
Withdrawn
Douglas Wilhan, Aquest Corp

Estimation of Plankton Densities in Ballast Water when Colonial Species are Present, and their Implications in Compliance Testing on IMO Density Standards
Harshana Rajakaruna, Fisheries and Oceans Canada

A Literature Review of Hull Husbandry Methods
Stephanie Robbins-Wamsley, Excet, Inc.

Determining the Toxicity of Antifreeze to Quagga Mussels
Kelly Stockton-Fiti, KASF Consulting

Asian Carp Canada Social Media and Web Tactics
Lauren Tonelli, Invasive Species Centre

Confused with Carp
Lauren Tonelli, Invasive Species Centre

Evaluating Risk of African Longfin Eel (*Anguilla mossambica*) Aquaculture using a Bayesian Belief Network of Freshwater Fish Invasion
Katherine Wyman-Grothem, U.S. Fish & Wildlife Service

Mussel Dog Demonstration

6:50 to 7:00 PM and 7:20 to 7:30 PM

Have you ever wanted to see a mussel detection dog in action? Come see Nemo from Mussel Dogs demonstrate his canine skills and learn a little about how he was trained, his capabilities and what it takes to start a canine program of your own.

Tuesday, October 24, 2017

Plenary Session

8:45 AM
Welcome to Day 2
Lyn Gettys, University of Florida - IFAS

9:00 AM
Invited Keynote Presentation
Session Chair: Lyn Gettys, University of Florida – IFAS

Knowledge to Action on Invasive Species: North America and Global Linkages
David M. Lodge, Director, Atkinson Center for a Sustainable Future, Cornell University, USA

9:50 AM
Networking Break

Session 1D

Response and Control IV
Session Chair: Lindsay Chadderton, The Nature Conservancy

10:20 AM
Development of a Novel Tool to Deliver Control Agents to Targeted Aquatic Invasive Fishes
Jon J. Amberg, U.S. Geological Survey

10:40 AM
Control of Common Carp through Biocontrol and Species-specific Toxin Delivery
Josh Poole, University of Minnesota

11:00 AM
Removal of *Phragmites australis* ssp *australis* and Site Augmentation with Native Vegetation in Wisconsin, USA
Paul M. Skawinski, University of Wisconsin - Extension Lakes Program, Stevens Point

11:20 AM
STA Vegetation Management and Invasive Species Control
Eric Crawford, South Florida Water Management District

11:40 AM
Utilizing a Rapid Response Team for Landscape Level AIS Survey & Management in the Adirondack Park
Erin Vennie-Vollrath, The Nature Conservancy

12:00 PM
Luncheon

Session 2D

Biotic Drivers III
Session Chair: Brenda Koenig, Ontario Ministry of Natural Resources and Forestry

10:20 AM
The Interaction of Experimental Warming and Biotic Resistance to Invasion of Non-native Poeciliids in Replicated Pond Ecosystems
Quenton M. Tuckett, University of Florida

10:40 AM
Influence of Phylogenetic Community Structure on Introduced Fishes in the Southeast United States
Matthew E. Neilson, U.S. Geological Survey

11:00 AM
Sensitivity of European Native and Alien Freshwater Bivalve Species to Climate Related Environmental Factors
Frank P.L. Collas, Radboud University Nijmegen

11:20 AM
Association between the Ratio of Organic to Inorganic Nitrogen and Growth of the Invasive and Itchthyotoxic Golden Alga
Rakib Rashel, Texas Tech University

11:40 AM
Does Extreme Flooding Affect the Alien Macrophytic Assemblage: Insight from Recent Floods in Kashmir Himalaya, India
Ayaz Bashir, University of Kashmir

12:00 PM
Luncheon

Session 3D

Tools II
Session Chair: Matthew First, U.S. Naval Research Laboratory

10:20 AM
Serious Gaming to Derive Cost-effective Management Measures for the Invasive Alien Pumpkinseed Sunfish in Europe
Rob S.E.W. Leuven, Radboud University Nijmegen

10:40 AM
Man and Exotic Fish: Incorporating YouTube Videos and Citizen Science Data to Explore Spatial and Demographic Patterns in Urban Fishermen Attitude and Behavior with Respect to Exotic and Invasive Species
Jason Post, Texas Tech University

11:00 AM
Can Environmental DNA (eDNA) be used for the Early Detection of *Gobiusculus leniusculus* in Scotland? Withdrawn
Kristen J. Harper, University of Stirling

11:20 AM
How Do We Identify High-risk Genotypes for Adaptive Management of Eurasian and Hybrid Watermilfoil?
Ryan A. Thum, Montana State University

11:40 AM
Environmental DNA (eDNA) and Environmental RNA (eRNA) Markers for Invasive Species Detection
Joshua Finn, University of Windsor

12:00 PM
Luncheon

Tuesday, October 24, 2017

Session 1E

Response and Control V

Session Chair: Christopher J. Wiley, IMO Ballast Water Working Group

1:30 PM
Examining Zooplankton Patchiness Inside Ship Ballast Tanks to Improve Estimates of Average Abundance for Compliance Monitoring
Sarah A. Bailey, Fisheries and Oceans Canada

1:50 PM
The Efficacy and Practicability of Combining Ballast Water Exchange with Treatment: Results of Shipboard Trials
Lisa A. Drake, Naval Research Laboratory

2:10 PM
Effect of the Temperature on Chlorine as Ballast Water Treatment to Eliminate Freshwater Phytoplankton Populations: A Bench Scale Test
Oscar Casas-Monroy, Fisheries and Oceans Canada

2:30 PM
Quantifying the Extent of Niche Areas in the Global Fleet of Commercial Ships: The Potential for "Super- Hot Spots" of Biofouling
Cameron Moser, Naval Research Laboratory

3:10 PM
Networking Break

Session 2E

Policy Drivers I

Session Chair: Erika Jensen, Great Lakes Commission

1:30 PM
The Strategic Vision of the Great Lakes Fishery Commission: A Mid-Decadal Review
Robert G. Lambe, Great Lakes Fishery Commission

1:50 PM
Funding for Invasive Species: A Review of Progress, Gaps, and Opportunities
Cecilia Weibert, Great Lakes Commission

2:10 PM
Regulating Organisms-in-Trade through a Permitted Species List: the Good, the Bad, and the Ugly
Nicholas Popoff, Michigan Department of Natural Resources

2:30 PM
Integrated Management Approach of Aquatic Invasive Species for Québec Province, Canada
Olivier Morissette, Ministère des Forêts, de la Faune et des Parcs

2:50 PM
Asian Carps Enforcement Activities: Approaches across Great Lakes Jurisdictions
Brenda Koenig, Ontario Ministry of Natural Resources and Forestry

3:10 PM
Networking Break

Session 3E

Tools III

Session Chair: Stephen Phillips, Pacific States Marine Fisheries Commission

1:30 PM
Underwater Video is an Effective Tool to Reveal *Dreissena* Spatial Distribution
Alexander Karatayev, Buffalo State College

1:50 PM
Using a High-Throughput Sequencing Assay to Assess Dreissenid Mussel Communities
Nathaniel T. Marshall, University of Toledo

2:10 PM
Integrating Remote Sensing and Underwater Imagery to Enhance Invasive *Dreissena* Distribution Assessment in Large Rivers
Knut Mehler, Buffalo State College

2:30 PM
Feasibility and Efficacy of three Methods of Zebra Mussel Larvae Detection
Sharon Lavigne, University of Windsor

2:50 PM
Comparison of Traditional and eDNA Metabarcoding Sampling Methods to Detect Low Abundance Species in Complex Aquatic Communities
Seth Herbst, Michigan Department of Natural Resources, Fisheries Division

3:10 PM
Networking Break

Tuesday, October 24, 2017

Session 1F

Response and Control VI

Session Chair: Lauren Tonelli, Invasive Species Centre

3:40 PM
Integrated Management of Waterhyacinth (*Eichhornia crassipes*)
Lyn Gettys, University of Florida, IFAS/FLREC

4:00 PM
Water Chestnut (*Trapa natans*) Removal and Monitoring in the Erie Canal, Tonawanda, New York, USA
Heidi Himes, U.S. Fish & Wildlife Service

4:20 PM
Adaptive Management of Multi-resistant *Hydrilla* in a Central Florida Chain of Lakes
Amy L. Giannotti, City of Winter Park

4:40 PM
Senegal Tea (*Gymnocoronis spilanthoides*) Aquatic Weed Risk Assessment and Management
Paul Champion, National Institute of Water & Atmospheric Research

5:00 PM
Endothall Behavior in Eurasian watermilfoil (*Myriophyllum spicatum*) and Hydrilla (*Hydrilla verticillata*)
Mirella Ortiz, Colorado State University

Session 2F

Policy Drivers II

Session Chair: Erika Jensen, Great Lakes Commission

3:40 PM
Update on the Status of the IMO Ballast Water Convention
Christopher J. Wiley, IMO Ballast Water Working Group

4:00 PM
Establishing Research Priorities for Aquatic Invasive Species
Nicholas B.D. Phelps, University of Minnesota

4:20 PM
A Brief History of the Aquatic Invasive Species Program for the Keweenaw Bay Indian Community, a Sovereign Nation Assisting in Modern Management of the Resources of Lake Superior
Gene Mensch, Keweenaw Bay Indian Community Natural Resources Department, Ojibway Community College

Session 3F

Prevention I

Session Chair: Stephen Phillips, Pacific States Marine Fisheries Commission

3:40 PM
Dreissenid Prevention Across the Pacific Northwest
Stephen Phillips, Pacific States Marine Fisheries Commission

4:00 PM
Watercraft Inspection and Decontamination Programs: Western Region of the United States
Debra Davis, Pacific States Marine Fisheries Commission

4:20 PM
A Dog's Nose Knows: Utilizing Canines to find Quagga and Zebra Mussels
Debra DeShon, Mussel Dogs

4:40 PM
Leveraging Partnerships to Advance the Adirondack Aquatic Invasive Species (AIS) Prevention Program: A Landscape-scaled Voluntary Boat Inspection and Decontamination Program
Eric Holmlund, Paul Smith's College and Meg Modley, Lake Champlain Basin Program

5:00 PM
Dreissenid Mussel Dispersal through Boat Hull Mediated Overland Dispersal
Frank P.L. Collas, Radboud University Nijmegen

5:20 PM
Investigation of the Edwards Protocol on Dreissenid Mussels
Kelly Stockton-Fiti, KASF Consulting

Wednesday, October 25, 2017

Plenary Session

8:45 AM
Welcome to Day 3
Tracey Cooke, Invasive Species Centre

9:00 AM
Invited Keynote Presentation
Session Chair: Tracey Cooke, Invasive Species Centre

Aquatic Invasive Species in Singapore: Perspectives from a Highly Urbanised Tropical City
Darren Yeo Chong Jinn, Assistant Professor, Department of Biological Sciences, National University of Singapore

9:50 AM
Networking Break

Session 1G

Response and Control VII
Session Chair: Hugo Verreycken, INBO

10:20 AM
Rapid Response Achieves Eradication – Chub in Ireland
Joseph M. Caffrey, INVAS Biosecurity Dublin

10:40 AM
Improving Response of Asian Carp Detections in the Canadian Waters of the Great Lakes
Julia Colm, Fisheries and Oceans Canada

11:00 AM
Movement of Bigheaded Carp Related to Temperature, Discharge, and Lock Operations on the Illinois River
Marybeth Brey, U.S. Geological Survey

11:20 AM
Understanding the Carp Virome: What Could it Mean for the Control of Invasive Carp?
Sunil Kumar Mor, University of Minnesota

11:40 AM
Freshwater Alien Fish in the Southern Western Ghats, a Biodiversity Hotspot in India
Raj Smrithy, University of Kerala

12:00 PM
Luncheon

Session 2G

Impacts I
Session Chair: John Darling, U.S. Environmental Protection Agency

10:20 AM
Predicting Invasive Species Impacts under Context-dependencies
Jaimie T.A. Dick, Queen's University Belfast

10:40 AM
Vulnerability of Freshwater Biodiversity to Non-native Aquatic Species and other Anthropogenic Stressors across the Continental United States
Amy J.S. Davis, U.S. Environmental Protection Agency

11:00 AM
Effects of Invasive Species on Native Populations of Aquatic Organisms in the San Francisco Bay-Delta and Freshwater Tributaries: A Review
Bryson Finch, Compliance Services International

11:20 AM
Predatory Impacts of the Invasive Portunid Crab, *Charybdis Japonica*, in New Zealand: Implication for Functional Change, Risk Assessment and Ecosystem Goods and Services
Michael Townsend, National Institute of Water and Atmospheric Research

11:40 AM
Got Mussels? Work your Quaggals
Patrick Simmsgeiger, Diversified Waterscapes Inc.

12:00 PM
Luncheon

Session 3G

Prevention II
Session Chair: Sophie Monfette, Ontario Federation of Anglers Hunters

10:20 AM
Assessing the Applicability of the Aquatic Species Invasiveness Screening Kit (AS-ISK) Across a Broad Range of Non-native Species and Risk Assessment Areas
Gordon H. Copp, Centre for Environment, Fisheries and Aquaculture Science

10:40 AM
A Rapid Assessment of Marine Non-native Species in Harbours and Marinas on the Southwest Coast of Norway and the Northeast Coast of Scotland and the Potential for Coastal Connectivity
Ian Campbell, Scottish Marine Institute

11:00 AM
Evaluating the Use of a Novel Bayesian Risk Assessment Tool to Inform Regulatory Decisions for Aquatic Invasive Species in Ontario
Sarah Nienhuis, Ontario Ministry of Natural Resources and Forestry

11:20 AM
Evaluating the Effectiveness of Aquatic Animal Health Programs in Preventing Disease Introductions: A Canadian Case Study
Kristin E. Thiessen, University of Toronto Scarborough

11:40 AM
Predicting the Large Scale and Long Term Distribution of Invasive Species using Habitat Suitability Models
Jeffrey Buckley, Ontario Ministry of Natural Resources and Forestry

12:00 PM
Luncheon

Wednesday, October 25, 2017

Session 1H

Response and Control VIII

Session Chair: Lisa Drake, U.S. Naval Research Laboratory

1:30 PM
The Nonindigenous Aquatic Species Flood and Storm Transport (NAS FAST) Mapper
Wesley Daniel, U.S. Geological Survey

1:50 PM
Exotic Freshwater Fishes of Florida
Nick Trippel, Florida Fish and Wildlife Conservation Commission

2:10 PM
Assessment of UV Irradiation Effect on Downstream Settlement of the Colonial Hydroid, *Cordylophora caspia*
Sherry Pucherelli, Bureau of Reclamation

2:30 PM
Graminicide Development for Aquatic Invasive Grass Control in Florida
Stephen Enloe, University of Florida

2:50 PM
The Performance of Band Non-biocide Coatings to Prevent Biofouling by Invasive and Non-native Species in Newfoundland
Ashley Bungay, Memorial University of Newfoundland

3:10 PM
Break

Session 2H

Impacts II

Session Chair: Jaimie Dick, Queen's University Belfast

1:30 PM
Effect of *Dreissena* on Benthos of Laurentian Great Lakes
Lyubov E. Burlakova, Buffalo State College

1:50 PM
Understanding the Drivers and Impacts of *Cherax quadricarinatus* Invasion in Singapore
Zeng Yiwen, Department of Biological Sciences, National University of Singapore

2:10 PM
Determination of Invasive Round Goby (*Neogobius melanostomus*) Impact on Native Benthic Fishes in the Upper Allegheny Watershed
Casey Bradshaw-Wildon, Allegheny College

2:30 PM
Round Goby (*Neogobius melanostomus*) Expansion to European Rivers
Michal Janáč, Academy of Sciences of the Czech Republic

2:50 PM
Is the "Killer Shrimp" Resistant to Non-consumptive Effects of Predators?
Łukasz Jermacz, Nicolaus Copernicus University

3:10 PM
Break

Session 3H

Prevention III

Session Chair: Gordon Copp, Cefas

1:30 PM
Binational Ecological Risk Assessment of Grass Carp in the Great Lakes Basin
Becky Cudmore, Fisheries and Oceans Canada

1:50 PM
The Crayfish Invasiveness Risk Assessment Model (CIRAM): A Bayesian Belief Network for Assessing Risk Posed by Nonnative Crayfish
Katherine Wyman-Grothem, U.S. Fish & Wildlife Service

2:10 PM
Climate Match Fails to Explain Variation in Establishment Success of Non-native Freshwater Fishes in a Warm Climate Region
Jeffrey E. Hill, University of Florida

2:30 PM
The Use of Co-Spatial Modeling to Inform Aquatic Invasive Species Management
Nicholas B.D. Phelps, University of Minnesota

2:50 PM
Possible Ballast Water Transfer of Lionfish to the Eastern Pacific Ocean
Emma M. De Roy, University of Windsor

3:10 PM
Break

Wednesday, October 25, 2017

Session 1I

Response and Control IX

Session Chair: Lyn Gettys, University of Florida – IFAS

3:40 PM
Reduction of Pesticide Applications using New Microsponge™ Technology
Lucía G.I. Marshall, TAPT/Biosorb and Scott Schermerhorn, Charlotte County

4:00 PM
Evaluation of Chemical Biocides and Algaecides for Controlling Sprouting of *Nitellopsis obtusa* Bulbils
John H. Rodgers, Clemson University

4:20 PM
PROCELLACOR™– A Novel Herbicide Technology for Selective Management of Aquatic Invasive Plants
Mark A. Heilman, SePRO Corporation

4:40 PM
Control of Colonial Hydroids using EarthTec QZ
David Hammond, Earth Science Labs, Inc.

Session 2I

Impacts III

Session Chair: Alexander Karatayev, Buffalo State College

3:40 PM
Functional Feeding Traits as Predictors of Competitiveness of Alien Freshwater Fishes
Leopold Nagelkerke, Wageningen University & Research, Aquaculture & Fisheries Group

4:00 PM
Assessing the Impacts of the Invasive Channel Catfish *Ictalurus punctatus* in Central Italy
Phillip J. Haubrock, University of Florence

4:20 PM
Invasive Species and Plankton Dynamics of the Columbia River Estuary
Stephen M. Bollens, Washington State University

4:40 PM
Potential Ecological Concerns of Grass Carp on Great Lakes Fish and Bird Communities
Withdrawn
Erin L. Gertzen, Fisheries and Oceans Canada

5:00 PM
Interagency Coordination to Develop a Statewide Python Management Plan
Evan Freeman, Florida Fish and Wildlife Conservation Commission

Session 3I

Prevention IV

Session Chair: Marybeth Brey, U.S. Geological Survey

3:40 PM
Preliminary Characterization of Risk Posed by Aquatic Insect Bait to the Spread of AIS in the Great Lakes Region
Patrice Charlebois, Illinois-Indiana Sea Grant and Illinois Natural History Survey

4:00 PM
A Hotspot for Aquatic Alien Species? Evidence for Recreational Angling as an International Invasion Pathway
Emily R.C. Smith, University College London, Environmental Change Research Centre

4:20 PM
Using Environmental DNA for Sea Lamprey Assessments in Great Lakes Tributaries
Christopher M. Merkes, U.S. Geological Survey

4:40 PM
Human-mediated and Natural Dispersal of an Invasive Fish in the Eastern Great Lakes
Mattias Johanssen, Great Lakes Institute for Environmental Research, University of Windsor

Thursday, October 26, 2017

Plenary Session

8:30 AM
Closing Plenary Session
Lyn Gettys, University of Florida - IFAS

9:00 AM
Invited Keynote Presentation
Session Chair: Lyn Gettys, University of Florida – IFAS

Knowledge to Action on Aquatic Invasive Species: Island Bbiosecurity – the New Zealand and South Pacific Story
Paul Champion, Principal Scientist - Freshwater Ecology, National Institute of Water and Atmospheric Research (NIWA), New Zealand

9:50 AM
Networking Break

Session 1J

Information Management

Session Chair: Alexander Karatayev, Buffalo State College

10:20 AM
Data Aggregation: Data Goes in, Data Goes Out. You Can't Explain that!
Rebekah Wallace, University of Georgia

10:40 AM
Risk Assessment Database for the Great Lakes Region
David Nisbet, Invasive Species Centre

11:00 AM
Noteworthy Distribution Changes to Non-native Aquatic Plants in the U.S. Since 2015
Ian Pfingsten, Cherokee Nation Technologies

11:20 AM
Application of a Watch List of High Risk AIS to Inform Surveillance Site Selection and Sampling Methods in the Laurentian Great Lakes
Andrew J. Tucker, The Nature Conservancy

12:00 PM
Conference adjourns

Session 2J

Investigation

Session Chair: Rob Leuven, Radboud University Nijmegen

10:20 AM
From Bad to Worse: Update on the Non-native Freshwater Fishes in Flanders (Belgium)
Hugo Verreycken, Research Institute for Nature and Forest (INBO)

10:40 AM
Postglacial Colonizer or Cryptic Invader? Case of *Gammarus roeselii* (Crustacea Amphipoda) in Europe
Tomasz Rewicz, University of Lodz

11:00 AM
Early Invasion Dynamics of New Zealand Mudsnails in Michigan Rivers
Samantha Stanton, Michigan State University

11:20 AM
Alien Freshwater Fish in Italy Have Over Passed the Native One as Number of Species and Locally also as Biomass and Number of Specimens
Pier Giorgio Bianco, University of Naples Federico II

11:40 AM
Starry Stonewort i... (US)
G. Doug... Aquest Corp

Withdrawn

12:00 PM
Conference adjourns

Session 3J

Prevention V

Session Chair: Frances Lucy, University of Technology, Sligo

10:20 AM
But it's So Pretty… Florida's Lovely Invasive Aquatic Plants
Lyn Gettys, University of Florida, IFAS/FLREC

10:40 AM
Slowing the Spread of Invasive Alien Species: Biosecurity Best Practice and Stakeholder Engagement
Caitriona Shannon, University of Leeds

11:00 AM
Population Genetics Characterization of Silver and Bighead Carps Invasion Fronts Approaching the Great Lakes
Carol A. Stepien, University of Toledo

11:20 AM
Tributary Use and Large-Scale Movement of Grass Carp: Patterns to Inform Control Efforts in Western Lake Erie
Cleyo Harris, Michigan Department of Natural Resources

11:40 AM
Multi-Jurisdictional Collaborations and Structured Approach for Grass Carp Control in Lake Erie
Seth J. Herbst, Michigan Department of Natural Resources, Fisheries Division

12:00 PM
Conference adjourns

Invited Keynote Presentation

Unravelling the Ecology of Non-native Species to Inform European Strategy

Helen E. Roy
Centre for Ecology & Hydrology

Biological invasions are large-scale processes and cross-boundary collaborations are critical to ensure knowledge on invasive non-native (=alien) species (INNS) is shared between countries. This not only advances understanding of invasions but also enables successful implementation of strategies to manage INNS. Indeed there have been a number of policies developed across Europe which recognise the importance of INNS as a driver of biodiversity loss. Most notably the European Commission has addressed the threat of invasions in their Regulation 1143/2014. At the heart of the Regulation is the development of a list of INNS of EU Concern which explicitly focuses on potential future invaders, derived through horizon scanning, that require management.

Species inventories are recognised as critical for the management of biological invasions, informing horizon scanning and surveillance, and underpinning prevention, control and elimination of INNS. There have been major developments in the availability of high quality data INNS. Here I will provide an overview of the ways in which this information can be used to inform science, policy and ultimately conservation. I will specifically focus on our research that has underpinned the European Regulation including insights into invasion ecology from broad patterns and processes to approaches in surveillance and monitoring, particularly involving citizens and highlighting the importance of collaborations. Networks established through these collaborative initiatives have benefits for people, science, and nature.

Helen Roy

Head of Zoology, Biological Records Centre
Centre for Ecology and Hydrology, UK

Helen is a community ecologist with particular interest in the way in which our changing environment is impacting wildlife. She is the Head of Zoology within the Biological Records Centre (part of the Centre for Ecology & Hydrology, UK) and has the privilege of working with volunteers with expertise in recording wildlife to compile big datasets that span centuries on many species. Her work focuses on the collaborative use of these large-scale and long-term datasets to understand and predict the effects of environmental change on biodiversity. She leads multi-partner projects across the UK and Europe and has also worked in South America and Africa. Recently Helen led a European COST Action involving more than 35 countries in a network to facilitate enhanced knowledge gathering and sharing in relation to invasive species. Furthermore Helen has been privileged to lead a number of research projects to inform European legislation including horizon scanning and prioritisation of invasive species for risk assessment. Helen is also leading the GB Non-Native Species Information Portal which provides information on non-native species for decision-making.

She has a passion for natural history and science communication, and has contributed to the media throughout her career. She is a regular contributor to the BBC Wildlife magazine. Helen is keen to involve people in science and she has expertise in doing so through a number of citizen science initiatives. She coordinates the UK Ladybird Survey, which has more than 18,000 participants, but has also developed a number of other citizen science initiatives including the Big Bumblebee Discovery, involving more than 400 schools. Helen was awarded the Zoological Society of London Silver Medal in recognition of her contribution to understanding and appreciation of zoology and has recently received an honorary fellowship from the British Naturalist Association.

Zebra Mussel Control - 16 Years of Ozone Treatment at Lennox G.S.

Mike Farrell[1]
[1]*Ontario Power Generation*

The intent of the presentation is to provide the audience with an introduction to zebra / quagga mussel control in an industrial setting using an on-site ozone generator. Located on the north shore of Lake Ontario in the town of Greater Napanee, Lennox GS is the only facility in Canada currently utilizing an ozone system for zebra mussel control. The system was originally installed in 2000 as part of a corporate initiative by Ontario Power Generation to reduce the use of sodium hypochlorite as a zebra mussel control method within our facilities.

Throughout our 16 years of treatment at the facility, ozone has proven to be both environmentally friendly and effective at controlling zebra mussel settlement within plant infrastructure. However, proper operation of the system has created many challenges that could easily be overlooked when considering ozone as a zebra mussel control option in an industrial setting.

The intent of the presentation is to provide the audience with information to consider when determining if ozone could be a control method in other industrial facilities. The discussion will include an introduction to our facility and how the ozone system functions. The talk will outline the challenges we have faced in installing and operating our system through a "lessons learned" approach based on 16 years of operational experience.

Key focus points of the presentation would include: capital cost of system, annual operational costs of system, effectiveness of the system, occupational health & safety concerns as well as regulatory requirements from the Ontario Ministry of Environment & Climate Change (MOECC) and Health Canada's Pest Management Regulatory Agency (PMRA).

NOTES

Chemical Free Disinfection for Macro / Micro Biofouling (AIS) to Protect Cooling Water Systems of Hydroelectric Facilities

Ytzhak Rozenberg[1], *Dennis Bitter*[1]
[1]*Atlantium Technologies*

Macro and Micro biofouling has critical concern to the cooling water systems within hydroelectric facilities. Flow restrictions or blockages due to mussel infestation increase maintenance costs and the threat to water delivery and power reliability. During 1998 several power-generating facilities on the Great Lakes experienced significant power losses due to fouling of cooling water circuits by zebra mussels that cost them $1.48M, and a nuclear plant on Lake Ontario recorded losses of power due to macrofouling estimated at 70,200 MW hours. Macro biofouling from aquatic invasive species (specifically mussels) and micro biofouling from various tiny organisms (hydrozoa's and Byrozoa's) can impede heat transfer, and worse, plug the flow of critical cooling water.

In 2014, USBR installed an advanced HOD UV technology to control the macro biofouling with increased interests to control the micro biofouling at Parker. The HOD UV technology recycles the desired dose through a hydro optic chamber and changes the dose based on UV transmittance of the water (quality). The technology's extraordinary efficiencies significantly reduce Capital and Operating costs compared to traditional UV. The systems are smaller and easier to install.

In 2015, the USBR installed at Parker Dam and Firstlight Energy installed at Shepaug Dam. In 2016, Firstlight Energy's Stevenson and Ontario Power Generation (OPG) moved forward and installed the HOD UV technology. This presentation will review the studies, results, cost analysis and experiences on macro and micro biofouling control including current performances from the existing installations, as well as, newly installed installation in 2017.

NOTES

Influence of Water Temperature on the Toxicity of Molluscicides to Zebra Mussels (*Dreissna polymorpha*)

James Luoma[1], *Todd Severson*[1], *Jeremy Wise*[1], *and Matt Barbour*[1]
[1] *U.S. Geological Survey, Upper Midwest Environmental Sciences Center*

Natural resource managers have increased their capacity to detect early infestations of zebra mussels (Dreissena polymorpha), however, limited tools are available for the subsequent eradication of localized populations. Additionally, recent eradication attempts during times of variable water temperatures were hampered by the lack of knowledge regarding molluscicide selection and the dose (concentration x time) required to achieve a complete kill of zebra mussels. Water temperature is known to significantly influence the toxicity of several molluscicides, therefore, thereis a need to determine the dose of molluscicides required to achieve a complete kill of zebra mussels at various water temperatures. We evaluated the potential use of two EPA registered molluscicides and two other molluscicidal compounds for eradication efforts at four different water temperatures (7, 12, 17, and 22°C). Zebra mussel test animals were collected from Lake Minnetonka, MN in the late summer - fall of 2016 when the water temperatures were ± 2°C of the target test temperature. The test animals were brought to the Upper Midwest Environmental Sciences Center and placed into a flow-through holding system containing temperature-adjusted water. Zebra mussels were exposed to various concentrations of Zequanox®, Earthtec QZ®, niclosamide, and potassium chloride for exposure durations ranging from 8 to 336 hours. The static (8 to 96 h) and static-renewal (336 h) exposures were conducted in replicated 4-L glass jars. Mussels were held up to 31 days after exposure, depending on water temperature, before being assessed for survival. Zebra mussels were fed a continuous diet of Reed Mariculture Instant Algae® during the pre- and post-exposure periods. Results of trials will be presented. Additionally a treatment guide for eradication of localized zebra mussel infestations at various water temperatures will be discussed.

NOTES

Mussel Management Partnership Strategies

Dan Butts[1]
[1]*ASI Group Ltd.*

Zebra and quagga mussels (*Dreissena polymorpha* and *D. bugensis*) have been present in North American waters for over 20 years. Since the mussels' introduction in the late 1980s, ASI Group Ltd. (ASI) has developed and refined invasive mussel management strategies for all industry sectors. The key component of our service is the establishment of long term partnerships with our clients to address ongoing needs and to design site specific, time tested management strategies. Key service components include:

- Initial assessment to determine vulnerability to colonization
- Biological monitoring
- Control Strategy determination
- Engineering Assessment/Integration
- Environmental Permits
- Treatment implementation

Paper will discuss a typical partnership application with a local electric utility.

NOTES

Environmentally Sustainable Management of Invasive Dreissenid Mussels using Zequanox

Seth Donrovich[1], *Carolyn Link*[1]
[1]*Marrone Bio Innovations (MBI)*

Zebra and quagga mussels (*Dreissena polymorpha* and *Dreissena rostriformis bugensis*) are rapidly spreading on a global scale. It is well known that invasive dreissenids cause ecological damage by colonizing native unionid mussels, creating harmful algae blooms, and disrupting food webs in their new ecosystems. In addition, billions of dollars in economic turmoil resulting from clogged piping and disruption of industrial water systems, wear and corrosion on boating and docks, and recreational hazards make zebra and quagga mussels a primary concern for management and eradication.

Zequanox® is an effective and environmentally conscious method for control and management of these invasive dreissenids. As of now, this biomolluscicide has effectively controlled veligers, juvenile mussel settlements, and adult mussel colonies in enclosed and semi-enclosed water systems, and more recently, open water systems. As the spread of invasive dreissenids continues to grow and continues to inflict ecological and economic damage, so must control and management. MBI has begun to register Zequanox into new global markets, in addition to undertaking new treatment strategies domestically. This presentation will provide an update on Zequanox applications in the United States and outline the steps that are being taken to expand the use of Zequanox globally.

NOTES

Biodiversity Entering United States Ports *via* Ballast Water Discharge: An Analysis using High Throughput Sequencing

John A. Darling[1], *Yunguo Gong*[2], *Yuping Zhang*[3], *John Martinson*[1], *Sara Okum*[4], *Erik Pilgrim*[1], *Katrina Lohan*[5], *and Greg Ruiz*[5]
[1]*U.S. Environmental Protection Agency, National Exposure Research Laboratory*
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[3]*University of Michigan*
[4]*ORISE participant, U.S. Environmental Protection Agency, National Exposure Research Laboratory*
[5]*Smithsonian Environmental Research Center*

Ballast water has long been one of the most active vectors for introduction of non-indigenous aquatic species, particularly in coastal environments. Despite the establishment of regulatory frameworks and management practices aimed at mitigating the risks of invasion posed by ballast water, continued translocation of coastal biodiversity remains a substantial management challenge. Here we apply high throughput sequencing (HTS) to characterize the biodiversity being conveyed via ballast water discharge into three heavily trafficked US ports in the Chesapeake Bay, Texas, and Alaska. Using standard bioinformatics approaches based on sequence data derived from the nuclear 18S ribosomal RNA locus, we describe the delivery of biodiversity into these ports and the factors that determine the rate at which that diversity accumulates, considering variables such as number of ships, the number of ecologically distinct source regions, and the application of management practices during transit. We also investigate the degree to which this HTS data can be used to draw inferences regarding the sources of ballast water-borne diversity or the effectiveness of management, especially mid-ocean ballast exchange. In addition, in order to explore the utility of HTS for early detection and prioritization of management practices, we utilize existing lists of marine invasive species to examine ballast samples for the presence of species that are known to be or have potential to become invasive in recipient port environments. Our research provides additional evidence that HTS is emerging as an important tool for understanding invasion risks associated with ballast water discharge, and for assessing the effectiveness of management approaches designed to mitigate those risks.

NOTES

Identifying 'Risky' Sites in the Laurentian Great Lakes: Development of a Spatially Explicit Method for Selecting Sites for AIS Surveillance

W. Lindsay Chadderton[1], *Andrew J. Tucker*[1], *Gust Annis*[1], *Alisha D. Davidson*[2], *Donna R. Kashian*[2], *Joel Hoffman*[3], *Anett Trebitz*[3], *Timothy Strakosh*[4], *Stephen Hensler*[5], *Sarah LeSage*[6]

[1]*The Nature Conservancy*

[2]*Wayne State University*

[3]*U.S. Environmental Protection Agencyh, Mid-Continent Ecology Division*

[4]*U.S. Fish and Wildlife Service*

[5]*Cerulean Center*

[6]*Michigan Department of Environmental Quality*

With a surface water area of 95,000 square miles (245,759 square km) and shoreline length of 10,210 miles (17,017 km), and just over 50% of the shoreline area occurring in U.S. territory, where to sample for aquatic invasive species (AIS) is a daunting challenge in the Laurentian Great Lakes. Management resources are finite hence it is important that monitoring efforts concentrate on those sites with the highest risk of introduction. Furthermore, because the potential surveillance burden is unlikely to fall evenly across jurisdictions given shoreline extent varies across each of the Great Lakes' states, it is important that any process used to set priorities is objective, data driven and based on testable transparent criteria and assumptions. Here we describe the development of a site prioritization method designed to address such challenges. The U.S. waters of the Great Lakes and tributaries were divided into standardized management units (9 km x 9 km). An index of invasion pressure was defined using a standardized set of spatial surrogates to estimate cumulative propagule pressure for each management unit. Weighting multipliers were applied to the attributed spatial surrogate data so that both historic patterns and future predicted patterns of introduction were incorporated into the final calculation of the index of invasion pressure for each management unit. Of the total of 5,953 management units in the U.S. Great Lakes basin (land and water), about 1,800 units have attributes resulting in index scores greater than zero. The site prioritization method can be used to select surveillance priorities for fish, invertebrates, and/or plants across the U.S. waters of the Great Lakes basin.

NOTES

Enhanced Aquatic Connectivity through Regional Coordination and Selective Fish Passage Solutions

*Daniel Zielinski[1], Andrew Muir[1], **Lisa Walter**[1], John Dettmers[1]*
[1]Great Lakes Fishery Commission

Simultaneously blocking invasive species while improving aquatic connectivity for production of desired fishes is a global challenge. In the Great Lakes, control of the invasive sea lamprey (*Petromyzon marinus*) depends on dams that restrict access to spawning habitat. Those same dams block desirable species, impair ecological function, and change water quality. The decision to remove or rebuild a dam can be contentious because competing management objectives, differing perspectives, and prohibitive construction costs, resulting in deliberation that can easily span a decade. The Great Lakes Fishery Commission seeks to improve both regional coordination of these decisions and selective fish passage tools. The Great Lakes Aquatic Habitat Connectivity Collaborative, coordinated by the Commission and the US Fish and Wildlife Service, is a multi-disciplinary collaborative of agencies, organizations and researchers that strategically addresses connectivity through agreed-upon regional priorities, focused deployment of resources, and science capacity to support informed decisions. The Commission also is leading fisheries biologists and managers, engineers, and sea lamprey control agents in developing novel and effective tools to selectively pass desirable fishes while simultaneously blocking invasive species. An experimental facility will be constructed at the Boardman River's Union Street Dam (Traverse City, MI) to engage in experiments that integrate a suite of technologies and techniques for bi-directional selective fish passage. At the proposed facility, tools developed during the past 50 years to manipulate sea lamprey behavior and remove them from systems will be integrated with fish passage solutions. This presentation will discuss the status of the Connectivity Collaborative and development of selective fish passage tools in the Great Lakes including conceptual designs, research agenda, and next steps.

NOTES

Asian Carp Early Detection Surveillance in the Canadian Waters of the Great Lakes

David Marson[1], *Julia Colm*[1] *and Becky Cudmore*[1]
[1]*Fisheries and Oceans Canada, Asian Carp Program*

Fisheries and Oceans Canada's Asian Carp Program has been created in response to the threat of invasion by Asian carps in the Canadian waters of the Great Lakes. To address the threat of Asian carps, Fisheries and Oceans (DFO) has developed an early detection surveillance program. Early detection sampling techniques combine a variety of traditional sampling gears. In the five year span that the Asian Carp Program has operated, a total of 23 Grass Carp have been collected from Canadian waters of the Great Lakes basin. DFO's Asian Carp program captured 15 of the Grass Carp, and 6 more were captured using gears that DFO uses in the surveillance sampling. Trammel nets and boat electrofishing have proven to be effective in capturing Grass Carp. The combination of trammel nets as block nets, and boat electrofishing to push fishes, has proven to be the most effective capture method for DFO. This presentation will highlight the sampling gears and techniques used by DFO to target Asian carps, with an emphasis on targeting Grass Carp.

NOTES

Early Detection of a Highly Invasive Bivalve Based on Environmental DNA (eDNA)

Zhiqiang Xia[1,2,3], *Aibin Zhan*[3,4*], *Yangchun Gao*[3,4], *Lei Zhang*[2,5], *G. Douglas Haffner*[1,2,5], *Hugh J. MacIsaac*[1,6]

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[4]*University of Chinese Academy of Sciences*

[5]*Southwest University*

[6]*Yunnan University*

Management of invasive non-indigenous species is challenging owing in part to limitations of early detection and identification. The advent of environmental DNA (eDNA) techniques provides an efficient way to detect non-indigenous species when their abundance is extremely low. However, eDNA-based methods often suffer from uncertain detection sensitivity, which requires testing before applying the method in the field. Here we developed an eDNA-based early detection method using the mitochondrial cytochrome *c* oxidase subunit I gene (COI) for invasive golden mussels, *Limnoperna fortunei*. Further, we tested technical issues including sampling strategy and detection sensitivity, based on a laboratory experiment. We then applied the method to field samples collected from water bodies in China where the animal has colonized or is expected to spread.The detection limit varied extensively among primer pairs, ranging from 4×10^{-2} to 4×10^{-6} ng of total genomic DNA. Laboratory detection was affected by availability of eDNA (i.e. both mussel abundance and incubation time). Sampling water containing re-suspended matter from the bottom layer had a higher capacity for detecting golden mussels versus sampling only surface waters. Among 22 field sites, detection was 100% at sites with high mussel abundance and as low as 40% at sites with low abundance when tested using our most sensitive primer pair. Early detection of non-indigenous species present at low abundance in nature requires not only sensitive genetic markers and corresponding primers, but an optimized sampling strategy to prevent false negatives. Careful selection of genetic markers and primer pairs is essential to effective eDNA-based non-indigenous species.

NOTES

INVASIVESNET Initiative: Towards the Development of the International Association for Open Knowledge on Invasive Alien Species

Frances Lucy[1]

[1]*Centre for Environmental Research Innovation and Sustainability (CERIS), Institute of Technology, Sligo*

In a world where invasive alien species (IAS) are recognised as one of the major threats to biodiversity, leading invasion biology scientists from five continents propose the concept of developing an international association for open knowledge and open data on invasive species (INVASIVESNET). This new association aims to develop a sustainable network of networks on IAS. In addition to their inclusion in the CBD Strategic Plan for Biodiversity, the increasing ecological, social and economic impacts associated with IAS have driven the development of legal instruments globally. This increases the need for greater co-operation and information flows among scientists, management and the community of practice.

INVASIVESNET will be formed by linking networks of all interested stakeholders including scientists, citizens, international and national expert working groups and initiatives, database managers, thematic open access journals, environmental agencies, practitioners, managers, industry, non-government organisations and educational bodies. The association will promote networking opportunities, knowledge sharing and learning. INVASIVESNETS will provide resources via high quality communication, information, publication and education services.

To date, sustainability of many strategic national and international initiatives on invasive species has unfortunately been hampered by time-limited grants or funding cycles. Recognising that IAS initiatives need to be on-going, we aim to develop a sustainable knowledge sharing association to network the outputs of developing invasion biology and inform the consequential management and societal challenges arising from introductions of invasive alien species.

NOTES

Invasive Mussel Collaborative: Developing Tools and a Strategy for Managing Zebra and Quagga Mussels in the Great Lakes

Erika Jensen[1], *Sandra Morrison*[2], *Sarah Cook*[1], *Cecilia Weibert*[1]
[1]*Great Lakes Commission*
[2]*U.S. Geological Survey*

The Invasive Mussel Collaborative is working to advance scientifically sound technology for invasive mussel control to produce measurable ecological and economic benefits. The Collaborative provides a framework for communication and coordination and is identifying the needs and objectives of resource managers; prioritizing the supporting science, implementing communication strategies; and aligning science and management goals into a common agenda for invasive mussel control. The founding members of the collaborative are the U.S. Geological Survey, Great Lakes Commission, National Oceanic and Atmospheric Administration and the Great Lakes Fishery Commission. The Great Lakes Commission provides coordination and neutral backbone support for the collaborative. A broad membership base of states, provinces, tribal and other entities and a well-organized communication network facilitates the exchange of information between scientists, managers and stakeholders. Strong connections with other regions outside the Great Lakes in place to provide opportunities to share lessons learned. The Collaborative sponsors regular webinars to facilitation information-sharing on priority issues related to management and control of dreissenid mussels. Webinar recordings are available on the Collaborative website (www.invasivemusselcollaborative.net) and an email list (invasivemussels@great-lakes.net) provides a quick and efficient mechanism for research and managers to connect to one other and solicit information from a broad network of stakeholders. In 2017, the collaborative is focusing its efforts on developing a series of products and tools to support and advance management activities, including a regional strategy to advance zebra and quagga mussel management for the Great Lakes region. This presentation will provide an update on these efforts.

NOTES

LINVEXO: A New Tool for Invasive Species Education in The Netherlands

Annerie Rutenfrans[1], *Laura Verbrugge*[2,3]
[1]*Adviesbureau Beleef en Weet*
[2]*Institute for Science, Innovation and Society, Radboud University*
[3]*Netherlands Centre of Expertise for Exotic Species*

A lack of knowledge and awareness of invasive species among crucial stakeholders, such as landscape and retail professionals, impedes successful risk prevention. The implementation of educational or training programs can aid in increasing public awareness about invasive species in the horticultural and pet trade. We performed an inventory of the availability and applicability of teaching materials about invasive species at Dutch secondary vocational schools (which combine practical classroom learning with hands-on training) and applied universities. Given the paucity of materials at secondary vocational schools, a new 3D multimedia-application was developed (named LINVEXO) suitable for classroom and individual training. LINVEXO contains information about eight non-native and invasive species present in the Netherlands and aims to provide pupils with a basic understanding of the introduction pathway(s) and impacts of the species, as well as suitable management strategies and characteristics for determination. The species were selected to represent a broad range of environments and species groups, thus to appeal to a variety of educational programs and professions. One of the main challenges during development was to use short and simple language that could easily be understood by secondary school pupils and teachers who may not have any pre-existing knowledge of invasive species. Ways to overcome these challenges were to (1) make use of many examples and visual elements, such as animations (for example about ballast water) and videos in which practitioners explain their management strategies, and (2) apply suitable methods and skills for knowledge transfer, such as mind mapping, expert groups and storytelling. It is expected that LINVEXO will contribute to an increase of knowledge and awareness of impacts of invasive species in important professions. Moreover, it will help to establish a network of professionals from education and practice which will aid in integrated approaches in invasive species education.

NOTES

Underpinning Invasive Species Outreach with an Effective Communications Plan

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Biodiversity in Ireland, like the rest of the world, is threatened by Invasive Alien Species (IAS). As an island our biodiversity is particularly vulnerable to this threat. However, islands also offer greater opportunities for protection from IAS than individual states in a continental land mass. A three-year research project (2016-2019) on the prevention, control and eradication of IAS, funded by the Environmental Protection Agency (Ireland), involves a whole-island approach involving the two separate political jurisdictions of Northern Ireland and the Republic of Ireland.

Raising awareness of the risks associated with IAS and understanding methods to prevent their introduction and secondary spread is the biggest initial undertaking in any prevention campaign. Our communications plan is central to the impact of this project. A list of relevant stakeholders was identified through expert consultation with academic, governmental and other organisations in both jurisdictions. These stakeholders were then targeted through specific forms of communication chosen to maximise interactions and impact on the target audience.

Communicating IAS issues effectively, to the general public, without the provision of sustainable dedicated funding, challenges programmes of prevention and rapid response. Social media has provided a new platform with which to freely open a conversation with a broad range of citizens. Its participatory nature and conversational style appears to suit the Irish psyche. In this project, by linking broadcast media opportunities to tailored social media campaigns, we have achieved positive responses in species recording and also in terms of opening the debate with key individuals and community groups. An interlinked and evolving communications plan has been crucial to these outcomes.

NOTES

A Redesigned Volunteer AIS Monitoring Program in Wisconsin, USA

Paul M. Skawinski[1]

[1] *University of Wisconsin – Extension Lakes Program, Stevens Point*

Wisconsin's statewide volunteer AIS monitoring program began in 2006. Participation was strong for several years and rose to a high of 348 volunteers reporting data in 2010, before falling to only 65 volunteers reporting in 2016. A survey of volunteers suggested several reasons for the rapid decrease, including discomfort with AIS identification (inadequate training), necessary changes to guidance materials and protocols, and more. An all-new volunteer handbook, new monitoring protocols, and a new, one-day AIS monitoring event were developed for the 2017 monitoring season to address these challenges.

NOTES

Evaluation of Carbon Dioxide as a Dreissenid Mussel Control Tool

Diane Waller[1], *Michelle Bartsch*[1], *James Luoma*[1]
[1] *U.S. Geological Survey, Upper Midwest Environmental Sciences Center*

Control technology for dreissenid mussels (*Dreissena polymorpha* and *D. bugensis*) currently relies heavily on chemical molluscicides that can be both costly and ecologically harmful. There is a need to develop more environmentally neutral control tools to manage dreissenid mussels, particularly in cooler water. Carbon dioxide has been shown to be lethal to several species of invasive bivalves, including zebra mussels and Asian clams (*Corbicula fluminea*). We evaluated the effects of various treatment regimes [i.e., exposure duration and pCO_2 (partial pressure of carbon dioxide)] on mortality, byssal thread formation and attachment, narcotization behavior, and filtration rate of zebra mussels. The effects of elevated carbon dioxide on nontarget native freshwater mussels (*Lampsilis* spp.) were also measured. Trials were conducted in water of different temperatures and chemistry. Initial results of trials conducted at 12°C indicated that carbon dioxide exposure induced narcotization behavior and reduced attachment of zebra mussels within 24 h. An extended exposure duration (96 h) produced 80-100% mortality of zebra mussels, and was safe to juvenile *L. siliquoidea* (fat mucket) mussels. Results of additional planned trials will be presented including comparisons of sublethal and lethal responses of zebra mussels to elevated pCO_2 at varying water temperatures and chemistry. The potential application of carbon dioxide into an integrated pest management program for dreissenid mussels will be discussed.

NOTES

Taking No Prisoners Beating Back Invasive Species – Bureau of Reclamation

Leonard Willett[1]

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The presence of quagga mussels in Lake Mead is a primary concern to the Lower Colorado Dam Office of the Department of Interior's Bureau of Reclamation responsible for maintaining the Hoover, Davis and Parker dams and their associated hydroelectric plants. Reclamation began a series of feasibility studies in 2007 to outline best low-ecological-impact management practices for coping with invasion, and identify control options for raw water systems to prevent invasion and infestation. As part of those studies Reclamation evaluated UV treatment systems, traditional and Hydro-Optic UV (HOD), to prevent dreissenid veligers settlement. Both UV systems proved effective; however, HOD UV used a dose rate significantly less than 100 mJ/cm². Another study was then undertaken to determine the impact of HOD UV at doses of 100, 50, 40, and 20 mJ/cm². For each dosage level, the effects on veliger behavior, physical damage and/or immediate or delayed mortality were measured. The effects of UV exposure were analyzed for each veliger life stage to determine if one life stage is affected over another. All of the doses tested in this study produced delayed veliger mortality. Mortality rates appear to be variable based on the UV dose, month/temperature, and veliger size. The 100 mJ/cm2 dose reduced settlement by 99%. To determine the effectiveness of UV in other mussel management applications such as biofilming common in raw water system, Reclamation undertook a study of freshwater colonial hydroids after installation HOD UV at Parker Dam for mussel control. Early indications of the research show promise that HOD UV may successfully prevented the formation of colonial hydroids. This paper will discuss Reclamation's feasibility studies on UV treatment to prevent dreissenid veligers settlement and possible future colonial hydroids controls.

NOTES

Temperature and Dose Response of Invasive Quagga Mussels to Various Molluscicides in High Conductivity Water

Michael Booth[1], Katherine Ayres[1], and ***Renata Claudi***[2]
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The development and use of molluskicidal agents to control or eradicate the invasive quagga mussel, *Dreissena bugensis*, in open waters and within water infrastructure is rapidly evolving. Product efficacy trials have primarily been conducted in relatively low conductivity waters (e.g., Laurentian Great Lakes) but recent work in the Colorado River (conductivity ≈1000 µS/cm) has indicated that ionic treatment chemicals must be applied at substantially higher concentrations to achieve similar efficacy in higher conductivity waters. Because dreissenid mussels are ectothermic, water temperature greatly impacts their rates of biological activity and potentially their uptake of or exposure to molluscicides (i.e., treatment chemicals are typically most effective at warm temperatures)—however, the application of these agents may be most feasible under less than ideal circumstances. In addition, although there are many chemical compounds that will control mussels, most are non-specific and may have undesirable side effects on the receiving environment and non-target species. The presence of threatened or endangered species in the target water body may necessitate application of chemicals at their minimum effective dosage to minimize non-target effects. In order to develop potential control and eradication strategies for quagga mussels at Lake Piru, Ventura County, California, a high conductivity reservoir (≈1400 µS/cm) on Piru Creek, which contains the federally endangered southern California steelhead downstream of the dam, we tested the efficacy of three molluskicidal compounds: EarthTec QZ (a copper compound), ZM-X (an organic acid), and potash (as potassium chloride) at three product concentrations and three temperature ranges typically observed in Lake Piru. Mussels were held in 40 L aerated bioboxes for up to 30 days and time to mortality was assessed for each chemical, concentration, and temperature. Results from this study will identify minimum product concentrations, application times, and interactions with local water chemistry to determine reasonable application methods at the field scale.

NOTES

Control of Zebra and Quagga Mussels with a More Rational Use of Copper

David Hammond[1]
[1]*Earth Science Labs, Inc.*

EarthTec is a unique formulation of liquid copper ions labeled by EPA and all 50 states for control of algae and bacteria. It is NSF-certified for drinking water and is often used as a pre-treatment by WTPs that dose either into open waters such as lakes, or into pipelines that lead to the treatment facility. Aside from achieving algae control, some municipal users have a history of successfully using EarthTec to remove taste and odor compounds in the raw source water; a summary of the data collected by those municipalities will be presented. In 2013 the EPA approved an expansion of the product label to include control of quagga and zebra mussels under the sub-label EarthTec QZ, establishing it as one of very few products that is both NSF-certified and legal for use against invasive mussels that infest open waters or pipelines. Full-scale field experience with EarthTec QZ in the past 3 years has proven that mussels can be reliably and successfully controlled at unprecedentedly low doses that are cost-effective, non-corrosive to equipment, and do not contribute to disinfection by-products. Dose-response results and economic data from several municipal WTPs that have adopted use of EarthTec QZ liquid copper to control zebras and quaggas will be presented as case studies. Results of Rapid Response efforts to eradicate mussels in lakes will also be presented.

NOTES

Field Evaluation of the Service Life of Foul-release Coatings in Columbia River, Oregon and Washington, USA

Steve Wells[1] *and Mark D. Sytsma*[1]
[1]*Portland State University*

A field experiment was conducted to assess effective service life of foul-release coatings to mitigate the impacts of invasive zebra and quagga mussels (*Dreissena*). Coated concrete and steel panels were deployed in Columbia River (Oregon and Washington, USA) field conditions to compare SherRelease (Fuji/ Sherwin Williams), Intersleek970 (International), and HempasilX3 (Hempel) relative the current protective coatings used on submerged concrete (CrystalSeal), and steel (Corps V-766e). Effective service life was evaluated by the resistance of coatings to physical damage after different service periods in the main-stem Columbia River as well as the resistance to zebra mussel attachment. Approximately 1,000 panels were deployed in the Columbia River at the onset of the experiment in April 2012. A subset of panels was removed from the Columbia River every six months, and inspected for physical damage (e.g., substrate adhesion), and then deployed in a zebra mussel-infested water body to evaluate the resistance to zebra mussel biofouling (e.g., adhesion strength). The Intersleek970 foul-release coating was resistant to both physical damage caused by Columbia River field deployment for 39-months as well as zebra mussel in-situ attachment on both concrete and steel panels. The other foul-release coatings blistered after several months of immersion in the Columbia River. The protective coatings were resistant to physical damage but were heavily fouled by zebra mussels. There was a significant effect of coating type on zebra mussel adhesion strength, $F(7,201) = 1{,}166.2$, $p<0.001$, and post hoc Tukey tests found significant differences ($p<0.005$) between the foul-release coatings and the protective coatings. A limited number of zebra mussels were able to attach to foul-release coatings but these mussels were easily removed. The foul-release coatings were susceptible to physical damage from direct impact and gouging, and this was not the case for the protective coatings. The foul-release coatings, however, outperformed the protective coatings in a sanding disk abrasion test. There was a significant effect of coating type on coating mass loss, $F(7,251) = 110.7$, $p<0.001$, and post hoc Tukey tests found the following groups to be significantly different ($p<0.005$): concrete control group (Crystal c and Bare c), foul-release on steel group (Hempasil s, Intersleek s and Sher Release s), and group 3 (Corps vinyl, Intersleek c and Sher Release c). The foul-release coatings on steel panels were the most resistant to mass loss, and this resistance was not affected by immersion periods up to 39-months.

NOTES

Pollution – A Gateway for Freshwater Amphipod Invaders to Cause Ecosystem Change?

Calum MacNeil[1]

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I investigated how changes in water quality in freshwaters in a small British Island, the Isle of Man, influenced the relative survivorship of native and invasive amphipods and also the predatory interactions between natives and invaders. I also investigated the 'knock-on-effects' for rest of the resident macroinvertebrate community by changes in the co-occurring amphipod assemblage, as amphipods can often be 'keystone' species influencing the rest of the riverine community through competition and predation. *Gammarus pulex* and *Crangonyx pseudogracilis* are invaders which have become firmly established in river systems over the past several decades. The European *G. pulex* and the North American *C. pseudogracilis*, the former deliberately introduced, the latter by accident, often co-occur with the native amphipod *Gammarus duebeni celticus* under a range of water quality regimes. Using survey, laboratory and field experiment, I use examples of mixed native and invasive amphipod assemblages in rivers suffering long term chronic pollution and short term acute pollution incidents, to show how both deterioration in water quality and subsequent recovery in quality, can strongly influence predatory interactions between these species. I show how the current water quality states of many rivers could plays a significant role in the relative dominance of natives and invaders and that this could consequently be reflected in overall community structure.

NOTES

Comparative Assessment of Gammarids under Stressful Conditions

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New non-indigenous species are constantly arriving to the Baltic Sea, most likely via ballast water, hull fouling and/or aquaculture. A relatively high number of those species originate from the Ponto-Caspian region (*i.e.*, Black, Azov and Caspian Seas) and some of them are known to have a high impact on local communities and ecosystem functioning. In addition, future global warming may open new environmental and niche opportunities for continuously arriving species. Here, we tested temperature tolerance of three amphipod species, *Gammarus oceanicus* (native to the Baltic Sea), *Gammarus tigrinus* (native to the North West Atlantic) and *Pontogammarus maeoticus* (native to the Ponto-Caspian region) to determine their performance under current and future temperature conditions (6 to 26°C). The two different salinity treatments (10 and 16 ppt) showed very similar results for species originally from 10 ppt or 16 ppt. All three amphipod species have survival rates between 60 and 100% when exposed to 26°C for a short time (up to six days). However, when kept at 26°C for two weeks, mortality increases dramatically for *G. tigrinus* (75 %) and *G. oceanicus* (100 %). Only *P. maeoticus* had survival rates of up to 80%, indicating that in the case of global warming *P. maeoticus* that evolved under higher temperatures of the Caspian Sea might outcompete *G. oceanicus*, which evolved under lower temperatures of the Baltic Sea.

NOTES

Are Ponto-Caspian Species Inherently Predisposed to Cross Salinity Boundaries? Experimental Selection of a Ponto-Caspian Gammarid

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For species to cross habitat boundaries during the invasion process, broad tolerances and phenotypic plasticity of species are needed. Hence, adaption from marine to freshwater habitats and vice-versa require within-population genetic variation for salinity-sensitive life history traits and their heritability. It has been demonstrated recently that the Ponto-Caspian region is a major donor region of non-indigenous species for Northern Europe, as well as for the Great Lakes, while invasions going the other way around have rarely been reported. We aimed to determine whether Ponto-Caspian species are evolutionary predisposed to adapt to different salinities. The Ponto-Caspian gammarid *Pontogammarus maeoticus*, collected from a salinity of 10, was pre-selected for higher and lower salinities based on its optimal salinity. Subsequently, fitness, adaptation potential and reproductive success of pre-selected adults, as well as the fitness of their offspring were tested experimentally. Independent of the level of selection, adults were not able to survive under fully marine conditions (>34 PSU), while survival under freshwater conditions was high in all treatments. In addition, hatching success was lower in high salinities compared to freshwater conditions. This could hint at a freshwater origin of this species, rather than a marine heritage as previously hypothesized.

NOTES

Experimental Assessment of Emerging Invasion Threat: A Host-Parasite Coevolutionary Association Modulating Invasional Meltdown

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Invasional meltdown occurs when establishment of one invasive species facilitates the invasion of other non-native species in that region. Coevolution describes the process of reciprocal adaptation between two species, leading to an escalation of arm races (e.g. host-parasite relationship) or to a mutually beneficial state (e.g. symbioses). *Anodonta (Sinanodonta) woodiana* is a unionid mussel currently expanding across European freshwaters. *Rhodeus amarus,* like all other bitterling fishes (Acheilognathidae), is a brood parasite of freshwater unionids, laying its eggs into their gills. *Rhodeus amarus* can use all European unionids as a host but cannot use invasive *A. woodiana* that coevolved with Asian bitterlings, and that eject all eggs of European *Rhodeus amarus*. Chinese rosy bitterling, *Rhodeus ocellatus*, is an invasive fish species in several Asian countries, and is available in global pet trade. We experimentally tested invasion potential of *Rhodeus ocellatus* in Europe using a combination of behavioral and mesocosm population-level experiments. We found that native *R. amarus* readily outcompetes *R. ocellatus* when coexisting in mixed communities. However, *R. ocellatus* has a longer reproductive season and, unlike *R. amarus*, commonly uses invasive Asian *A. woodiana* as its host. While the recruitment of *R. amarus* largely outnumbered that of *R. ocellatus* in experimental communities with European unionids, this difference disappeared when *A. woodiana* (used by coevolved *R. ocellatus* but not by *R. amarus*) was added to unionid communities. With a rapid establishment of *A. woodiana* and increased ability of later hatched juveniles fish to survive over winter in a warming climate, *R. ocellatus* shall outnumber the reproductive success of *R. amarus*. Hence, despite *R. amarus* is competitively superior to *R. ocellatus* under normal circumstances, *R. ocellatus* may rapidly establish in European freshwaters and quickly dominate in some habitats. This effect is primarily driven by co-invasion with a coevolved *A. woodiana* and climate change.

NOTES

Experimental Evaluation of Microhabitat Preferences of Ponto-Caspian Gammarids

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Ponto-Caspian gammarids have recently spread in Europe, considerably influencing local communities. We conducted laboratory experiments to determine habitat preferences of two species from this group: *Dikerogammarus villosus* (the killer shrimp) and *Pontogammarus robustoides* with regard to substratum, flow, temperature, salinity, depth, predators and interspecific interactions.

Usually they are spatially separated in the field: *P. robustoides* occupies shallow sandy areas or macrophytes, whereas *D. villosus* lives in deeper, rocky habitats. However, in our experiments both species selected similar rocky substrata over small-grained ones. *D. villosus* displaced its competitor to suboptimal substratum, but the presence of predators enabled their coexistence. In a flow-through chamber (0-30 cm/s) with stagnant water refuges, both species did not prefer flowing water, though withstood up to 10 cm/s without behavioural changes. In a thermal gradient (0-40 °C), they generally selected warmer water than their acclimation temperature. Moreover, they selected low salinity water (*D. villosus*) in a Y-maze or remained non-selective (*P. roibustoides*). In a vertical gradient (10-100 cm), *P. robustoides* occupied shallower depths than *D. villosus*.

In the presence of benthivorous fish, *D. villosus* moved to shallower water, clung to above-bottom objects and, surprisingly, approached predator scent, probably responding to food cues in fish faeces. *P. robustoides* avoided predation cues and increased activity in their presence. Moreover, both species responded to predators by increasing their aggregation level.

Altogether, both species have similar microhabitat preferences, selecting warm, slowly flowing waters with low ionic content and rocky substrata. Their separation in the field may result from different depth preferences, anti-predator responses or competitive displacement. Their range limitation to large rivers and absence from smaller affluents seems to be unrelated to the lower ionic content of the latter (as often postulated), rather resulting from temperature and/or flow rate differences.

The study was supported by a National Science Centre grant #2012/05/B/NZ8/00479.

NOTES

Sticky Habits: Insights into Behaviors by Recreational Boaters

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Complex mechanisms of motivation for action are the basis for desired and undesirable behaviors. Conventional experimental behavior paradigms assume that responses are correlated with goal-directed actions. When considering AIS campaign prevention messages, can "one-size fits all" goal-directed actions work? Can messages stick? Ensuring that behavior changes and connections last necessitate use of approaches like community based social marketing, which support underpinnings of actions and fostering habits. *Stop Aquatic Hitchhikers!*™ capitalizes on stressing positive motivational messages. It has been shown to raise awareness and change behaviors among recreational audiences to stop the AIS spread across the Great Lakes and beyond.

Human dimensions research examining the efficacy of the campaign has shown that implementation at multiple scales can result in increased performance-based actions. Motivation by offering explicit action-oriented directions can solve performance issues for those who are: 1) already receptive to prevention messages and ready to act (doers), and 2) somewhat receptive but for various reasons have not taken action (ready doers). Supporting motivations of the 'do-righters' is the nexus for establishing personal and social norms to bring about change and make it 'stick'.

What about those unwilling to act? Maybe we cannot motivate these people – perhaps they need to motivate themselves. With regard to AIS management, this takes a different mindset. Breaking down audience values, attitudes and motivations can give further insights into what makes them 'tick'. We know that all people are inherently motivated to do or value something that they believe in. Refocusing appealing messages that capture motivations for those seemingly unwilling to change is critical. This presentation will offer insights into how we can promote change and inspire our audiences to take greater action against AIS.

NOTES

Invading Species Hit Squad: Community Based Education and Outreach

Alison Morris[1], *Sophie Monfette*[1]
[1]*Ontario Federation of Anglers and Hunters*

A coordinated approach, supported with strong cooperation is important to successfully prevent the introduction and spread of invasive species. Utilizing available funding sources, partnerships and collaboration can provide more opportunities to engage local communities in invasive species education and awareness. Since 1992, the Ontario Federation of Anglers and Hunters has partnered with the Ministry of Natural Resources and Forestry (MNRF) to deliver the Invading Species Awareness Program (ISAP), focusing on education and outreach, and programs designed to monitor the occurrence and distribution of invasive species. For over 10 years, the ISAP has partnered with MNRF district offices, stewardship councils, conservation authorities and non-governmental organization to deliver the *Invading Species Hit Squad* – a team of 25+ summer students that deliver on the ground, community based invasive species education, awareness and monitoring initiatives. The key messages shared across communities are: 1) how to identify invasive species, 2) How to prevent the introduction and spread, 3) impacts and reporting invasive species, and 4) managing and controlling priority invasive species. Throughout the summer, the students are featured in the media and are able to reach hundreds of thousands of people through local events and educational resources. By continuing to educate the public on invasive species, we can empower communities to help protect our environment and native species.

NOTES

Asian Carp Exhibit at the Toronto Zoo

Lauren Tonelli[1], *David Nisbet*[1]
[1] *Invasive Species Centre*

The Invasive Species Centre partnered with Fisheries and Oceans Canada, the Toronto Zoo, and the Ontario Ministry of Natural Resources and Forestry to create an Asian carp exhibit at the Toronto Zoo. This exhibit is housed in the Indo-Malaya Pavilion which is the area of the world where Asian carp are native to; the tank holds other species found in their range. The exhibit hopes to engage children in the discussion on Asian carps and how to prevent their entry. The exhibit is intended to show how much Bighead, Grass, and Black carps eat and how quickly they grow. Knowing these key features will help show the public the potential threat of Asian carps to the Great Lakes. The tank where they are housed also has outreach and education messaging that informs Zoo goers of Asian carp ID, biology, threats, and keys to prevention. This exhibit is situated at the beginning of the pavilion, making it a high traffic area. This talk will walk through the exhibit and the education tactics associated with it. This presentation will discuss the hurdles faced, how they were overcome, and the importance of this sort of exhibit.

NOTES

A Perfect Match: Increasing Impact in Invasive Species Outreach through Extension and Cooperative Invasive Species Management Area Collaboration

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[2]*The Nature Conservancy*

University of Florida IFAS Extension Polk County and the Heartland CISMA (Cooperative Invasive Species Management Area) have been collaborating on invasive species outreach and education since 2012. Recent work to develop training workshops focused on aquatic invasive species issues demonstrates how Cooperative Extension and CISMAs can work together for the mutual benefit of both organizations.

The target audience for the Heartland CISMA's events primarily include public and private lands managers and technicians, biologists, aquatic system managers and technicians, state and county parks employees, and invasive plant contractors. The Natural Resources and Conservation Agent for UF/IFAS Extension Polk County serves on the steering committee for the Heartland CISMA and provides expertise in the design of outreach documents, instructional design of workshops and community events, and strategies for workshop evaluation.

Historically, the Heartland CISMA's events focused on upland invasive exotic species like climbing fern (*Lygodium spp.*), air potato (*Dioscorea bulbifera*), and cogongrass (*Imperata cylindrica*). Workshops often included an aquatic species or two, but event evaluations indicated that the participating audience needed more information regarding the identification and management of aquatic invasive species.

In 2014, the Natural Resources Extension Agent was tasked with providing continuing education credits for area aquatics pesticide applicators as a result of a colleague's position change. In partnership with the Heartland CISMA, UF/IFAS Extension Polk County began offering an Aquatic Invasive Species Management Workshop in the fall of 2015. As of January 2017, there have been two workshops serving a total of 97 participants and providing up to eight CEUs in the aquatic category.

This partnership improved the diversity of subjects the CISMA was able to offer clientele and provided a mechanism for recruiting Extension Specialists to the area to share their expertise. Additionally, the workshop served as a valuable outreach event for the Natural Resources Agent, fulfilling the aquatics education responsibility.

NOTES

Illinois Aquatic Pet Surrender Events, Rehoming and Care Networks

Greg Hitzroth[1,2], *Patrice Charlebois*[1,2], *Danielle Hilbrich*[2]
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One way to interdict the organisms in trade pathway is through providing resources for water gardeners and aquarium hobbyists to re-home or humanely euthanize their unwanted aquatic pets. To achieve this we created three resources for hobbyists. First, we hosted three aquatic pet surrender events during the summer and fall of 2017 near Chicago, Illinois. These events gave hobbyists the chance to surrender any aquatic pets to be re-homed. These events were modeled after Florida Fish and Wildlife Conservation Commission's Pet Amnesty events. Second, we populated a pet surrender network list on TakeAIM.org. The list consisted of for profit and not for profit institutions that take unwanted aquatic pets. Third, we populated an exotic pet veterinarian network list on TakeAIM.org. The list consisted of veterinarians that have expertise in aquatic or semi aquatic pet care. This presentation will summarize aquatic pet surrender events and network building efforts with the intended purpose of discussing next steps in re-homing or responsible disposal of unwanted aquatic pets.

NOTES

Management Review of AIS in Ontario

Lauren Tonelli[1], *David Nisbet*[1]
[1]*Invasive Species Centre*

Aquatic invasive species (AIS) pose a serious threat to Ontario's connected waterways; their cryptic nature makes it difficult to detect the species early in the invasion cycle. Often, once AIS is discovered in a system it is difficult to remove completely. There are various management options available for the different taxa of AIS, this review considered the effectiveness and scale in which it could be administered. Different options for submergent and floating aquatic plants, invertebrates, and fishes are discussed and case studies for specific species are highlighted. Our case study species include, but isn't limited to, Water Chestnut, European Frogbit, Round Goby, Asian carps, and Rusty Crayfish. This review is intended to give landowners, conservation authorities, lake associations, and others the information available to control AIS on their properties.

NOTES

Evolving Strategies for AIS Response: Lessons Learned from 10 years of Research in Newfoundland, Canada

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[2]*Fisheries and Marine Institute of Memorial University of Newfoundland*

In part because of its isolated and northern geography and relatively recent and dramatic increase in shipping traffic, the history of aquatic invasive species (AIS) research in Newfoundland (NL), Canada only spans approximately 10 years. Since 2006, the Fisheries and Oceans Canada AIS program in NL has evolved from a species-based approach to a comprehensive vector management and ecosystem centred research program. In Newfoundland, invasive green crab have particularly thrived, with new introductions, expanding geographical ranges, and increasing abundances, whereas introductions of colonial and solitary invasive tunicates have been predominantly site and vector specific. Biofouling of submerged surfaces (e.g. docks, wharves, vessels) have played a prominent role in the establishment and movement of AIS in NL. Although populations of AIS are difficult to control once established, targeted attempts in NL to mitigate and control populations of green crab and invasive tunicates have demonstrated short-term success and lessons learned. This has led to emphasis on biofouling prevention, vector analyses, and development of a rapid response framework to approach future management of AIS. For example, attempts to manage established populations of invasive green crab using trapping have confirmed declines in abundances of crab and shifts in population demographics. However, trends are short lived without continuous trapping and reversal of observed ecosystem impacts, such as eelgrass decline and associated changes to fish communities likely require long-term management efforts. Regular regional stakeholder workshops are held to document and discuss key challenges, successes, and recommendations for the advancement of this program. The undertaking to prevent new introductions and further spread through vector based response and stakeholder best practices as well as determining ecosystem and commercial fishery impacts in new regions, such as the Canada arctic (e.g. Labrador), continue the evolution of this program.

NOTES

Development of a Selective, Environmentally Safe and Low Cost Carp Pesticide

Maurice Sadowsky[1]

[1]*MJSTI Corp.*

This presentation will discuss the importance of the key product specifications for carp pesticides: bio-selective, safe and low cost. We have developed a proprietary formulation to meet these requirements and demonstrated its effectiveness. Koi, inbred carp, will voluntarily eat it with deadly results. The formulation is selective by digestion and habitat, safe using only FDA approved food and animal feed ingredients, and low total cost, including raw materials, processing and regulatory approval. The active ingredient is a known EPA registered aquatic pesticide making the approval requirement a new application rather than a new product. MJSTI filed a provisional US patent in January 2017. In addition, MJSTI is researching a second technology for another selective, safe and low cost carp pesticide.

NOTES

Do Ecological Interactions Explain Dominance Shift between Ponto-Caspian Bivalves *Dreissena polymorpha* and *Dreissena rostriformis bugensis* in their Introduced Range?

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The invasive bivalve species *Dreissena polymorpha* and *Dreissena rostriformis bugensis* are native to the Ponto-Caspian area (i.e., rivers basins northern of the Black sea, Caspian sea and Azov sea). In the 19th century *D. polymorpha* started extending its geographical range. Nowadays this species can be found throughout Europe, Eurasia and North America on hard substrates in fresh to oligohaline rivers, lakes and canals. However, since circa 20 years ago the closely related *D. r. bugensis* too started showing invasive behaviour, causing a dominance shift from *D. polymorpha* to *D. r. bugensis*. Although, this is a widely observed phenomenon, mechanistic understanding of displacement of *D. polymorpha* by *D. r. bugensis* is still limited. Therefore, we focused on two sites in the Rhine-Meuse river delta where both species co-occurred since 2006. We assessed the ecological interactions within these mixed populations on fouling plates 3, 6 and 12 months after settlement. This may shed more light on the mechanistic understanding of the displacement of *D. polymorpha* by *D. r. bugensis* at other sites.

NOTES

Managing Invasive Plants and Animals Amidst Endangered Species

Mike Bodle[1]

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Invasive aquatic plants are managed for many reasons including simple right-of-way, navigation and water flow maintenance along with maintaining open areas for growth and utilization of plants and animals listed as endangered and threatened species. Serious invaders tend to overwhelm critical habitat, alter food chains and limit resources needed for endangered species to proliferate. A range of activities are available for invasive management ranging from no action to active physical, environmental and chemical methods.

Endangered species examples include West Indian manatee (*Trichechus manatus*), Everglades snail kite (*Rostrhamus sociabilis*) and Okeechobee gourd (*Cucurbita okeechobeensis*). Numerous invading plants and animals include island apple snail (*Pomacea insularum*), hydrilla (*Hydrilla verticillata*), feathered mosquito fern (*Azolla pinnata*), roundleaf toothcup (*Rotala rotundifolia*) and Tropical American watergrass (*Luziola subintegra*).

NOTES

Invasional Genetic Patterns Across Time and Space in North American *Dreissena* Mussels

Nathaniel T. Marshall[1], *Carol A. Stepien*[1,2]
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Invasive species are a leading cause of worldwide biodiversity decline, with the Laurentian Great Lakes experiencing ~186 introductions. The zebra mussel first appeared in the Great Lakes in 1986, shortly followed by the quagga mussel in ~1989; both were accidentally introduced from ballast water discharge from trans-Atlantic ships. This research aims to test for changes and patterns in temporal genetic variation and population structure of these two closely related invasive species using Lake Erie and the Hudson River as model sites for trends across the North American invasion. Comparisons are made between temporally congruent dreissenid invasions in two sites with differing invasion histories. Comparisons are also made across life history stages (larvae vs. adults), to evaluate the possible association between genetic variation and planktonic larval dispersal. Genetic data are analyzed from 15 selectively neutral microsatellite (μsat) loci, which are useful for assessing population changes across short time scales. We use bioinformatics and statistical analyses to evaluate three hypotheses about temporal invasions: 1) **genetic Stasis** – genotypes of the initial established colonists have persisted over time and may have provided resistance against later-arriving genotypes, 2) **genetic Replacement** – genotypes of the initial established colonists were replaced by later-arriving genotypes from single or multiple sources, which may be more successful or persistent than the original colonists, and 3) **genetic Supplement** – genotypes of the initial established colonists have persisted, along with later-arriving genotypes from single or multiple sources. This research investigates temporal population trends of two related invasive species across life stages in two invasional areas, comparing and contrasting their genetic strategies in light of invasional success.

NOTES

Introducing the Quagga Mussel as a Method for Water Quality Improvement: Assessed Risks and Permit Criteria

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The quagga mussel (*Dreissena rostriformis bugensis*) is a Ponto Caspian species that is rapidly spreading across North America and Western Europe. Lately, this invasive alien species (IAS) is increasingly being regarded as a potential biological filter of algae, pathogens and suspended solids in eutrophic or chemically polluted water systems. The species has already been deliberately introduced to urban ponds by water boards and municipalities in several countries. But is the deliberate introduction of IAS a sensible measure for water quality improvement?

There are two main issues relating to the eco-engineering application of IAS. Firstly, IAS can cause negative as well as positive ecological and socio-economic effects. Therefore, a risk assessment of the quagga mussel for Dutch inland waters was performed. This risk assessment shows that the species has a high risk for invasiveness and negative effects on biodiversity, the functioning of ecosystems, ecosystem services and infrastructure. For example, due to a highly efficient filtering capacity, high densities of the species exert significant influence on the integrity of the ecosystem by affecting biotic factors (e.g., decrease in algal biomass and other freshwater mussels, growth of dense macrophyte stands) and abiotic factors (e.g., stronger benthic-pelagic coupling). These results are in line with risk assessments carried out for North American states.

The second issue concerns the potential conflict between eco-engineering with IAS and legislation for the conservation of (endangered) flora and fauna. An exemption is required before an IAS can be released to nature. However, criteria to assess whether an application for such an exemption may be granted have not been established for eco-engineering with the quagga mussel. The risk assessment has therefore been used to derive evaluation criteria and to develop a protocol to judge applications for exemption. The results of the risk assessment, the protocol and evaluation criteria for eco-engineering with quagga mussels will be discussed.

NOTES

What Really Scares Zebra Mussels? A Few Words about the Impact of Biotic Factors on Valve Movement Reactions of the Zebra Mussel Dreissena polymorpha

Anna Dzierżyńska-Białończyk[1], *Jarosław Kobak*[1], *Łukasz Jermacz*[1]
[1]*Nicolaus Copernicus University, Department of Invertebrate Zoology*

Dreissena polymorpha, one of the best-known invasive species in the world, is more and more often used in water reclamation, bioindication and biomonitoring. Some early warning systems are based on changes in zebra mussel behaviour (valve movements) due to anthropogenic pollution. However, mussels are also likely to change their behaviour in response to natural environmental factors, which are neutral from the point of view of the contaminant detection. Nevertheless, such studies are missing in the scientific literature. We decided to check how biotic factors: alarm substance (secreted by injured conspecifics), predator scent (roach *Rutilus rutilus*), combination of these two substances and the presence of the cohabiting amphipod *Dikerogammarus villosus*, may influence mussel valve movements. All of these factors are potentially stressful which was confirmed in previous studies dealing with other behavioural aspects. Under laboratory conditions, we video-recorded individual mussels in the above treatments and analysed their valve movements with Ethovision® XT software. The alarm substance significantly decreased time spent by mussels with open valves. They responded similarly to the presence of *D. villosus*, probably irritating mussel soft parts, exposed during valve opening. In contrast, we did not observe any specific reactions to the predator scent. Even more interestingly, the combination of alarm substances and fish scent (which resembles a natural situation of roach preying on *D. polymorpha* and therefore expected to cause the strongest response) also did not induce any valve movement changes of test individuals. Certainly, our results show that environmental factors may markedly change mussel reactions, which may be potentially misinterpreted as a reaction to contaminants by early warning systems. To eliminate errors in interpretations of outcomes generated by these systems, reactions of zebra mussels to environmental factors should be examined in detail.

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NOTES

Does the Invasional Meltdown Exist? The Case of the Ponto-Caspian Community

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The "invasional meltdown" (IMD) hypothesis seems to explain well mechanisms of acceleration of invasion process. This is a community-level phenomenon, where the presence of invasive species facilitates the establishment and amplifies the environmental impact of subsequent non-indigenous organisms. It is supposed to result from the greater number and importance of positive interactions among aliens compared to their negative relationships. We conducted comprehensive studies on this phenomenon to determine its range and universality using the Ponto-Caspian exotic community inhabiting Polish inland waters: (zebra mussels, amphipods and Gobies) as a model. It is often suggested as an example of IMD: zebra mussels serve as shelters for invertebrates and increase their density, then invertebrates serve as food for the fish. If that is the case, the zebra mussel would facilitate the fish invasion. But the overall effect of mussels on particular predators may vary from positive to negative, depending on prey density increase and predator ability to prey in a structurally complex habitat. Another problem is that the zebra mussel influences also native fauna, and invasive fishes may be facilitated the same by native prey.

We proceeded with a set of different experiments to answer the following questions:

1. What levels of prey abundance would make a mussel bed a better feeding ground for invasive gobies?
2. Are invasive amphipods a profitable prey for invasive gobies compared with natives?
3. How do subsequent introductions of amphipod species influence their dispersal.

Our results suggest that, if IMD does take place within this community, it is based exclusively on the interactions of the zebra mussel with other community members. In contrast, alien gammarids were less beneficial food for fish than their native counterparts, not contributing to IMD. Thus, a thorough experimental verification of ecological consequences of interspecific interactions is necessary to provide unambiguous support for IMD.

NOTES

Methods for Quantifying Biofouling: An Initial Examination of Optical and Acoustic Approaches

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The process of biofouling occurs in all natural waters and ranges in magnitude from microbial biofilms to complex communities dominated by invertebrates. When transported to new environments, organisms attached to ships may detach from hulls and niche areas or reproduce, potentially becoming invasive species. To mitigate the risk of biological invasions due ships' fouling, port authorities may require inspections of the wetted surfaces and quantification of the biofouling load. The purpose of this pilot study was to evaluate optical and acoustic approaches to quantify biofouling: imaging fluorometry, acoustic imaging (with single and dual beam sonars), and optical imaging (using an underwater, digital camera). The methods were evaluated using panels fouled with natural communities from subtropical waters in Key West or Lemon Bay, Florida. Using the imaging fluorometer, the distribution of chlorophyll a fluorescence of a heavily fouled panel corresponded well to the arrangement of organisms. Similarly, a map of fluorescence intensities corresponded well to locations of macroalgae and algal biofilms. In the acoustic approach, the 450-kHz sonar could distinguish between highly fouled panels and panels without fouling, but it was unable to resolve areas of fouling within a panel. Initial testing of a higher frequency sonar (2250 kHz) showed improved special resolution. While underwater imaging using a digital camera was an easily deployed approach, image processing and analysis would be required to automate and standardize the quantification of organisms. In general, all three technologies generated data rapidly, and all three could be configured for continuous analysis through repeated imaging, although imaging fluorometry would require test panels to be evaluated *ex situ*.

NOTES

Performance Evaluations of Instruments Designed for Rapid, Shipboard Detection of Living Microorganisms in Ballast Water

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Instruments designed to rapidly assess ballast water in shipboard environments are in development and (in many cases) commercially available. The purpose of these instruments is to determine whether the discharge water complies with national and international limits on the concentrations of living organisms in ships' discharge. Six such instruments (all employing variable fluorescence fluorometry) were evaluated in a series of laboratory and field trials, in collaboration with the Alliance for Coastal Technologies. Here, trials were designed to examine the fidelity between measurements of living organisms determined by the compliance tool vs. epifluorescence microscopy, the standard, but time-consuming, approach. As part of this effort, laboratory-based trials tested samples with a range of concentrations of cultured microalgae (*Prorocentrum micans* and *Tetraselmis marina*). Field trials were conducted in freshwater, estuarine, and marine environments to measure the performance of the fluorometers in different aquatic systems. Precision, accuracy (i.e., agreement with standard microscope counts), and linear response were considered when evaluating instrument performances. To determine the probability—at a given cell concentration—that the instrument would correctly identify the risk of exceeding the discharge standard, logistical regression analyses were conducted. While performances metrics varied among instruments, the probability of detecting an exceedance of the discharge standard was high (>90%) when organism concentrations were >30 mL-1 (i.e., 3x the discharge standard for organisms ≥10 µm and <50 µm, typically dominated by phytoplankton). The results are, in general, encouraging for shipboard compliance testing, and these findings demonstrate that portable variable fluorescence fluorometers can indicate whether sampled water meets or exceeds the discharge standard.

NOTES

Assessment of Ballast Water Management Systems: Science in Support of Policy

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Accreditation of ballast water management systems to conform to regulatory standards defined by the International Maritime Organization (IMO) or US Coast Guard (USCG) requires accurate detection of very low concentrations of viable (IMO) or living (USCG) organisms in the 10-50 and >50 µm size-classes. Methods for assessing the former focus on phytoplankton, which dominate the size-class. By definition, an assessment of viability requires measuring the ability to proliferate. The Serial Dilution Culture – Most Probable Number (SDC–MPN) assay is a reproducible but imprecise test for viability. It can be used to assess the effects of biocides that kill cells (e.g., heat stress) and disinfectants that sterilize cells without killing them (e.g., UV radiation). Tests for vitality (live vs dead) may target membrane integrity, metabolic competence, or nucleotide function. These include the USCG-mandated FDA+CMFDA stain plus motility test and chlorophyll a variable fluorescence, F_v. The former tests membrane integrity. Objective and replicated tests on a wide range of phytoplankton (24 species from 7 divisions) showed high error rates (>10%) in the majority when stain-treated, living cells were compared to the appropriate controls (stain-treated, heat-killed cells). Use of living cells not exposed to stains as the control increased the proportion of stain-treated, living cells that were correctly classified as living but also increased the proportion of stain-treated, dead cells that were incorrectly classified as living. Error rates remained unacceptably high. Bulk measurement of F_v tests for photosynthetic competence but interpretation of the signal is complicated by intrinsic pathways of loss and repair that do not necessarily reflect vitality. Because there is high inter- and intra-specific variability in per-cell F_v reflecting cell size and physiological status, F_v cannot be used with confidence to estimate concentrations of living cells. Carefully controlled and replicated experiments show that neither FDA+CMFDA plus motility nor F_v are generally suitable for assessing viability (reproductive ability) in UVC-treated cells. In all species tested, both tests were completely insensitive to loss of viability or overestimated viability by orders of magnitude. Careful consideration of experimental evidence is important in the evaluation of methods for testing ballast water management systems.

NOTES

Advances in Validating MPN and Stain-Motility Methods for Assessing Phytoplankton for Ballast Water Treatment

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The United States Coast Guard (USCG) recently rejected an application for the use of the Most Probable Number – Serial Dilution Culture Method (MPN) as an alternative method for measuring treatment of organisms in the 10-50 um size category, leaving the use of fluorescein-based stains (FDA and CMFDA) as the only approved method. The stains are purported to assess the live/dead status of organisms, and are thus thought to be "safer" than a culture-based method like MPN that assesses reproductive ability. However, the stains do not measure damage done by UV treatment systems. UV systems inactivate organisms by damaging their DNA and preventing reproduction and thus preventing invasions. The stains measure the activity of an organism's esterase system and its membrane integrity, which are not directly impacted by UV treatment. Significantly higher UV doses and significantly larger UV systems will be required to meet USCG standards using stains as the measurement method. This paper will give an overview of the issue and will also present the results of recent scientific studies done to validate both methods using both cultures and mixed assemblages from field samples. Validation of any method on field samples is difficult as the live/dead status of cells is not known a priori unless they are growing in culture. Novel methods for assessing the status of cells in natural samples were developed and used in validation efforts for both methods.

NOTES

Implementing DNA Metabarcoding as Cost-effective Tool to Provide Biological Data for Port Baseline Survey

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The international Convention for the Control and Management of Ships' Ballast Water and Sediments, which will enter into force in 2017, has been developed to prevent the introduction of aquatic non-indigenous species via discharged ballast water. Under the Convention's, ships are required to manage their ballast water; but they can also ask to be exempted to comply with ballast water management requirements by providing a risk assessment, ensuring that the threat of transferring harmful organisms between specified ports is limited. Biological data are essential components of such risk assessment, and robust port biological baseline surveys are needed to provide inventories of native and non-native biodiversity. Yet, these detailed biological baseline surveys are complex, as they imply exhaustive sampling followed by species identification, which usually relies on time-consuming and expertise-dependent morphological taxonomy. To ease port baseline surveys, we developed and applied a protocol that relies on metabarcoding, a method that allows the simultaneous taxonomic characterization of hundreds of complex samples (water, sediment) based on sequencing a conserved DNA fragment. To this aim, we sampled the commercial port of Bilbao (Spain) during the four seasons to collect fouling organisms attached on port structures, benthic macroinvertebrates living on sediment and filtered water containing zooplankton, phytoplankton and expelled material such as feces, cells, and tissues released from larger organisms. Our analysis is the first thorough metabarcoding-based biodiversity assessment applied to port baseline survey. We show that metabarcoding enhances detection sensitivity, provides a time saving and cost-efficient alternative to visual identification and is easily standardizable and reproducible. In sum, we provide early insights into the advantages and drawbacks of implementing such genetic-based species identification to depict port communities for biological risk assessments.

NOTES

Optimization and Performance Testing of a Sequence Processing Pipeline Applied to Early Detection of Nonindigenous Species

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Molecular detection has potential to provide greater sensitivity than classical methods in detection of aquatic invasive species (AIS). Sequence processing is performed to reduce error in molecular detection, but it can also be a source of error since users do not know beforehand appropriate parameters to use. We optimized a sequence processing pipeline separately for two common research goals: estimation of biodiversity and detection of AIS. We then tested its performance with optimal parameter sets through simulations. In optimization, we tested 1050 combinations of parameters for the pipeline to determine optimal parameter sets for each research goal. We tested performance by computationally inoculating sequences from 20 AIS into ten zooplankton community samples from ports across Canada, determining detectability and sensitivity. Optimization revealed that optimal parameter selection depends on the research goal. We found regardless of research goal that sequences of length ≥ 375bp should be kept and sequence quality filtering should be relaxed ($2.0 \leq MEE \leq 3.0$, $Q = 10$). However, clustering or denoising were only viable when the goal was to estimate biodiversity, as low-abundance target sequences for some taxa were undetectable in some ports. With appropriate parameter selection, 90% of AIS were detectable with fewer than 11 sequences in a sample with appropriate parameter selection, regardless of whether clustering or denoising were used. Despite developments in next-generation sequencing, sequence processing continues to be an important issue. There is no 'magic bullet' with respect to sequence processing, though appropriate parameter selection increases robustness of sequence processing pipelines against community diversity and potential AIS targets. Users must ensure that reference databases are up-to-date and contain entries for important AIS, and users should test multiple parameter sets for their pipeline when searching for AIS.

NOTES

An Exotic Fish, Bullseye Snakehead (*Channa marulius* [Hamilton, 1822]), in the Canal System of Southern Florida, USA

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The first appearance of the Bullseye Snakehead, *Channa marulius*, was on October 5, 2000 in a residential pond in Tamarac, Florida. It was caught by an angler and reported to the Florida Fish and Wildlife Conservation Commission for identification. Subsequent sampling uncovered a population numbering in the hundreds. Since the initial discovery this species had spread into the canal system in portions of two adjacent counties in southeastern Florida. It is not known how and where this fish, a native from India to Southeast Asia including southern China, entered the United States. It is suspected to have been imported for the live food trade. *Channa marulius* is the largest member of the Channidae family reaching over one meter in length. Because this species is a large predator, there is concern for its introduction beyond the canal system into natural ecosystems including Everglades National Park which may provide suitable habitat.

NOTES

Dry Ice - A Novel Control and Eradication Method for Invasive Asian Clam Corbicula fluminea?

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Asian clam *Corbicula fluminea* is a high impact freshwater invader that dominates macroinvertebrate communities and physically alters benthic habitats. Since its first detection in April 2010, *C. fluminea* has been confirmed present at six sites across the island of Ireland. Globally, extensive control and eradication experiments have been conducted both in situ and in vivo – however, to date, none have been successful in providing significant control or eradication of *C. fluminea* populations. Therefore, innovative biosecurity techniques for the control and eradication of *C. fluminea* are urgently required. We have examined the use of commercially available dry ice pellets (at -78ºC) to kill *C. fluminea*. Our research shows that such pellets sink into crevices between clams and will freeze specimens to death *via* thermal shock. In an experiment comprised of exposed, semi-submersed and fully submersed clams, 100% mortality can be achieved with dry ice application, with all control specimens surviving. Moreover, we examine the effects of (1) dry ice pellet type (degree of compacting, size, mass); (2) density of clams; (3) volume of water; (4) number/mass of pellets applied; and (5) dry ice pellet delivery mechanisms (e.g. spraying pellets on surface of water, direct application to river bed).We suggest that the application of dry ice pellets can potentially be used for significant control and eradication of *C. fluminea* populations. In addition, dry ice application could be deployed as a rapid reaction response to an emerging *C. fluminea* threat. Moreover, the use of dry ice avoids and/or reduces damaging, non-target effects which often accompany chemical and mechanical control methods. Given the rapid recovery/recolonization associated with lotic systems, dry ice application will have a minimal impact on native species populations.

NOTES

Multiple Introductory Events Shape the Phylogeographic Structure of a Globally Invasive Marine Mussel

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Data repositories such as Dryad and GenBank play a crucial role in enforcing scientific rigor by housing datasets generated from experiments, which can be used for replication and meta-analyses. The diminishing cost of sequencing combined with increased computing power and more complex algorithms, means that Ecology and Conservation has entered the 'big data' revolution. Despite the availability of these databases, their use in invasion biology has mostly been restricted to DNA barcoding, phylogenetic analyses and supplementing author-generated sequence data for regional population genetic studies. The aim of this study was to evaluate the global phylogeographic pattern of the marine invader *Mytilus gallopronvicialis* strictly using repository data. A scanning program was coded in C++ to mine cytochrome c oxidase 1 (CO1) DNA sequences from the NCBI database, GenBank, which resulted in a tally of more than 250 candidate sequences. Using a MUSCLE alignment, we produced an aligned data file (~360 bp) representing 22 populations (native and introduced) from across the globe. Bayesian analysis based on 20 million generations showed strong phylogeographic signal despite the presence of multiple gap regions in the alignment. We present data on haplotype patterning, global genetic diversity, genetic structure and discuss their implications on the invasion history of *M. galloprovincialis*. Since some of these sequences were generated by researchers who were not interested in population studies the types of analyses that could be carried out was restricted. As a consequence, we also call for the addition of new source modifiers (e.g. GPS co-ordinates) as part of the submission process to repositories.

NOTES

Do Ecological Interactions Explain Dominance Shift between Ponto-Caspian Bivalves *Dreissena polymorpha* and Dreissena rostriformis bugensis in their Introduced Range?

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The invasive bivalve species *Dreissena polymorpha* and *Dreissena rostriformis bugensis* are native to the Ponto-Caspian area (i.e., rivers basins northern of the Black sea, Caspian sea and Azov sea). In the 19th century *D. polymorpha* started extending its geographical range. Nowadays this species can be found throughout Europe, Eurasia and North America on hard substrates in fresh to oligohaline rivers, lakes and canals. However, since circa 20 years ago the closely related *D. r. bugensis* too started showing invasive behaviour, causing a dominance shift from *D. polymorpha* to *D. r. bugensis*. Although, this is a widely observed phenomenon, mechanistic understanding of displacement of *D. polymorpha* by *D. r. bugensis* is still limited. Therefore, we focused on two sites in the Rhine-Meuse river delta where both species co-occurred since 2006. We assessed the ecological interactions within these mixed populations on fouling plates 3, 6 and 12 months after settlement. This may shed more light on the mechanistic understanding of the displacement of *D. polymorpha* by *D. r. bugensis* at other sites.

NOTES

Addressing AIS Introductions from Aquariums and Water Gardens using Outreach and Retailer Inquiry in Michigan

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Aquatic plants and animals introduced through channels of trade pose a significant threat to Michigan waters and to address this threat we developed a new outreach campaign, RIPPLE (Reduce Invasive Pet and PLant Escapes), in 2015 in cooperation with the Michigan Department of Agriculture and Rural Development. The goal of the campaign is to establish and foster mutual understanding, promote public involvement, and influence the behaviors, attitudes and actions of consumers and retailers in the pond and pet store industry. Outreach materials were designed for retailers to showcase in their store or on the web and include two short videos for aquarium and pond hobbyists focused on negative impacts of aquatic invasive species and various print materials including fish and pond plant tank clings designed for placement on containers at retail locations. While the need for retailer education and engagement regarding aquatic invasive species is clear, we know very little about current retailer behavior or their willingness to participate in education programs. To address this knowledge gap we distributed a mail survey to independently owned pet and water garden retailers in Michigan. The goal of the survey was to answer questions never asked of Michigan pet and water garden retailers, including their knowledge of aquatic invasive species, current preventative behavior and recommendations shared with customers, and their willingness to participate in aquatic invasive species prevention programs. Findings from this study will aid in future outreach and engagement efforts with retailers and consumers, reducing future aquatic invasive species introductions from pet and water garden sources in Michigan.

NOTES

Contrasting Patterns of *Pomacea maculata* Establishment and Dispersal in the Everglades vs a Central Florida lake system

Silvia Maria Millan Gutierre[1], *Philip Darby*[1]
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The exotic apple snail, *Pomacea maculata*, was likely introduced to Florida in the 1990s; the first confirmed population was Lake Munson (100 ha) in 2002. Since then *P. maculata* spread to lakes and wetlands throughout Florida, and in many cases they are found where native *P. paludosa* are not. We observed distinct scenarios by which *P. maculata* become established and dispersed in two wetland systems; 1) Lake Tohopekaliga (LTOHO), 18,000 ha, in central Florida, and 2) the southern portion of Everglades Water Conservation Area 3A (WCA3A), 100,000 ha. Native snails were nearly non-existent in our 2001-2002 LTOHO samples. In Goblets Cove (GC), LTOHO, we observed *P. maculata* eggs in 2001 just outside the littoral zone. By 2003 we trapped a few exotic apple snails in the GC littoral zone. Following a managed draw down, exotic snails were abundant in GC; no snails of either species were found in the rest of LTOHO. From 2004-2009, *P. maculata* were observed in hydrilla (*Hydrilla verticillata*) mats and the snails spread throughout the lake at densities sufficient to support foraging Snail Kites. In contrast to LTOHO, WCA3A supported relatively abundant native snails in its southwest region. *P. maculata* , first observed in WCA3A in 2011, likely dispersed into WCA3A from the canal bordering southern WCA3A. Dispersal in WCA3A has radiated out northward and eastward, against the general direction of water flow. The native snail population constrained to southern WCA3A has co-existed with *P. maculata* for over 5 years. *P. maculata*, but not *P. paludosa*, has dispersed into long-hydroperiod poor quality habitat in eastern WCA3A. Unlike reports of exotic apple snail impacts in agricultural systems or in smaller wetland systems (i.e., Lake Munson), the overall plant community composition in both LTOHO and WCA3A does not appear to have been impacted by *P. maculata*.

NOTES

How the Burrowing Activity of the North American Crayfish *Procambarus clarkii* alters the Seepage Process in River Levees

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The North American crayfish *Procambarus clarkii* is responsible for biodiversity declines and dramatic habitat change in Europe for its several impacts (e.g. increased turbidity, loss of fauna and flora) and damage to levees of rice fields, irrigation ditches and small rivers caused by its intensive burrowing activity. To better understand the last one, experiments have been conducted in artificial environments at the University of Florence, using a small-scale model of a levee built inside a tank. The model was composed of the favored soil for the burrowing activity of the species (e.g. clay). On one side of the levee, the water level was kept constant while the other side was left dry with a barrier on top of the levee to keep both sides separated. Two couples of equally sized crayfish (one adult male and one adult female) were transferred into the tank to observe their burrowing activity for four days under a natural light-dark cycle. Animals were fed daily to limit the probability of aggression and cannibalism among specimens. Animals were removed from the tank at the end of the experiments and burrows were filled with polyurethane foam. After one day, the cast of consolidated foam was removed from the levee to measure the volume and to analyze the shape of burrows. Animals started digging immediately after being placed into the tank, affecting water clarity and increasing the suspended solids. Burrows were irregular, with crayfish producing generally more than one tunnel per experiment and in six cases with a chamber. The ratio of the excavated volume to the initial volume of the physical model ranged from 1 to 7 % among the experiments. Burrows favor the raise of the phreatic line, increasing the possibility of its emergence on the landside and affecting the integrity of the levee.

NOTES

Microbial Communities Associated With Aquatic Invasive Species Using High-Throughput Sequencing Approaches

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Aquatic invasive species (AIS) such as Eurasian watermilfoil (EWM) and zebra mussels (ZM) pose a serious threat to the health, structure, and function of aquatic ecosystems. Traditional approaches for AIS control, such as use of chemicals and manual removal, have been ineffective, calling for new management and eradication strategies such as the use of biological control. Some microorganisms have evolved to live in close association with aquatic organisms. These host-microbe interactions could be commensal, symbiotic, or pathogenic in nature, and such relationships could potentially be targeted to develop microbe-mediated AIS management strategies. This study proposes to characterize the microbial communities (bacterial and fungal) associated with EWM and ZM, both temporally and spatially, using amplicon-based sequencing approaches. To accomplish this, EWM, ZMs, sediment and water were sampled from 25 lakes across Minnesota for 6 months (June to November) in 2016. Field samples were processed, DNA extracted and high-throughput sequencing was performed on all field samples using the Illumina platform. Sequencing results showed a distinct clustering of each sample type, irrespective of sampling time and location. The greatest number of operational taxonomic units (OTUs) was observed in sediment samples, and the lowest in EWM and ZM samples. Several OTUs were identified that were either specific or present in higher relative abundance in EWM and ZMs when compared to sediment and water samples. Results from this study will help define the distribution of microbes associated with these AIS, and be useful for the development of future biological control strategies.

NOTES

Potential Dispersal of Grass Carps in the St. Lawrence River Network (Québec, Canada) based on Barrier Mapping

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In May 2016, the Ministry of Forests, Wildlife and Parks of Québec government, in accordance with the Québec Maritime Strategy Action Plan, implemented the Québec Asian Carp Program. The objectives of this program include the risk assessment of Asian carp invasion in the St. Lawrence River and its tributaries as well as the development of an early detection monitoring program and a rapid response action plan if Asian carps are captured. In parallel to this implementation, the risk of Asian carp invasion in Québec waters became real with the first capture (May 27th, 2016) of a mature grass carp near Contrecoeur (45°51.58'N; 73°14.16'W) in the St. Lawrence River. Grass carp environmental DNA was also detected along the St. Lawrence River and in the downstream part of two tributaries (water samples taken in 2015 and 2016 for eDNA projects). Both events indicate that grass carp has been present in Québec waters since at least 2015, demonstrating the urgent need of addressing this issue.

Parts of the risk analysis consist in assessing the dispersion potential of Asian carps from the St. Lawrence River to Québec inland waters. Identifications of existing barriers to Asian carp upstream movements are used to determine tributaries at risk of being invaded by Asian carps. Near 300 potential barriers were classified and sensible areas were identified by taking into account known regional realities. The resulting maps cover an area from the Ontario border to Saguenay River. This first analysis will be an important management tool to help the planning of more efficient monitoring activities as well as possible mitigation measures.

Early detection monitoring program includes eDNA sampling campaigns and targeted experimental sampling for juvenile and adult Asian carps, with common carp as a surrogate species, along the St. Lawrence River (freshwater areas) and the downstream section of some of its main tributaries. Detection is also assured by partnerships with voluntary commercial fishermen. Summary of 2017 actions will be presented.

NOTES

Phragmites australis Management in Florida Under a Changing Climate

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Acres of native wetland plant communities throughout North America have been replaced by dense monocultures of *Phragmites australis* (common reed; hereafter referred to as *Phragmites*), which alter important ecosystem services such as carbon storage and nutrient cycling. This species is divided into haplotypes, with both native and exotic haplotypes present in the United States. Two haplotypes have recently presented management concerns in Florida: Haplotype M, an aggressive invader from Eurasia that was first identified in the state in 2013, and haplotype I, which has unclear origins but has recently become aggressive in disturbed freshwater wetlands throughout the state. Increases in atmospheric CO_2 concentrations and temperature can have a significant impact on the growth and physiological processes of C_3 species such as *Phragmites* through a "fertilization effect," potentially altering their herbicide tolerance. We examined this relationship in a greenhouse experiment. Haplotypes I and M were grown under elevated (700 ppm, 22/34°C) or ambient (390 ppm CO_2, 18/30°C) CO_2 concentrations and temperature for six weeks, at which point they were treated with glyphosate (0.5 lb.-a.i. per acre). Stem number, height, specific leaf area, and leaf gas exchange were recorded prior to herbicide application. Visual injury symptoms were recorded weekly for 30 days, before height, stem number, and aboveground biomass were measured. Plants were allowed to regrow for another 30 days before height, stem number, and both above- and belowground biomass were measured.

NOTES

Herbicide Resistance and Microbiomes in Michigan (USA) Lakes

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Herbicide resistance is not new in Michigan where it has often been the impetus for development of new aquatic weed management strategies. In many cases herbicide resistance cannot be attributed to a single control agent, but is often expressed over a wide range of control agents with very different modes of action. Biofilms and the microbiome have been implicated as the primary factors that have conferred various degrees of aquatic herbicide resistance to a wide variety of aquatic plants and weeds. Michigan lake managers and herbicide application contractors have devised ways to overcome herbicide resistance and these strategies are based on a fundamental understanding of the microbial mechanisms. However, the dynamic nature of the aquatic microbiome still challenges the Michigan lake management community. There is a need to develop a better understanding of how the aquatic microbiome is affected by weather and cultural disturbance to increases the efficacy and efficiency of selective aquatic weed management.

NOTES

Estimation of Plankton Densities in Ballast Water when Colonial Species are Present, and their Implications in Compliance Testing on IMO Density Standards

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In view of controlling aquatic invasions globally, the International Maritime Organization (IMO) has set limits on allowable plankton densities in ballast water discharge. Previous guidance on ballast water sampling and compliance decision thresholds was based on the assumption that density distributions of plankton are Poisson when homogenous, or negative binomial when heterogeneous. However, some ballast water contains colonial species, which results in the selection of an individual in a colony in a sample with the same probability as any other individual in the whole colony. Therefore, here, we propose to model the probability of the number of individuals attached to a particle, forming colonies, and the probability of the number particles, both the discrete individuals and the colonies, in a sample, in a hierarchical probability model structure to estimate plankton density. This is to reduce uncertainty regarding the estimations and increase the statistical power of compliance decisions for ballast water where species have both discrete individuals and colonies. We examined the performance of the models using plankton data of size class < 50 µm and ≥10 µm, collected from five different depths from a ballast tank of a commercial ship, in three independent surveys. We show that the distribution of the density data fits to both the negative binomial and the hierarchical models equally well, and better than the Poisson model, at the scale of our sampling. However, the hierarchical model, which accounts for both the number of particles and the total number of individuals within particles, separately, in a sample, markedly improves the uncertainty regarding point density estimations and the power of rejecting decisions on noncompliance. We show examples as to how to test ballast water compliance using the tested models. We discuss implications of using alternative estimation models on compliance monitoring on IMO discharge density standards.

NOTES

A Literature Review of Hull Husbandry Methods

Stephanie H. Robbins-Wamsley[1], *Matthew R.First*[2], *Lisa A. Drake*[2]
[1]*Excet Inc.*
[2]*Chemistry Division, Naval Research Laboratory*

Underwater ship husbandry, also known as hull husbandry, is an important economic maintenance step in the shipping industry since fuel consumption can represent up to 50% of a ship's operational costs. To that end, given that biofouling increases the hydrodynamic drag of a vessel—resulting in increased fuel consumption—the removal and prevention of ship-associated biofouling is a primary focus. From the perspective of invasive species, fouling of the hull and specialized niche areas is responsible for the transport and delivery of invasive species, and in some locations, it has resulted in more biological invasions than the discharge of ballast water. While focused on the hull, husbandry approaches may be used for vessels' niche areas (e.g., sea chests and propellers). Proper hull husbandry improves a vessels operation and fuel costs, but hull husbandry also mitigates the risk of bioinvasions, especially if the waste is collected or treated. There is an immediate need to identify hull husbandry techniques that meet vessel operation goals while minimizing the threat of invasions during the cleaning process. We reviewed international, national, and regional policies and guidelines on reducing biofouling to prevent species introductions. We summarized current literature (primarily from 2014 to 2016) and categorized the different hull husbandry approaches (including whether waste collection and treatment was performed).

NOTES

Determining the Toxicity of Antifreeze to Quagga Mussels

Kelly Stockton-Fiti[1]
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Boats are potential vectors of spreading quagga and zebra mussels (*Dreissenia* sp.) from infested lakes to uninfested lakes and rivers, but many states have initiated boat inspection and decontamination stations to educate the public and prevent spread. Boat owners in the fall to winter go through a final decontamination and inspection and then follow the winterization process, which is to drain out all remaining water and charge antifreeze into the boat piping system. In the spring, boat owners flush out the antifreeze from the boat's piping system before re-entry into the water the following year. Antifreeze prevents freezing of remaining water and damage to boat components. Propylene glycol is the active ingredient and is considered non-toxic. Propylene glycol is used to cryopreserve larval blue mussels and bacteria with good survival upon thawing.

This study examined three commercially available propylene glycol formulations rated at -50, -100, and -200°F. Quagga mussel veligers and juvenile were held at three temperature (20, 4, and -20°C) and analyzed periodically for up to a month.

We found that all three formulations of antifreeze killed veligers in 48 h at all temperatures tested. Juvenile mussels were protected at all temperatures with all three formulations of antifreeze, with the -100°F formulation being the most toxic and the -200°F formulation was the least toxic. Results from this study should help managers make informed decisions about the need to decontaminate watercraft in the spring that were winterized with propylene glycol antifreeze.

NOTES

Asian Carp Canada Social Media and Web Tactics

Lauren Tonelli[1], *David Nisbet*[1]
[1] *Invasive Species Centre*

In partnership with Fisheries and Oceans Canada, the Invasive Species Centre runs the social media and website for the Asian Carp Canada outreach and education brand. The tactics used for social media campaigns are focused on filling the gaps in knowledge that exist in Ontario towards Asian carps. We utilize Facebook, Twitter, and www.asiancarp.ca to connect with a broader audience to increase awareness about Asian carps and their associated risks. This talk will take listeners through the various campaigns that we have run as well as the multiple platforms we use to get the messages across. It will also discuss what has worked and what hasn't.

NOTES

Confused with Carp

Lauren Tonelli[1], *David Nisbet*[1]
[1]*Invasive Species Centre*

In 2016/2017 Asian Carp Canada added new tactics in outreach and education based on past survey results of baseline knowledge in Ontario. We analyzed gaps in the knowledge that Ontarians had about Asian carps and formulated our outreach and education around that. One of these campaigns was our Confused with Carp campaign that highlighted the ID features of Asian carps versus the species that often get reported as Asian carps to the Invading Species Hotline. The campaign ran on Facebook, Twitter, and on www.asiancarp.ca, received over 100 000 impressions, and won an award. This tactic opened the lines of communications between us and the public more than we have had in the past. It allowed for conversations to take place about where Asian carps are and what species they should be looking out for.

NOTES

Evaluating Risk of African Longfin Eel (*Anguilla mossambica*) Aquaculture using a Bayesian Belief Network of Freshwater Fish Invasion

Katherine Wyman-Grothem[1], *Nicholas Popoff*[2], *Michael Hoff*[1], *Seth Herbst*[2]
[1]*U.S. Fish and Wildlife Service, Midwest Region, Fisheries Division*
[2]*Michigan Department of Natural Resources, Fisheries Division*

Recent proposal of African Longfin Eel (*Anguilla mossambica*) aquaculture in the State of Michigan highlighted a need for greater understanding of the potential risk posed by introducing this species to the U.S. and the Great Lakes region. U.S. Fish and Wildlife Service rapid risk screening has previously characterized this species as posing "uncertain" risk to the continental United States. The State of Michigan organized the application of the U.S. Fish and Wildlife Service's Freshwater Fish Invasive Species Risk Assessment Model (FISRAM) for more detailed risk assessment. As a Bayesian belief network, FISRAM requires users to input estimated probabilities of harm to native species, ecosystems, and humans by a variety of mechanisms, as well as estimated probabilities of habitat suitability and transport. Eel and fish health experts from three continents provided inputs to run FISRAM for *A. mossambica*. Experts emphasized lack of knowledge about many of the species' ecological interactions, but rated its probability of transport high and expressed concern about concurrent introduction of the swimbladder nematode *Anguillicoloides papernai* that parasitizes *A. mossambica*. Use of FISRAM provided a framework for soliciting expert knowledge and translating that knowledge into a distribution of predicted probabilities of invasiveness.

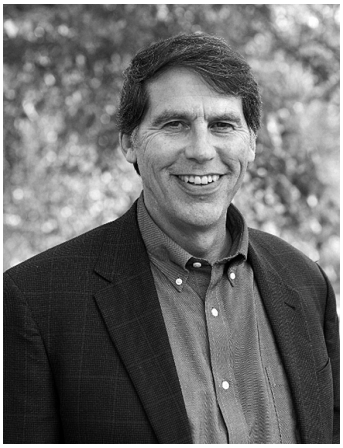
NOTES

Invited Keynote Presentation

Knowledge to Action on Invasive Species: North America and Global Linkages

David M. Lodge
Director, Atkinson Center for a Sustainable Future, Cornell University, USA

The invasive subset of almost 200 nonindigenous species in the North American Great Lakes cause at least $200M in annual damages. Those and the many other damages from invasive species throughout North America have mostly been accepted as a necessary by-product of global trade. Such fatalism is however unnecessary and financially foolish. Recent innovations are reducing invasions from ships, and from commerce in living organisms, while simultaneously increasing net economic benefits. New DNA-based technologies provide improved early detection tools, which, if combined with large-scale eradication and control technologies, open the door to a virtuous cycle of innovation, business opportunity, and environmental protection. Such a virtuous cycle will be hastened and enhanced by co-creation of research with decision-makers in the public and private sectors.



David M. Lodge
Director, Atkinson Center for a Sustainable Future, Cornell University, USA

David Lodge is the director of Cornell University's Atkinson Center for a Sustainable Future, and one of the world's leading experts on invasive species. His research focuses on ecological forecasting and environmental risk assessment, natural resource management, and policy. Lodge led the synthesis on freshwater biodiversity as part of the United Nations' Millennium Ecosystem Assessment. He served as the first chair of the U.S. government's national Invasive Species Advisory Committee, and served on scientific advisory boards for the US National Oceanic and Atmospheric Administration, US Environmental Protection Agency, and the US-Canadian International Joint Commission. He has testified numerous times before the U.S. Congress, served as an expert witness in federal court, and was a Jefferson Science Fellow in the US Department of State's Bureau of Oceans and International Environmental and Scientific Affairs. Lodge received his undergraduate degree from Sewanee (The University of the South). As a Rhodes Scholar, he received a D.Phil. in Zoology from the University of Oxford. Lodge has published over 200 scientific papers, and edited two books.

Development of a Novel Tool to Deliver Control Agents to Targeted Aquatic Invasive Fishes

Jon J. Amberg[1], *Blake Sauey*[1], *Joel Putnam*[1]
[1] *United States Geological Survey, Upper Midwest Environmental Sciences Center*

Resource managers in the United States are limited to only four piscicides to control invasive fishes: 3-trifluoromethyl-4-nitrophenol (TFM), niclosamide, rotenone, and antimycin-A. The currently available chemical controls are applied throughout the water column and impact all organisms within the treated body of water. TFM and niclosamide are somewhat selective to Sea Lamprey and comprise an important component of their control in the Laurentian Great Lakes. Whereas, rotenone and antimycin impact invasive and native fishes alike. A selective control chemical is highly desirable by resource managers to control invasive bony fishes, like the Asian carps and Common Carp. Using technologies developed for the aquaculture and food industries with a thorough understanding of the targeted fish's feeding behavior and physiology, one can begin to develop tools to selectively deliver a control agent to an invasive fish while minimizing impacts of many of the native fishes. In this presentation, we will provide a brief overview of the development and efficacy of this new delivery tool, as well as the limitations to its use. We will also describe the vital information needed for expanding its use with other species.

NOTES

Control of Common Carp through Biocontrol and Species-specific Toxin Delivery

Josh Poole[1,2], *Przemyslaw Bajer*[1,2], *Blake Sauey*[3], *Jon Amberg*[3]
[1]*University of Minnesota*
[2]*Minnesota Aquatic Invasive Species Research Center (MAISRC)*
[3]*U.S. Geological Survey, Upper Midwest Environmental Sciences Center*

Species-specific control of common carp (Cyprinus carpio) using a toxin, antimycin-a (ANT-A), was tested in laboratory tanks and outdoor ponds. Experiments were based on the hypothesis that carp eat foods (grains, such as corn) most native species do not, and that a toxin could be incorporated into such food items to selectively target carp populations. To test this hypothesis, corn-based pellets containing ANT-A were developed and tested. Gavage (force-feeding) trials showed ANT-A to be lethal to carp at 8 mg/kg. A leaching study showed that less than 1% of ANT-A leached from pellets causing no unintended mortality. Single-exposure lab tests with mixed species showed >40% mortality among carp and a native cyprinid, but no significant mortality among two common native species, the bluegill (Lepomis macrochirus) and yellow perch (Perca flavescens). Mixed-species tests in outdoor ponds showed 33% mortality of carp and no mortality of bluegills or perch. These results suggest that carp-specific toxin delivery systems might be possible by exploiting carp's gustatory preferences and foraging behavior. Toxin application methods could be further optimized to reduce mortality among native cyprinids.

NOTES

Removal of *Phragmites australis* ssp *australis* and Site Augmentation with Native Vegetation in Wisconsin, USA

Paul M. Skawinski[1]

[1] *University of Wisconsin – Extension Lakes Program, Stevens Point, Wisconsin, USA*

A thirty-five year-old stand of *Phragmites australis* ssp. *australis* was treated for two consecutive years (2014, 2015) with foliar-applied Imazapyr. The treatments were very successful, and subsequent *Phragmites* re-colonization of the site was controlled via manual removal efforts. An in-situ seedbank study resulted in germination of 21 plant species, consisting mostly of weedy, exotic species. To facilitate establishment of desirable species, the site's three distinct depressions received different degrees of restoration effort, including native plant plugs + seeds and seeds only. In an effort led by volunteers and University of Wisconsin students, a total of approximately 8,000 2-inch plugs and nearly three pounds of seeds of native plant species were added to the site to augment colonization by natives. Weather conditions and colonization by other invasive species presented challenges to site managers and will be discussed.

NOTES

STA Vegetation Management and Invasive Species Control

Eric Crawford[1]
[1]*South Florida Water Management District*

While the original purpose of the STAs was to filter and remove excess nutrients, primarily phosphorus (P) from surface waters flowing into the Everglades natural areas, these constructed wetlands also serve to reduce the spread of exotic plants into the Everglades. Thousands of acres of FAV flow into the STAs each year and are captured in our marshes and removed from the water before it enters the protected areas.

Vegetation management in the STAs includes herbicide applications and mechanical removal as well as limited manual removal to control invasive FAV, SAV, and emergent herbaceous and woody species. Controlling FAV, such as water lettuce (*Pistia stratiotes*) and water hyacinth (*Eichhornia crassipes*), is necessary in SAV cells, where FAV can form dense beds that shade out the SAV species underneath. Dense FAV can also hinder the growth of EAV, impede flow through cells and lead to hydraulic short circuiting. Invasive woody species, such as primrose willow (*Ludwigia* spp.), are controlled because they are aggressive exotics and also because they tend to displace cattail (*Typha* spp.) and do not provide the same level of P removal as cattail or sawgrass (*Cladium jamaicense*).

NOTES

Utilizing a Rapid Response Team for Landscape Level AIS Survey and Management in the Adirondack Park

Erin Vennie-Vollrath[1], *Dan Kelting*[2], *Sean Regalado*[2]
[1]*Adirondack Park Invasive Plant Program*
[2]*Paul Smith's College, Adirondack Watershed Institute*

Since the early 2000s, Adirondack Park Invasive Plant Program (APIPP) volunteers and partners have conducted early detection surveys for aquatic invasive species (AIS) on over 350 lakes and ponds across the 6+ million acre Adirondack region. Survey findings indicate that at least 70% of the region's surveyed lakes and ponds remain free of AIS, presenting an exciting opportunity in conservation at a scale rarely seen anywhere else in the country. In 2015, APIPP formalized an AIS regional response team approach to conduct additional early detection surveys and carry out rapid response management actions to any newly found pioneer infestations. To date this team has surveyed 76 prioritized lakes and ponds, only finding three to be newly invaded. A summary of strategies implemented, work accomplished, and lessons learned will be presented.

NOTES

The Interaction of Experimental Warming and Biotic Resistance to Invasion of Non-native Poeciliids in Replicated Pond Ecosystems

Quenton M. Tuckett[1], *Jeffrey E. Hill*[1]
[1] *University of Florida, Tropical Aquaculture Laboratory*

The potential negative effects of non-native species has increased interest in identifying those species which pose an elevated invasion risk before they become a problem. For the invasion of tropical fish into Florida, climate, especially cold winter water temperatures, has been considered a major barrier to invasion. Other studies have focused on identifying the importance of biotic resistance, including the influence of strongly-interacting predators such as Largemouth Bass (*Micropterus salmoides*) and aggressive competitors like the Eastern Mosquitofish (*Gambusia holbrooki*) in affecting invasion success. While these factors have often been examined singly, the potential for interactions between climate change and biotic resistance leaves many unknowns. We used a replicated pond experiment to examine the effects of Largemouth Bass and experimental warming on two common non-native poeciliids, Guppy (*Poecilia reticulata*) and Southern Platyfish (*Xiphophorus maculatus*). Ponds were also stocked with three native poeciliids, Eastern Mosquitofish, Least Killifish (*Heterandria formosa*), and Sailfin Molly (*Poecilia latipinna*), and ponds were harvested after the winter season. Native poeciliids exhibited no numerical response to the presence of bass, but non-native poeciliids exhibited much lower average size and survival. Somewhat unexpectedly, the native poeciliids exhibited a greater positive response to experimental warming than the non-native poeciliids, especially the aggressive Eastern Mosquitofish, which could alter the strength of biotic resistance. The interactive effects of bass and warming were always positive for native poeciliids, but always negative for the non-native poeciliids. Our results indicate invasion predictions under climate change scenarios must consider the response of native species, especially those strongly-interacting species which contribute to invasion resistance.

NOTES

Influence of Phylogenetic Community Structure on Introduced Fishes in the Southeast United States

Matthew Neilson[1], *Pam Fuller*[1]
[1]*US Geological Survey, Nonindigenous Aquatic Species Database*

A central goal of invasion ecology and management efforts for introduced species is to identify both the communities susceptible to introduction and the likelihood of success of a species' introduction within a given community. Ecological theory suggests multiple roles for the influence of phylogenetic relatedness and community structure on a community's invasion potential and success of introduced species, including a reduction in available niche space in diverse communities or successful invaders occupying unique niches. 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. Successful introduced species were significantly more closely related to communities than failed introductions at both the HUC6 and HUC8 level. Native community diversity likely provides some resistance to successful introduction, but phylogenetically related non-native species are likely to be successful within a community due to pre-adaptations promoting species' fitness.

NOTES

Sensitivity of European Native and Alien Freshwater Bivalve Species to Climate Related Environmental Factors

Frank Collas[1], *Tom Buijse*[2], *Jan Hendriks*[1], *Gerard van der Velde*[3,4,5], *Rob Leuven*[1,5]
[1]*Department of Environmental Science, Radboud University, Nijmegen*
[2]*Deltares, Department of Freshwater Ecology and Water Quality*
[3]*Department of Animal Ecology and Physiology, Radboud University, Nijmegen*
[4]*Naturalis Biodiversity Center*
[5]*Netherlands Centre of Expertise for Exotic Species*

While native freshwater bivalve species are declining, several alien bivalve species become invasive, thereby impacting ecosystem functioning and services. These biodiversity changes can be attributed to multiple human activities such as deliberate and unintentional species introductions, deterioration of water quality, hydro-morphological alterations and the overarching effect of global change. Therefore, a systematic assessment of the sensitivity of alien and native freshwater bivalve species nowadays occurring in European inland waters to environmental factors is urgent. The present study reviewed 493 relevant papers, resulting in 8405 data entries on presence-absence of native and alien bivalve species in relation to environmental factors that are affected by global change (i.e., water temperature, water depth, air exposure, oxygen availability and flow velocity). From these worldwide field data, minimum and maximum values measured in their habitat and water bodies were selected. In addition, data on laboratory derived tolerance ranges were collected. Subsequently, novel species sensitivity distributions (SSDs) were derived for each environmental factor using field based occurrence data and laboratory derived tolerance ranges of bivalve species. These SSDs can be used to determine the potentially not occurring fraction of regional or continental native and alien species pools in specific ecosystems or habitats. This makes the SSD approach useful for determining ecological risks and predicting effects of interventions on native and alien bivalve diversity. The derived SSDs also allow for the ranking of freshwater bivalve species sensitivity to these environmental stressors and the evaluation of management measures to optimize their biodiversity and ecosystem services.

NOTES

Association between the Ratio of Organic to Inorganic Nitrogen and Growth of the Invasive and Itchthyotoxic Golden Alga

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[1]*Department of Biological Sciences and Texas Cooperative Fish and Wildlife Research Unit, Texas Tech University*

[2]*Department of Natural Resources Management, Texas Tech University*

[3]*U.S. Geological Survey, Texas Cooperative Fish and Wildlife Research Unit and Departments of Natural Resources Management and Biological Sciences, Texas Tech University*

Golden alga (*Prymnesium parvum*) is an invasive, harmful bloom-producing microalga. In inland waters is typically found in brackish ecosystems. While nitrogen (N) is an essential general nutrient, the relative importance of the organic (N_O) and inorganic (N_I) fractions to golden alga growth is uncertain. N_I at relatively high concentrations is toxic to golden alga and a field study of the Colorado River (TX) reported seasonal declines in golden alga abundance as levels of N_I increased. Recently, a study of the Pecos River (TX and NM) reported that, in addition to a negative association with N_I, golden alga abundance is also positively associated with N_O. These laboratory and field observations have provided convincing evidence that N_I can negatively affect golden alga growth, but data for N_O are insufficient for proper evaluation. The objective of this study is to experimentally characterize the influence of N_O (urea) and N_I (sodium nitrate) on golden alga growth. Different molar ratios of N_O to N_I were tested for their effects on specific growth rate (day^{-1}) and maximum cell density (cells/ml) while keeping total N constant (880 µM) – 0%:100%, 25%:75%, 50%:50%, 75%:25% and 100%:0% (N_O:N_I). Cultures were inoculated at 100 cells/ml and other conditions were standard (5 psu, 22°C, 36 µM total phosphorous). Specific growth rate was not affected by changes in initial N_O:N_I ratio. Maximum cell densities, reached at days 21-24 of culture, however, gradually increased with increasing relative content of N_O up to 75%, followed by a precipitous decline at 100%. In conclusion, while golden alga can grow in cultures containing exclusively N_O or N_I, optimal growth occurs when both are present but N_O is the predominant fraction. These observations are consistent with field observations and provide context for a better understanding of the association between N and golden alga growth.

NOTES

Does Extreme Flooding Affect the Alien Macrophytic Assemblage: Insight from Recent Floods in Kashmir Himalaya, India

Ayaz Bashir[1], *Zafar A. Reshi*[1], *Manzoor A Shah*[1]
[1]*Department of Botany, University of Kashmir*

The state of Jammu and Kashmir in North India experienced one of the worst floods in the past 60 years, during the first week of September 2014. Flooding in river Jhelum inundated about 557 km^2 of the Kashmir Valley's geographical area. While the socio-economic impact of this flood has been well studies, ecological impact has not received any attention. It is in this context that we investigated the impact of flooding on alien macrophyte assemblages in lower basins of river Jehlum i.e., Wullar Lake and Dal Lake. The 60 areas rich in macrophytic infestations (30 in Dal Lake, 30 in Wullar Lake) were surveyed before and after floods. A total of 80 species of alien aquatic macrophytes were recorded prior to flood events (68 in the Dal Lake and 78 species in Wullar lake, respectively). After the floods only 68 species of alien aquatic macrophytes were recorded (59 in the Dal Lake and 65 species in Wullar Lake, respectively). The significant decline was reported after flood disturbance in the abundance patterns of some invasive species such as *Typha angustata, Ceratophyllum demersum, Hydrilla verticillata, Sparganium erectuum, Potamogeton sp.,Nymphea sp.,* and *Nymphoides peltatum*. In addition to this the most frequent invasive species among rooted floating type showed poor emergence rate after floods which signifies that water fluctuations may prove an effective tool in managing alien aquatic species.

NOTES

Serious Gaming to Derive Cost-effective Management Measures for the Invasive Alien Pumpkinseed Sunfish in Europe

Rob S.E.W. Leuven[1,4,*], *D. Hilbers*[2], *F.P.L. Collas*[1], *K.R. Koopman*[1], *H.H. van Kleef*[3,4], *H.M.J. Frencken*[5] *& W.L.M. Tamis*[6]
[1]*Radboud University, Institute of Water and Wetland Research, Department of Environmental Science*
[2]*Crossbill Guides Foundation*
[3]*Bargerveen Foundation*
[4]*Netherlands Centre of Expertise on Exotic Species*
[5]*Graduate School of Teaching (ICLON), Leiden University*
[6]*Institute of Environmental Sciences, Leiden University (CML)*

Development of scientific sound management strategies for invasive alien species (IAS) requires academic professionals that are well trained in deriving cost-effective measures. Management actions for IAS are often very costly and may also affect non-target species or deteriorate ecosystems. Extensive field or experimental based assessments of management strategies are also limited by ethical or practical considerations. Therefore, model based serious gaming is regarded as an appropriate alternative for real world approaches in educational and professional training settings. Moreover, it may also be used for arising public awareness or increasing stakeholder involvement. Recently, a novel ECOSIM-module on the spread and management of the alien pumpkinseed sunfish (*Lepomis gibbosus*) in fresh water lakes has been developed, allowing cost-effectivity analyses of various management measures in virtual reality. We present our experiences with the development and application of serious gaming within the context of IAS management. ECOSIM applications in academic education will be evaluated using a strengths, weaknesses, opportunities and treats analysis to outlook feasible options of serious gaming in training professionals on management of biological invasions.

NOTES

Man and Exotic Fish: Incorporating YouTube Videos and Citizen Science Data to Explore Spatial and Demographic Patterns in Urban Fishermen Attitude and Behavior with Respect to Exotic and Invasive Species

Jason M. Post[1], *Perry L. Carter*[1]
[1]*Department of Geosciences, Texas Tech University*

The City of Los Angeles plans to spend $1.3 billion in Los Angeles River revitalization. The river is human created landscape, the biota and hydrology of the river depend on, and serve human activity. Currently, the fish assemblages of the river are dominated by exotic fish species such as Common Carps (*Cyprinus carpio*), Tilapias (*Oreochromis spp.*) and aquarium releases. Prior studies suggest native fish species have been extirpated from the river. Despite legalization, fishing on the LA River is stigmatized and often done in secret. This project explores patterns in fishing behavior of LA River fishermen from a critical perspective, situating a complex human-environment interaction as a social justice issue. Language barriers, complex laws and restricted access are central to understanding how people interact with the surrounding aquatic landscape, namely exotic and invasive species. The data for this study combines internet videos of fishing along the LA River with citizen science acquired, iNaturalist fish observations. These are used to describe the experience of fishermen and understand how perceptions and treatment of exotic fish varies across demographics. Despite the health risks, both subsistence and recreational fishing occur, further influencing patterns in behaviors. The perspective offered in the videos reflects the fishermen's own reality. These videos and accounts reveal the LA River to be a diverse cultural landscape, a reflection of the surrounding city. Latino/Hispanic fishermen targeted Common Carp for food, using homemade baits. Expensive fly tackle was employed mostly by White fishermen, who targeted Bass for sport. White fishermen treated fishing on the LA River as lampoon, which often translated into unethical treatment of caught fish. A cultural difference is evident in perceptions of exotic fish as either "nature" or "pest". This has significant implications for management efforts geared towards multicultural urban systems.

NOTES

Can Environmental DNA (eDNA) be used for the Early Detection of *Pacifastacus leniusculus* in Scotland?

Kirsten J. Harper[1], *Michael J. Leaver*[1], *James F. Turnbull*[1], *Colin W. Bean*[2]
[1]*Institute of Aquaculture, University of Stirling*
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Environmental DNA (eDNA) is a rapid, non-invasive method for species detection and distribution using DNA deposited in the environment by the organism. eDNA has become a recognised and powerful tool for detecting invasive species in a broad range of ecosystems; however, most studies focus on fish and amphibians. We examined the use of eDNA as a tool for detecting the invasive American signal crayfish, *Pacifastacus leniusculus*, in Scotland. Species-specific probe and primers were designed for *P. leniusculus* and a robust quantitative PCR (qPCR) assay and DNA extraction protocol were developed. We investigated the detection capability for *P. leniusculus* from water samples in a controlled laboratory experiment and determined whether crayfish density (low = 17 or high = 50 crayfish m^2) or length of time in tanks (samples taken at 1, 3 and 7 days) influenced DNA detectability. Additionally, the persistence of DNA was investigated after *P. leniusculus* removal (samples taken at 1, 3 and 7 days post removal). *P. leniusculus* DNA was consistently detected during the entire 7 day period independent of density. However, high density tanks yielded a stronger positive value. After removal of *P. leniusculus*, there was a rapid and continuous decrease in the detectability of DNA, influenced by density. *P. leniusculus* DNA could only be detected in high density tanks by the end of the 7 day period, while DNA was no longer detectable in low density tanks after 72 hours. Preliminary field experiments sampled water from three sites, two with known *P. leniusculus* populations and one where *P. leniusculus* are known to be absent. Despite all sites returning negative results, the *P. leniusculus* eDNA assay was successful under laboratory conditions and with refinement of sampling methodology, the assay will function in the field. Therefore, eDNA represents a promising technique to detect and monitor invasive *P. leniusculus*.

NOTES

How Do We Identify High-risk Genotypes for Adaptive Management of Eurasian and Hybrid Watermilfoil?

Ryan A. Thum[1]
[1]*Montana State University*

Genetic variation has not historically been a focus of traditional aquatic plant management. There are few published studies of molecular or heritable phenotypic variation for widely managed aquatic plant species in the United States. Yet, the few studies that have been published reveal that managed aquatic plant taxa can exhibit cryptic taxonomic variation and heritable phenotypic variation, both of which can be relevant to management issues such as potential for growth, spread, impact, and control. Here, I will present data on genetic variation in the widely distributed and managed invasive aquatic plant, Eurasian watermilfoil (*Myriophyllum spicatum* L.). I will show that 1) what is considered Eurasian watermilfoil *sensu lato* by aquatic plant managers is actually a cryptic complex of at least two distinct biotypes of pure Eurasian watermilfoil and numerous genotypes of hybrids with native northern watermilfoil (*Myriophyllum sibiricum* Komarov). 2) hybrid watermilfoil genotypes can exhibit different growth and herbicide response properties to herbicides differently than pure Eurasian watermilfoil, and 3) that the genetic composition of watermilfoil populations can change over time. The synthesis of the above indicates that problematic genotypes that genetic variation can impact management outcomes among lakes, or within the same lake over time. A critical question therefore is, "how do we identify high-risk genotypes in adaptive management programs?" I will present a genetic method to identify high-risk genotypes.

NOTES

Environmental DNA (eDNA) and Environmental RNA (eRNA) Markers for Invasive Species Detection

Joshua Finn[1], *Margaret Hunter*[2], *Daniel Heath*[1], *Hugh MacIsaac*[1]
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Presence of invasive species can be detected by use of environmental DNA (eDNA) in water samples. However, eDNA can be detected weeks after the species has departed or has been removed from the location and can be transported through the movement of nets, predators, and deceased animals. There is therefore uncertainty about when or if the species was actually present, which can hinder efforts to locate and manage invasive species. RNA may provide a smaller time window of detection than DNA owing to its much quicker degradation, thus positive detection using environmental RNA (eRNA) indicates more recent presence of the target species in the sampling area. Detection of eRNA would suggest that a live animal traveled through the area, and may provide estimates of the maximum distance traveled from the sampling location. To determine the viability of eRNA as a tool for species detection, we compared eDNA and eRNA detection using markers developed for grass carp (*Ctenopharyngodon idella*). We explored the utility of eRNA by testing eRNA detection through time and as a function of grass carp density. Water samples for eRNA and eDNA detection were taken throughout experiments and for a one month period following removal of grass carp. Successful detection of environmental eRNA from grass carp could lead to expanded use of eRNA markers for other species and in turn help to improve temporal and spatial information on targeted invasive species. In combination with eDNA markers, the potential use of eRNA markers could improve decision making and management of invasive species by providing more specific information on the location of targeted invaders.

NOTES

Examining Zooplankton Patchiness Inside Ship Ballast Tanks to Improve Estimates of Average Abundance for Compliance Monitoring

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Zooplankton populations are spatially heterogeneous in nature and inside ship ballast tanks. Sampling methods should take heterogeneity into account, particularly when estimating quantitative variables such as abundance. It is particularly important to generate unbiased estimates of zooplankton abundance (concentration) in ballast tanks when assessing compliance with recently ratified international ballast water discharge standards. We measured spatial variability within a ballast tank across five voyages using three sampling methodologies. In-tank pump samples were collected at fixed depths within the vertical part of the ballast tank (side tank). Vertical net-haul samples were collected from the upper accessible portion of the tank as a depth-integrated and historically-relevant methodology. In-line, time-integrated samples were collected during ballast discharge by an isokinetic sample probe installed on the ship's ballast water piping, likely representing the double bottom part of the ballast tank. The bias and precision associated with each sampling method was evaluated in reference to the estimated average abundance of the entire ballast tank, which was modelled from the data collected by all methods. In-tank pump samples provided robust evidence for vertical stratification of zooplankton in the ballast side tank. A weak trend was observed for in-line discharge samples across time/volume discharged. In-line discharge samples provided the least biased, and most precise, estimate of average tank abundance, particularly when collected around the time frame of 50% of the tank volume being discharged, or at initial discharge. Net-haul samples showed low bias on average, but had the lowest precision. Results were surprisingly consistent across voyages despite differences in ballast water source, season, and age. Our results can be used to guide enforcement officers on methods and timing of sample collection for the enforcement of Regulation D-2 under the International Ballast Water Management Convention.

NOTES

The Efficacy and Practicability of Combining Ballast Water Exchange with Treatment: Results of Shipboard Trials

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In the United States, at present, both the U.S. Coast Guard (USCG) and Environmental Protection Agency (EPA) are responsible for regulating ballast water discharges, and they have promulgated an identical standard for the allowable density of living organisms in discharged ballast water. To provide additional protection to the North American Great Lakes, the EPA Vessel General Permit (VGP) includes provisions for vessels entering the Great Lakes through the St. Lawrence Seaway System if they have (1) operated outside the Exclusive Economic Zone (EEZ) and >200 nm from any shore, and (2) taken on ballast water with a salinity of <18 ppt within the previous 30 days. If both of these qualifications are met, once a vessel is required to meet the numeric discharge standard—likely by treating the ballast water with a ballast water management system (BWMS)—it must also conduct "ballast water exchange" or "saltwater flushing". Here, this practice is defined as an exchange in the mid ocean, conducted either by emptying and refilling tanks or by overflowing tanks with a volume of water equivalent to three times the volume of the tanks.

This work is investigating the efficacy and practicability of combining exchange with ballast water treatment. Central to this effort are shipboard experiments aboard a commercial vessel to compare water that has been treated with a BWMS to water that has undergone exchange plus treatment. The BWMS installed aboard the ship combines filtration and electrolytic chlorine generation to treat ballast water; ballast water discharges are sampled using a shipboard filter skid, and they are analyzed as prescribed by the US Environmental Technology Verification (ETV) Generic Protocol for the Verification of Ballast Water Treatment Technology. The results of shipboard work (from trials that began in October 2016) will be discussed.

NOTES

Effect of the Temperature on Chlorine as Ballast Water Treatment to Eliminate Freshwater Phytoplankton Populations: A Bench scale Test

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Following the recent ratification of the Ballast Water Convention, compliance assessments will be needed to verify if ballast water treatment systems can protect aquatic ecosystems, minimizing the risk of new invasive species introductions. This study investigates the efficacy of chlorine as a biocide for ballast water in reducing natural freshwater phytoplankton organisms under extreme temperature conditions. Samples were collected from Hamilton Harbour during winter and summer seasons, acclimated during 24 hours in the laboratory, under in situ environmental conditions, ranging from 2 to 22°C, in the dark. Water was exposed to seven chlorine treatments (from 0.02 to 5.0 ppm), in addition to a control (0.0 ppm). Samples were then mixed and split into borosilicate tubes whereby phytoplankton densities (via calibrated Turner fluorometer and Hach Pulse Amplitude Modulation (PAM) pocket fluorometer) and free chlorine concentrations were measured before, immediately after, and up to 48 hours following treatment. After 8 hours, free chlorine neared 0.0 ppm irrespective of initial chlorine concentration or temperature regime. After 4-8 hours of treatment at low concentrations (less than 0.2 ppm), phytoplankton densities were reduced more than 50% without resurgence of cells. Similar reduction was recorded at high chlorine concentrations, immediately after exposure. Survival was higher in winter, although it decreases with increased exposure time, survival also decreased for organisms at high temperatures in the winter. Results indicate that chlorine may have an immediate effect eliminating phytoplankton organisms irrespective of the temperature, but more large-scale tests are needed to confirm effectiveness of chlorine as a biocide for treating ballast water.

NOTES

Quantifying the Extent of Niche Areas in the Global Fleet of Commercial Ships: The Potential for "Super-Hot Spots" of Biofouling

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Niche areas of ships, such as thruster tunnels, sea chests, and propellers, are often hot spots for the accumulation of biofouling organisms, and in turn are a potential source of aquatic invasive species. Nonetheless, the relative importance of different niche areas is poorly resolved, in terms of both the total surface area and the associated biota (i.e., the species of organisms and their abundances). To address this information gap, methods were developed to estimate the total wetted surface area (WSA) and the extent of various niche areas in the global fleet of 120,252 commercial ships that were active between 1999-2013. In this manner, the potential for niche areas to transport organisms could be assessed relative to that of the fleet's WSA. From these analyses, the total WSA and extent of niche areas was estimated to be 325×10^6 and $32{,}996 \times 10^3$ m^2, respectively. Here, the extent of niche areas represented approximately 10% of the total WSA available for colonization by biota. Considering the *sum of all niche areas* relative to the total WSA, it was highest for passenger vessels (27%), followed by tugs (25%), and fishing vessels (21%), with niche areas representing a small portion of the WSA for bulk carriers and tankers (7-8%). Examining the *different types of niche areas*, thruster tunnels had the greatest total extent ($10{,}189 \times 10^3$ m^2), representing a disproportionately large contribution (>50%) of the total niche area for passenger vessels and tugs compared to other vessel types. This result, combined with the use and cleaning of thrusters, may render thruster tunnels "super-hot spots" of biofouling. The uneven distribution and extent of niche areas across vessels has implications for the transfer of organisms as well as management strategies to reduce invasions associated with the surfaces of ships.

NOTES

The Strategic Vision of the Great Lakes Fishery Commission: A Mid-Decadal Review

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The Great Lakes Fishery Commission was established in 1955 by the Convention on Great Lakes Fisheries between Canada and the United States. The Convention outlines three major responsibilities for the Commission: coordinate fisheries research, control the invasive sea lamprey, and facilitate cooperative fishery management among state, provincial, tribal, and federal management agencies in the Great Lakes basin. The operations of the Commission are guided by ten-year (decadal) strategic visions, the most recent of which is the *Strategic Vision of the Great Lakes Fishery Commission 2011-2020*, which identifies key issues of concern, establishes objectives and strategies to address these issues, and provides associated rationales for doing so. The vision presents the Commission's major policy objectives as pillars, one for each area of responsibility: healthy ecosystems/sustainable fisheries, sea lamprey control, and alliances/partnerships. Each pillar is supported by a strategic formulation of what is to be accomplished in the broadest sense, and each, in turn, is operationally defined by one or more goals to be effected by one or more strategies, all having specified outcomes.

In 2016, the Commission conducted a mid-decadal review to allow for mid-course corrections in the second half of the decade, but also, in a larger sense, to ensure that progress is consistent with the aspirations of those who framed the Convention. This report illuminates the interconnectedness of the Commission's responsibilities (pillars). For example, effective sea lamprey control is critical for achieving healthy ecosystems and sustainable fisheries and is also reliant on strong alliances and partnerships with governments and stakeholders. Success, or a lack thereof, in any one of these pillars can impact the others. With a focus on sea lamprey control, we describe key linkages among pillars, identify progress to date, and discuss how these results can inform future efforts, influence resource allocation, and guide expectations.

NOTES

Funding for Invasive Species: A Review of Progress, Gaps, and Opportunities

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The Great Lakes Restoration Initiative (GLRI) is an incredibly valuable source of funding for invasive species work in the Great Lakes region. Since its inception in 2010, the GLRI has provided over $480 million in funding for research, education and outreach, and on the ground fieldwork dedicated to preventing and managing invasive species. The results of these individual projects are reported to the funding agencies and generally available to the public, but are seldom summarized or analyzed to show progress on Great Lakes regional invasive species priorities. The Great Lakes Panel on Aquatic Nuisance Species (GLP) is working with the Great Lakes Commission to conduct a review of invasive species funding since the implementation of GLRI in order to compare progress to GLP identified priorities, identify potential gaps, and define impediments and solutions to addressing remaining priority needs. This presentation will discuss the preliminary findings of this effort, focusing on distribution of funding by species and geographic locations and categorizing projects based on the invasion curve. Particular attention will be paid to the development of the framework and metrics for conducting the review. This effort utilizes GLRI data on invasive species funded work from FY 2010-FY 2015.

NOTES

Regulating Organisms-in-Trade through a Permitted Species List: the Good, the Bad, and the Ugly

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Invasive species directly contribute to the decline and disruption of ecosystems across the globe. Releases of organisms-in-trade by aquarists, gardeners, pond owners, pet owners and anglers have been documented as a pathway for invasive species introductions. In the United States, most state governments administer prohibited species lists with the purpose of eliminating or controlling possession thereby preventing new introductions of invasive species. In these regulatory circumstances, industry, private individuals, and law enforcement focus on one list of prohibited species when evaluating a purchase or considering surveillance or enforcement. However, new species can enter the marketplace daily and some jurisdictions require all species in trade to be recognized and listed. In 2015, Michigan Public Act 537 of 2014 formalized a recommendation to require the Michigan Department of Natural Resources and the Michigan Department of Agriculture and Rural Development to consult with industry and develop a Permitted Species List. In order to satisfy this requirement, Michigan officials consulted with affected industries to determine which aquatic species were, as live organisms, in commercial trade in Michigan. Initial consultation provided a list of species-in-trade in Michigan in the tens of thousands with legislation requiring risk assessments on all of the species to determine their assignment on one of three lists: prohibited, restricted, or permitted. The process to develop a Permitted Species List for Michigan presents a unique challenge to regulators and industry, alike, begging the question of how strict regulations should be to prevent AIS introductions through organisms-in-trade industries.

NOTES

Integrated Management Approach of Aquatic Invasive Species for Québec Province, Canada

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In the past few years, the arrival of several aquatic invasive species (AIS) in the province or near its borders has compelled the Québec government to adapt its strategy against them. The integrated management approach of AIS for Québec province encompasses several axis, including new regulatory guidelines as well as, prevention, early detection and risk modeling actions. This conference is an opportunity to share the Québec government positions on these issues and to list gathered investments.

The use and trade of bait fish are recognized as vectors of introduction and spread of AIS and pathogenic organisms. In order to fully fulfill its roles towards the conservation and development of wildlife resources, the government has tightened the regulation surrounding the use of bait fish, a approach to increase ecosystems protection against AIS. Since April 1, 2017, the use of live bait fish is now prohibited during all year throughout Québec and the prohibition of the use of dead bait fish in summer is now effective. A pilot project for boat cleaning stations as a way to improve AIS fight infrastructures are another example of prevention actions. Early detection actions include eDNA sampling campaign for Asian carps and other AIS (as the spiny water flea), targeted experimental fishing and partnerships with voluntary commercial fishermen.

One important step in the fight against AIS in Québec province was the implementation of the Québec Asian Carp Program in May 2016 by the Ministry of Forests, Wildlife and Parks in accordance with the Québec Maritime Strategy Action Plan. This program involves, in other, an early detection monitoring and a rapid response action plans as well as the development of risk assessments (e.g. identification of existing barriers to Asian carp upstream movements in the St. Lawrence tributaries). Actions comprised in this program for 2017 will be discussed.

NOTES

Asian Carps Enforcement Activities: Approaches across Great Lakes Jurisdictions

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In the Laurentian Great Lakes region, authority to manage the fishery, valued at more than $7 billion annually, is shared among eight states, the Province of Ontario, and Native American tribes. Fishery management—including cooperative law enforcement—is facilitated through a process identified in *A Joint Strategic Plan for Management of Great Lakes Fisheries*. The plan calls for the Great Lakes Law Enforcement Committee to serve as a conduit for the transfer of information between fisheries managers and law enforcement agencies and provide recommendations to senior-level fishery managers about the development and implementation of management policies, cooperative procedures, and enforceable regulations. Experience in the Great Lakes basin shows that successful fisheries management requires involvement of enforcement throughout the management process to ensure that management objectives, regulations, and the expected role of enforcement are clearly defined and commensurate. Efforts to prevent the introduction of Asian carp over the past two decades have strengthened this relationship and illustrate the benefits of this collaborative approach to combatting invasive species.

This presentation provides an overview of the approaches taken across Great Lakes jurisdictions to monitor adherence and promote compliance with applicable laws about Asian carps. The regulatory frameworks will be outlined with a focus on challenges encountered in determining if people are following the rules and the solutions implemented to address them. Selected outcomes from enforcement activities along the compliance continuum will be highlighted. Features of this talk include insights on monitoring programs in live food fish markets, description of working arrangements with other agencies to detect and prevent entry of live Asian carps into various jurisdictions, and a summary of statistics on convictions relating to Asian carps and penalties/seizures associated with them.

NOTES

Underwater Video is an Effective Tool to Reveal Dreissena Spatial Distribution

Alexander Karatayev[1], *Lyubov Burlakova*[1], *Knut Mehler*[1], *Vadim Karatayev*[2], *Thomas Nalepa*[3], *Ashley Elgin*[4] *and Elizabeth Hinchey*[5]

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Almost every study of dreissenids (zebra and quagga mussels) in the Great Lakes has relied on bottom grabs to characterize mussel presence and biomass, but until now, the scale at which mussel cover of the lake bed varies has largely been unknown. We developed a novel method, which analyses video footage recorded from a GoPro camera on a towed benthic sled, to estimate dreissenid cover and biomass over relatively large areas of the lake bed compared to using traditional sampling methods. Across 43 sites sampled in Lake Michigan in 2015, we compared quagga mussel cover and biomass estimates based on three replicate PONAR grabs vs. 500 m-long video transects. Overall, PONAR samples yielded very high variability in estimates of quagga mussel presence at a given site, especially at sites with low to moderate mussel cover, because mussel cover heterogeneity typically occurs at spatial scales much larger than the sample size collected by replicate bottom grabs. We hypothesize that the physical and biological drivers of dreissenid distribution follow the intermediate disturbance hypothesis. In the shallow littoral zone, quagga mussels have an abundant food supply but are limited by wave activity and therefore can only form large aggregations on hard substrates with almost no mussels found on soft and unconsolidated sediments, resulting in high heterogeneity in their distribution. In contrast, in the deep stable profundal zone with no wave action, mussels are food limited and will form small, evenly spaced aggregations on silty substrates, which is likely driven by competition for food and results in low heterogeneity in distribution. The highest *Dreissena* densities will therefore be observed in the intermediate depth zone, where particle deposition is highest and wave activity does not reach the bottom.

NOTES

Using a High-Throughput Sequencing Assay to Assess Dreissenid Mussel Communities

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The Great Lakes are one of the most invaded aquatic habitats, numbering 186 invasive species, including the notorious dreissenid mussels (zebra and quagga). Detecting invasive species prior to establishment and at all life-history stages greatly increases chances of eradication and control. Environmental (e)DNA (*i.e.,* genetic material shed from living organisms via urine, mucus, tissues, filter feeding, *etc.*) is a powerful technique to assess the presence/absence of invasive and/or rare species, which is especially effective at low population levels compared to traditional sampling. However, most eDNA assays just reveal single species presence/absence, lacking information about relative abundances and genetic diversity. Here a rapid high-resolution diagnostic genetic assay was tested to evaluate the relative proportions of dreissenid taxa within North American invasive communities. This assay utilizes eDNA or biological samples (*e.g.,* planktonic larval tows) that are found within the environment. Primers were developed and optimized to amplify two diagnostic regions of the COI mitochondrial DNA gene that reveal haplotypic information for both species. Accuracy of the assays was evaluated in the laboratory with, i) Illumina sequencing libraries of a series of mock communities containing known, varying concentrations of tissue DNA extractions from three quagga mussel haplotypes and five zebra mussel haplotypes, and ii) three lab aquaria experiments containing varying proportions of mixed species/haplotype composition. Results showed that observed relative abundances of aligned sequence outputs were highly correlated with expected relative abundances, confirming the assay's performance. The assay was then tested with iii) water and plankton samples from the field, in reference to traditional sampling. Findings are projected to be useful in light of addressing foundational ecological and population genetic questions, as well as helping to inform management agencies about the populations of invasive taxa. This approach can be used across other taxa of interest to reveal their composition, diversity, and relative abundances.

NOTES

Integrating Remote Sensing and Underwater Imagery to Enhance Invasive *Dreissena* Distribution Assessment in Large Rivers

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Dreissena spp. are aggressive invaders, and once invaded they become the most dominant benthic invertebrates in many waterbodies worldwide. Due to their tremendous ecological and socio-economic damages information about their spatial distribution is a prerequisite for better understanding of their impacts on the ecosystem scale. However, the accurate assessment of their spatial distribution in large rivers is difficult using traditional sampling techniques such as Ponar grabs or SCUBA diving. The aim of this study was to use sonar technologies and underwater imagery (videos, still images) in tandem with traditional Ponar sampling to predict *Dreissena* presence and produce a habitat suitability map to enhance our understanding of its spatial distribution in the lower Niagara River, New York, USA. Geo-referenced maps of environmental variables were generated using three sonar technologies: side scan sonar, multibeam sonar, and an Acoustic Doppler Current Profiler. *Dreissena* presence/absence was determined at 102 sites along a 10 km stretch by using Ponar grabs supplemented by an underwater imagery. Substrate and near-bottom flow and were the most important variables affecting *Dreissena* distribution. Habitats with coarse substrate and near-bottom flow of 0.6-0.8 m/s were predicted to be most often occupied. The habitat suitability model indicates that almost 90% of the stream bed in the river can be considered highly- or moderately-suitable habitat. Our results demonstrate that supplementing traditional sampling with sonar technologies and underwater imagery can greatly improve *Dreissena* distribution assessment. Analysis of Niagara River benthos also showed that *Dreissena* has now become an important factor affecting the abundance of major benthic groups indicating that *Dreissena* should be included in species distribution models besides environmental variables.

NOTES

Feasibility and efficacy of three methods of zebra mussel larvae detection

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Rapid action against invasive species early in the invasion process can increase the likelihood of successful control or eradication. This is more desirable than the effort required to manage an established population. Effective detection of invasive species during early phase of invasion is key to initialization of a response against them. Choosing the best method of detection for your target species is important. Zebra mussels, *Dreissena polymorpha*, introduced to North America in late 1980's economic and ecological harm as a biofouling species. Zebra mussels can be detected via the presence of their larvae in the water in the summer. There are several methods to detect veligers. Here we explore the feasibility of using conventional, automated and molecular methods in the analysis of veliger samples. The use of custom-made crossed-polarized lenses on stereomicroscope is the conventional method of detection. This tried and tested method is the most time consuming and labor-intensive but provides the most reliable results. This method of detection has successfully detected veligers in 92.2% of the plankton samples. The flow cytometer and microscope (flowCAM) is designed for rapid imaging of particles and saves time when analyzing plankton subsamples. We have positive detection of veligers in 30.9% of the same plankton samples. The fastest method was PCR analysis of plankton samples. This can be conducted in any molecular lab and can be a fast test for presence of target species. We discuss labor, time, pros and cons involved in each method of detection to help determine which method best suits the needs of the researcher or invasive management team.

NOTES

Multi-Jurisdictional Collaborations and Structured Approach for Grass Carp Control in Lake Erie

Seth J. Herbst[1], *Nicholas D. Popoff*[1], *Tammy Newcomb*[1], *Jim Francis*[1], *Rich Carter*[2], *John Navarro*[2], *Michael Jones*[3], *Kelly Robinson*[3], *Travis O. Brenden*[3], *Andrew Mahon*[4], *Kevin Pangle*[4], *and Jeff Tyson*[5]

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Grass carp have been sporadically captured in the four lower Laurentian Great Lakes dating back to the early 1980s. More recently, grass carp captures have become more frequent in the western basin of Lake Erie, which has increased concerns of population expansion among managers. Lake Erie captures were initially thought to have originated from either accidental releases or immigration of sterile individuals stocked for macrophyte control in adjacent waters. These concerns led to the formation of a collaborative grass carp workgroup between the Michigan and Ohio Department of Natural Resources. Since the workgroup formed they invested in research projects to address key knowledge gaps that limited the effectiveness of control actions, which have also improved the overall understanding of the status of the Lake Erie grass carp population. These recent studies refuted the original assumption that most captures were sterile. In fact, the majority (~86%) of Lake Erie grass carp captured and analyzed for ploidy in recent years have been fertile. Moreover, successful spawning and reproduction has been documented in the Sandusky River and further evidence indicates that the natal origin among feral captures is not linked to one tributary. The workgroup, armed with this new information, completed a structured decision making (SDM) process to help guide management decisions related to controlling these invasive fish in Lake Erie. During the SDM process the group invited regional managers and subject experts to help define the problem, determine objectives, brainstorm control actions related to achieving objectives, identify key uncertainties associated with performing those management actions, evaluate the effectiveness of control alternatives, and managers decided upon the potential strategies for grass carp control. Additionally, the group reflected upon policy options for preventing future contributions and associated risks of fertile fish to Lake Erie. The agencies' incorporation of current Great Lakes governance processes, a solid commitment to collaboration and regular dialogue is key to identifying appropriate strategies to reduce future risks presented by grass carp in Lake Erie.

NOTES

Integrated Management of Waterhyacinth (*Eichhornia crassipes*)

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Waterhyacinth is one of the two most intensively managed floating aquatic weed in Florida. More than $5.6 million in state and federal funds were spent in Florida in FY 2014-2015 to manage waterhyacinth and waterlettuce in public waters, so even a small reduction in herbicide use for waterhyacinth management could represent significant savings. Several biocontrol agents are utilized for waterhyacinth management; the newest is *Megamelus scutellaris,* which was released in 2010 and is currently being released on waterhyacinth throughout Florida. In these experiments we evaluated waterhyacinth growth after treatment with different rates of 2,4-D (the most common herbicide employed for waterhyacinth management) applied in conjunction with biological control agents. We used a 3 x 2 factorial with 3 rates of 2,4-D (control, low rate/2qpa, operational rate/4qpa) and 2 levels of biocontrol (no insects, unrestricted attack by *Neochetina* sp. weevils and *M. scutellaris*). Plants were cultured for 3 months after 2,4-D treatments, then rated, harvested and analyzed to evaluate combined and individual effects of insect biocontrol and herbicide rates on waterhyacinth growth. These experiments revealed that herbicide-treated plants without biocontrol insects recovered from 2,4-D damage, while herbicide-treated plants with biocontrol insects did not, and a second run of these experiments reinforced these findings. These results suggest that it may be possible to reduce 2,4-D applications for waterhyacinth management if biocontrol insects are introduced to or present in the treatment area.

NOTES

Water Chestnut (*Trapa natans*) Removal and Monitoring in the Erie Canal, Tonawanda, New York, USA

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Water chestnut (*Trapa natans*), an invasive plant in New York State, was first detected in the Ellicott Creek Park waters of the Erie Canal in Tonawanda, New York in 2008. It quickly became a 6-acre monoculture of plants within one year, with the potential to negatively impact native fish and plant species through changes in water chemistry and competition. The U.S. Fish and Wildlife Service (Service) immediately initiated and led a multi-partner response effort that was unique in several ways, illustrating the power of rapid action, partnerships, community outreach, and citizen involvement. The partners were: the Service, Buffalo Niagara Riverkeeper, Erie County Parks, Recreation and Forestry, Town of Amherst, and Niagara County Soil and Water Conservation District. The response included coordinated physical removal of plants using both mechanical harvesting and hand pulling as well as an immediate outreach component spanning multiple jurisdictions to educate the public and increase awareness. Continued public outreach has created a strong public investment in sustaining the success of the project. This informal citizen science effort expands upon the resources of the Service. While monitoring and control efforts continue today, in 2016 only 13 plants were found in the monitoring area from the Niagara River to Pendleton, New York, a 99% reduction from peak infestation years when mechanical harvesting removed over 500m^3 of plant material in addition to the over 3,000 plants removed by hand. The proximity of the waterway to the Niagara River, high recreational use by boaters, and the potential for water chestnut seeds to be viable for years makes this a project that will require continued vigilance in the years to come. By maintaining existing and building new partnerships and continuing to leverage their individual talents and resources, full eradication of water chestnut from this part of western New York seems increasingly attainable.

NOTES

Adaptive Management of Multi-resistant Hydrilla in a Central Florida Chain of Lakes

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The City of Winter Park, has been actively managing *Hydrilla verticillata* (hydrilla) in its public lakes for 60+ years. Historically, during the 1960s-80s, aquatic plant management efforts focused on a combination of mechanical removal and the contact herbicide endothall (Hydout™). With the introduction of fluridone herbicide in the 1990s, whole lake treatments performed every 3-8 years were adequately providing selective hydrilla control throughout the city until 2005 when resistance was confirmed. In just two short years, the cost of chemically controlling hydrilla had more than tripled, high rates of fluridone were phytotoxic to native plant communities, and managers had to re-implement spot-treatments with endothall (Aquathol™) to maximize efficacy and minimize non-target plant damage. Endothall-tolerant hydrilla was first documented on Lakes Maitland and Minnehaha in the winter of 2009/10, and marked the first record of an aquatic plant demonstrating tolerance to more than one herbicide mode of action. In response, innovative application techniques and unique treatment strategies have been implemented in an effort to keep the plant under control and better understand hydrilla maintenance control and regrowth on these urban lakes. Specifically, low rates of sterile grass carp are being used in an effort to target hydrilla while maintaining native SAV. In addition to herbicide tolerance, the Winter Park Chain of Lakes presents some challenging considerations for hydrilla managers due to its proximity to residential communities and luxury real estate properties and challenging hydrologic flow within the watershed. With a thriving recreational fishery and ecotourism base on the Chain of Lakes, preserving SAV habitat and water quality is critical, as is preventing the establishment and further spread of a herbicide-tolerant strain of hydrilla. Recent data illustrate the importance of herbicide rotation, combination, and altering products with differing modes of action in order to properly manage and control hydrilla abundance and distribution.

NOTES

Senegal Tea (*Gymnocoronis spilanthoides*) Aquatic Weed Risk Assessment and Management

Paul Champion[1]

[1] *National Institute of Water and Atmospheric Research (NIWA)*

Senegal tea (*Gymnocoronis spilanthoides* (D.Don ex Hook. & Arn.) DC.)) is a perennial emergent aquatic or wetland herb, which can also grow in a submerged form. The native range of the species is South America, mostly centred on Uruguay and Paraguay. It has a relatively recent history of naturalization outside of its native range, becoming problematic in several eastern Asian and Oceanian countries, such as Australia, Japan and New Zealand over the past few decades. The most recent naturalization in Italy, was reported in 2016. As with many aquatic plant pests, this species is traded as an aquarium and ornamental pond plant. This presentation discusses the invasion history of *G. spilanthoides*, summarizes various pest risk assessments undertaken for this species and outlines management actions for incursion response.

NOTES

Endothall Behavior in Eurasian watermilfoil (*Myriophyllum spicatum*) and Hydrilla (*Hydrilla verticillata*)

Mirella F. Ortiz[1], *Scott J. Nissen*[1], *Cody J. Gray*[2]
[1]*Colorado State University*
[2]*United Phosphorous, Inc.*

Endothall was first labeled for aquatic weed control in 1960, and the endothall label was expanded to include aquatic weed control in flowing water in 2010. Endothall is generally considered a contact herbicide; however, many field observations suggest that it could have systemic activity. The objective of this experiment was to determine maximum absorption, absorption rate, translocation and desorption of endothall in Eurasian watermilfoil (EWM) and two hydrilla biotypes. For herbicide absorption plants of each species with developed roots and 10 cm of shoot growth were transferred to test tubes sealed at the top with eicosane wax to isolate the root system from the water column. Mesocosms were treated with 3 µg mL^{-1} endothall plus ^{14}C-endothall. Plants were exposed to the herbicide over a time course of 192 hours. At predetermined time points three plants of each species were harvested, divided into shoot and root tissue, dried at 60C for 48 h, and oxidized. Radioactivity was determined by liquid scintillation spectroscopy. Herbicide desorption was evaluated over a time course of 72 hours using the same treatments as described before, but with higher concentration of radiolabeled endothall and 10 cm apical meristems shoots of each species. Hydrilla showed a linear increase in herbicide absorption, while herbicide absorption in EWM best fit a hyperbolic function. Translocation to EWM roots was limited, reaching a maximum translocation of 11% of total absorbed radioactivity. The distribution of radioactivity was 72% shoot:28% root for monoecious hydrilla and 75% shoot:25% root for dioecious hydrilla. Herbicide desorption was less than 30% for all the three species. These data provide strong evidence that endothall is systemic.

NOTES

Update on the Status of the IMO Ballast Water Convention

Christopher J. Wiley[1]
[1] *IMO Ballast Water Working Group*

The International Ballast Water Convention will come into force Sept 8 2017. Finland put it over the top on Sept 8 2016, closely followed by Panama. Current ratification status is 53 countries representing 53.28% of the worlds GRT. As such, the IMO, ship owners and administrations are all under pressure to ensure things are in place before the Convention comes into force.

It is imperative that the remaining guidance be finalized at the Marine Environmental Protection Committee at IMO before the Convention comes into force. For ship owners, it will be a key year for deciding on what Ballast Water technologies they will fit to their fleet, how they will finance the capital costs and where they will be fitted.(both physically onboard and in what shipyard). For administrations, training, and logistics will be required for enforcement actives that will be implemented.

The certainly appear to be sufficient technologies available for all ships and all types of ships that the Convention will apply to. Port State Control Guidelines are in place as are agreements to facilitate entry into force such as a two to three year trial period to allow the sampling and analysis protocols for D-2 compliance to mature. Additionally the intent to not penalize early movers has been agreed to. The revised Guidelines for Type Approval of Ballast Water Management Systems (G8) were approved at MEPC 70 in October

Since 2004, the Ballast Water Group at IMO has produced an unprecedented amount of Guidance to be used for uniform implementation of the Convention. This Guidance has ensured that the ballast water technologies that have been developed to date, not only meet the biological standards required by the Convention but have been tested and approved such that they are safe for the ships, the crews and the environment .

When the BWM Convention does come into force the reality is that the majority of ships will conduct ballast exchange. Over the next few years thereafter ship will be required to fit ballast water treatment technology to reduce the threat to the environment. Once that happens it is hope that science can show that the tremendous amount of work undertaken at IMO on this issue has paid off in showing that the shipping industry is an active part of the solution to the problem.

NOTES

Establishing Research Priorities for Aquatic Invasive Species

Nicholas Phelps[1,2], *Becca Nash*[1], *Susan Galatowitsch*[1,2]
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[2]*Department of Fisheries, Wildlife, and Conservation Biology, University of Minnesota*

The most effective and efficient statewide response to AIS is to have research-based solutions developed prior to arrival of a species and to have solutions that address multiple species at the same time. Accomplishing both of these aims requires prioritizing research that may seem less urgent relative to specific species that are already spreading. The Minnesota Aquatic Invasive Species Research Center (MAISRC) attempts to balance these demands through its research needs assessment process. With input from the public, a technical team of university scientists and agency AIS specialists review the status and trends of AIS already in Minnesota as well as AIS spreading elsewhere in North America that are likely to find suitable habitat in the state. For those priority species, online surveys and outreach presentations are used to engage diverse stakeholders, from the local to federal levels, to identify gaps in knowledge and research needs. This information is used by research needs assessment teams, which are organized into four broad organismal groups (harmful microbes, fish, invertebrates, plants). These teams identify critical uncertainties for all of the high priority species, regardless of whether they have arrived or are already established and spreading. Because this assessment process is inherently species-specific, updates to the process have been made to capture broader research needs that cut across natural and social systems to identify critical interdisciplinary gaps. This process will continue to evolve based on emerging threats, management needs, and research progress.

NOTES

Brief History of the Aquatic Invasive Species Program for the Keweenaw Bay Indian Community, a Sovereign Nation Assisting in Modern Management of the Resources of Lake Superior

Gene Mensch[1] *and Karen Anderson*[1]

[1]*Keweenaw Bay Indian Community Natural Resources Department, Ojibway Community College*

The Keweenaw Bay Indian Community (KBIC) is located in the western Upper Peninsula of Michigan, and is the successor in interest of the L'Anse and Ontonagon Bands of Lake Superior Chippewa Indians, signatories to the 1842 Treaty with the Chippewa, and the 1854 Treaty with the Chippewa. Several sections of our Integrated Resource Management Plan (IRMP; adopted February 12, 2003) mention the importance of control and management of Aquatic Invasive Species (AIS) in the Lake Superior Region. Although the KBIC Natural Resources Department (KBIC-NRD) has been working hard to address various AIS challenges for many years, we were heavily understaffed and underfunded until recent funding support provided through the Great Lakes Restoration Initiative (GLRI; Grants to support implementation of Tribal AIS management plans) allowed the development of an AIS Program with full and part time staff dedicated to AIS issues. Since 2015, the KBIC-NRD AIS Program has utilized these funds to assist multiple agencies, including the U.S. Fish and Wildlife Service (USFWS), in conducting Lake Superior Basin-Wide and standardized early detection protocols for AIS, in performing various levels of education and outreach to KBIC members and Non-Native American Communities of the Lake Superior Region regarding AIS control and management, and in developing and implementing various ways in which to monitor the impacts of AIS on vital natural resources of the Lake Superior region. This presentation is intended to disseminate the progression of the KBIC-NRD AIS Program.

NOTES

Dreissenid Prevention Across the Pacific Northwest

Stephen Phillips[1]
[1]*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 US 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 US. New infestations in Montana and California are providing new challenges.

An overview will be provided an overview of western watercraft inspection programs, data on number of boats inspected and source waters of infested boats. This talk will also highlight challenges and successes of watercraft interception programs and future direction of interjurisdictional cooperative planning, prevention and management amongst state, federal and provincial agencies.

NOTES

Watercraft Inspection and Decontamination Programs: Western Region of the United States

Debra Davis[1], *Stephen Phillips*[1]
[1]*Pacific States Marine Fisheries Commission*

The expansion of inspection programs has increased the need to have trained inspection and decontamination program staff and managers regionally adopt protocols and standards to guide uniformity to the procedures and language amongst the state/agency programs.

To serve these needs the PSMFC began the Watercraft Inspection Training (WIT) program in 2006. To date, over 100 WIT Level I and Level II training classes have been conducted in 19 Western states (and British Columbia) involving thousands of participants. These individuals have trained thousand more in their respective programs.

The purpose is to teach natural resource personnel watercraft inspection and decontamination techniques and methods utilizing the "Uniform Minimum Protocols and Standards for Watercraft Interception Programs for Dreissenid Mussels in the Western United States."

The trainings utilized WIT training manuals that have been recently updated by the Western Regional Panel (WRP) on Aquatic Invasive Species' WIDT committee. These trainings have proven critical, as properly decontaminating fouled watercraft using current standards is an arduous task, and resource agencies need to be able to trust the decontaminations and inspections conducted by other jurisdictions.

NOTES

A Dog's Nose Knows: Utilizing Canines to find Quagga and Zebra Mussels

Debra DeShon[1]
[1]*Mussel Dogs*

The search for more effective, efficient and boater friendly inspections of watercraft for aquatic invasive species is a goal of all proactive inspection stations. Canines have been utilized for their scent detection capabilities in many areas including security, medical and conservation. Combining the two has provided inspection services that are accurate, fast and educational. The inspections utilizing the canines are well received and offer opportunities to educate the public on aquatic invasive species and gives an opportunity to teach them how to properly clean, drain and dry their watercraft. This presentation will cover the abilities of canines, how canines are used, how to start a canine program, research completed determining the canine's ability to detect the veliger stage and possible other uses of scent detection canines.

NOTES

Leveraging Partnerships to Advance the Adirondack Aquatic Invasive Species (AIS) Prevention Program: The First Voluntary Boat Inspection and Decontamination Program in the Northeast

*Eric Holmlund[1], **Erin Vennie-Vollrath**[2], Brendan Quirion[2], Margaret Modley[3]*
[1]Paul Smith's College, Adirondack Watershed Institute
[2]Adirondack Park Invasive Plant Program
[3]Lake Champlain Basin Program

The Adirondack region of northern New York boasts over 3,000 lakes and ponds across a 6+ million-acre landscape. Abundant recreational boating opportunities, emphasized by their close proximity to major points of AIS entry into North America, have resulted in the introduction and spread of at least 11 species into the region. Survey data compiled since 2002 indicates that at least two thirds of the lakes and ponds in the region are still free of AIS. Since 2015, a collaboration of state agencies, local government officials, environmental organizations, lake associations, and invasive species programs have used historic AIS distribution and vector data to design and implement a landscape-scale AIS spread prevention program. The first program of its kind in the Northeast, The Adirondack AIS Prevention Program provides voluntary boat inspection and decontamination services at priority road and waterway locations while advancing strategic communications and awareness building initiatives. To date the program has inspected over 105,000 trailered vessels and intercepted 2,903 AIS on boats either attempting to launch into or being retrieved from Adirondack waters. The Program's success in leveraging partnerships amongst a diverse set of stakeholders provides a model for future collaborative invasive species prevention efforts. This session will provide a summary of the Program and strategy to promote consensus amongst stakeholders to combat the spread of AIS in the Adirondacks.

NOTES

Dreissenid Mussel Dispersal through Boat Hull Mediated Overland Dispersal

Frank Collas[1,2], *Alexander Karatayev*[1], *Lyuba Burlakova*[1], *Rob Leuven*[2,3]
[1]*SUNY Buffalo State, Great Lakes Center*
[2]*Department of Environmental Science, Institute for Water and Wetland Research, Radboud University, Nijmegen*
[3]*Netherlands Centre of Expertise for Exotic Species*

Introductions of the invasive zebra mussel (*Dreissena polymorpha*) and quagga mussel (*Dreissena rostriformis bugensis*) into hydrologically isolated water bodies have been attributed to overland transport via (recreational) boat hulls. Before a boat becomes a successful vector mussels must 1) attach to the hull, 2) survive air exposure during overland transport, and 3) establish a viable population either after detachment or release of spat during launching or sailing. These dispersal barriers were mimicked and the potential of boat hull mediated release into a recipient environment was assessed for both species. Individuals were allowed to attach to aluminium and fibreglass plates. Hereafter, attached individuals were exposed to air and subsequently submerged again. Zebra mussels had a significantly higher attachment rate than quagga mussels. The percentage of attached dreissenid mussels that detached alive during rewetting ranged between 7.9% and 21.8%. No significant difference was found between species and hull materials. However, alive detachment during rewetting was significantly higher after 24 hours compared to 48 hours of air exposure. The results indicate that dispersal of dreissenids via boat hulls is possible. This is supported by the historical distribution of the quagga mussel which is characterized by long distance dispersal events and occurrence in isolated water bodies. Our data allow modelling introduction pressure of lakes if quantitative data on overland boat movement and the density of attached mussels are available.

NOTES

Investigation of the Edwards Protocol on Dreissenid Veligers

Kelly Stockton-Fiti[1], *Christine Moffitt*[2]
[1]*KASF Consulting, LLC*
[2]*US Geological Survey, Cooperative Fish and Wildlife Research Unit, University of Idaho*

A treatment of 750 mg/L potassium chloride (KCl) for 1h prior to a 25 mg/L formalin treatment for an additional 2h was found to be an effective method of killing zebra mussel veligers while still being safe for fish in fish transport trucks. Studies conducted in other regions have found that this was not an effective treatment. Many hypothesis were suggested as to the reason for the discrepancies, variables of interest included temperature, water chemistry, recovery time, purity of KCl, and differences in response by zebra vs quagga veligers. This study looked at those hypothesis to test the treatment at 4 different temperatures across 3 levels of conductivities adjusted by sodium chloride with zebra veligers. Additional tests were conducted to test the mortality associated with analytical grade KCl and muriate of potash used for treatment at 4 different temperatures at 1 conductivity. The original study was repeated in a fish hauling truck with and without fish present. Veligers were observed after a short recovery time and Fast Green stain was used to assist in viability analysis. We achieved very similar results to the original study with zebra mussels at 27C in low conductivity water. Fish increased veliger mortality in the control and treatment was successful in tanks with fish. We found that increased temperature increased mortality while increased conductivity decreased veliger mortality. However, the largest explanation of the variability observed in previous studies was the susceptibility of different life stages to the treatment.

NOTES

Invited Keynote Presentation

Aquatic Invasive Species in Singapore: Perspectives from a Highly Urbanised Tropical City

Darren CJ Yeo
Department of Biological Sciences, National University of Singapore

Singapore is a highly urbanized island city-state, located within the equatorial tropics of Asia, with one of the world's busiest ports. A majority of the island's fresh waters are artificial or modified, containing numerous alien species that arrived through a few major pathways (e.g., ornamental pet trade, live food trade), and were released via a handful of modes/vectors (e.g., intentionally for aesthetical, ethical reasons, or as unwanted pets or live bait). There has been limited effort to manage these species, partly because of their restriction to urban or disturbed habitats, where few native species occur. However, a growing concern over the high numbers of alien species and their proximity to natural areas (e.g., forest streams) housing Singapore's remaining native freshwater biodiversity is now prompting a recent surge in research efforts. In this talk, I highlight some notable examples of aquatic alien species/taxa in Singapore, and the efforts to investigate distributions, pathways, spread, and potential impacts of these species. These efforts include studies that determine drivers of invasibilty/resistance of natural forest streams to invasion from connected urban reservoirs containing novel communities of alien species. In Singapore's urbanized coastal waters, the surprising scarcity of invasions despite theoretical high marine bioinvasion risk is similarly explored. Possible reasons for the apparent low rate of marine invasions are postulated, which relate to key knowledge gaps that need to be addressed not just in Singapore, but also throughout much of tropical Asia. In this vein, I discuss some of the challenges facing the study and management of aquatic invasive alien species in relation to biodiversity conservation, in a city where urban greenery and biodiversity enhancement are have become buzzwords for environmental sustainability.

Darren Yeo Chong Jinn

Assistant Professor, Department of Biological Sciences
National University of Singapore, Malaysia

Darren C.J. Yeo is an Assistant Professor at the Department of Biological Sciences, National University of Singapore (NUS), where he runs the Freshwater and Invasion Biology Lab; he is also a Research Affiliate of the Lee Kong Chian Natural History Museum and the Tropical Marine Science Institute (both NUS). His main research interests are in aquatic invasions, freshwater ecology and biodiversity, and freshwater decapod crustaceans, which the lab investigates through studies of tropical Asian freshwater ecosystems. Current projects include ecological studies of aquatic invasive species in Singapore and the surrounding Southeast Asian region, e.g., autecology, ecological niche modelling, population genomics, native-alien competitive interactions, trait-based risk assessments, and invasion pathways of freshwater invasive species such as Redclaw crayfish (Cherax quadricarinatus), Oriental river prawn (Macrobrachium nipponense), golden or channeled apple snail (Pomacea canaliculata), and African sharptooth catfish (Clarias gariepinus); biodiversity and ecology of Singapore's freshwater ecosystems and their associated native and non-native fauna; and systematics and taxonomy, biogeography, and conservation of Asian freshwater decapod crustaceans.

Rapid Response Achieves Eradication – Chub in Ireland

Joe Caffrey[1, 2,] *Jaimie T.A. Dick*[3], *Christine Maggs*[3], *Dermot Broughan*[2], *Kevin Gallagher*[3]
[1]*INVAS Biosecurity and Inland Fisheries Ireland*
[2]*Inlands Fisheries Ireland*
[3]*Queen's University Belfast*

Rapid reaction to the initial discovery of invasive alien species is key to eradication, but this is often frustrated by lack of resources and coordinated actions. Examples of successful eradications may empower others to follow. Chub (*Leuciscus cephalus*) were illegally introduced into the River Inny in midlands Ireland in the late 1990s, reputedly by British anglers. The habitat in this river is favourable to the establishment of Chub and should this species establish, it would compete directly with the indigenous fish communities. They could also introduce non-native pathogenic fauna that could have a detrimental impact on fish populations in this river system. Central Fisheries Board coordinated fish removal operations and provided the necessary resources (manpower and equipment) that were needed to effectively remove Chub from this large river. Three electric fishing crews supported by two tank boats and land-based personnel were required in each operation to effectively remove the Chub. These crews worked on this task for at least five days each year between 2006 and 2014. Between 2006 and 2008, some 27 adults and one juvenile Chub were removed and euthanised. In 2008 two Chub were radio-tagged, released back to the river and tracked monthly for 12 months. Over the next two years these 'Judas' Chub, and any associated specimens, were removed from the river. Intensive electric fishing of the river and regular contact with the local angling community between 2010 and 2016 revealed no further Chub specimens. Monitoring of the fish populations in the river will continue but it is suspected that Chub may have been eradicated from this river system, and hence, Ireland.

NOTES

Improving Response of Asian Carp Detections in the Canadian Waters of the Great Lakes

Julia Colm[1], *Becky Cudmore*[1], *David Marson*[1]
[1]*Fisheries and Oceans Canada*

Asian carps pose significant ecological and socio-economic threats to the Great Lakes and associated waterbodies and preventing their introduction is a high priority for governments on both sides of the border. No Asian carps are established in Canadian waters of the Great Lakes, but as individuals (specifically, Grass Carp) continue to appear, the importance of detecting them early, removing them quickly, and ensuring there are no others in the vicinity becomes an increasingly important and difficult task. For responsible agencies to respond effectively to the detection of Asian carps, we must all work together under a unified structure. Fisheries and Oceans Canada (DFO) has adopted a response protocol under the Incident Command System framework to respond effectively, with consistent roles and expectations, to detections of Asian carps. To test this protocol, an on-water training exercise was conducted in the spring of 2017 under a variety of different scenarios and threat levels. Senior managers, members of the media, and teams from other agencies that may get called in to assist with future incidents were invited to observe the training exercise to better understand the "boots-on-the-ground" work, and to be able to share with their agencies and the Canadian public what is being done to prevent the establishment of Asian carps. A description of this exercise and lessons learned will be presented, as DFO continues to improve and adapt response protocols to meet the challenges posed by these invasive fishes.

NOTES

Movement of Bigheaded Carp Related to Temperature, Discharge, and Lock Operations on the Illinois River

Marybeth Brey[1], *Mike Montenaro*[1], *Alison Coulter*[2], *Matt Lubejko*[2], *and Brent Knights*[1]
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[2]*Southern Illinois University-Carbondale, Carbondale, IL 62901*

Minimizing propagule pressure is a key objective in minimizing the establishment of Bighead Carp and Silver Carp (*Hypophthalmichthys nobilis* and *H. molitrix*) in the upper Illinois River and the Great Lakes. Currently, an electric dispersal barrier and contracted commercial fishing are the only measures in place to control fish movement. However, recent data suggest that characteristics of existing locks and dams on the river may also deter fish movement. Downstream of the electrical barrier, are five "high-head" navigation dams including Starved Rock, Marseilles, Dresden, Brandan Road, and Lockport. Evidence in the form of continued low abundance of AC in the navigation pools above Starved Rock dam suggests that the high-head dams might be acting as deterrents to AC because of their design (i.e., gated, with relatively high head). The design of these dams might generally limit AC passage to times when gates are open (during high discharge events) or via lock chambers during spring or fall carp migrations. If the barrier characteristics of these high-head dams under various hydrologic conditions and seasons can be better understood and enhanced with low cost measures, then the number of AC present to challenge the more comprehensive barriers would be reduced. To determine if these dams act as barriers and if barrier-characteristics of these dams can be enhanced, we used reach-specific hydrologic and temperature data, dam-specific design and operations data, and existing telemetry data (Southern Illinois University) on AC dam passage to assess the conditions conducive to passage. Alongside or following this assessment, we've begun to evaluate what combination of best management practices (including sound and CO_2) at locks could best deter AC from entering or using a lock chamber.

NOTES

Understanding the Carp Virome: What Could it Mean for the Control of Invasive Carp?

Sunil Kumar Mor[1], *Nicholas B.D. Phelps*[2]

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[2]*Minnesota Aquatic Invasive Species Research Center and the Department of Fisheries, Wildlife, and Conservation Biology, University of Minnesota*

One possible approach to controlling invasive carp would be through the introduction of species-specific pathogens. Considering biocontrol as a control measures, we aimed at collecting baseline data to better understand viral communities ("virome") of invasive carp species. We have collected samples of common carp (n=699) from across Minnesota from 2014-2015 and silver carp (n=120) from Illinios in 2015. A necropsy was performed to collect the kidney, spleen, brain, and gill tissues and processed for viral screening. All samples were screened for cyprinid herpes viruses (CyHV-1,2,3), carp edema virus and spring viremia of carp virus using specific real time assays, with no positive results. Samples were also processed for unbiased detection of viruses to generate the complete virome using the genome sequencing technique, Illumina MiSeq. Analysis of Illumina MiSeq reads identified a novel picornavirus from common carp mortality events. Additionally, divergent picornaviruses, aquareovirus, hepevirus and nodavirus were also detected in clinically healthy common carp, and hepevirus was detected in the clinically normal silver carp samples. Establishing and understanding what novel viruses are circulating in invasive carp will provide important baseline information in order to select a species-specific pathogen that could be introduced or promoted to act as a biocontrol. This research is proceeding with a high level of caution since protecting native species and promoting ecosystem health is a top priority.

NOTES

Freshwater Alien Fish in the Southern Western Ghats, a Biodiversity Hotspot in India

Raj Smrithy[1], *A. Biju Kumar*[1]
[1]*Department of Aquatic Biology & Fisheries, University of Kerala*

The Western Ghats biodiversity hotspot of India is characterized by high endemism of flora and fauna and in terms of aquatic biodiversity the documentation remains far from complete. Yet, invasive alien species is one of the major threats to the bewildering array of aquatic biodiversity of the region. The three year survey on invasive fish fauna of the southern Western Ghats recorded the presence of invasive fishes such as *Oreochromis mossambicus, Oreochromis niloticus, Clarias gariepinus, Poecilia reticulata, Gambusia affinis, Xiphophorus maculatus, Cyprinus carpio, Pterygoplichthys* spp., and *Trichopodus trichopterus*. The process of invasion and breeding behavior of South American armoured catfish *Pterygoplichthys* sp. have been documented for the first time in Indian waters during the study. The DNA barcoding studies using CO1 and cytochrome b genes could not confirm the identity of *Pterygoplichthys* sp. and indicate the possibility of hybrids in the region. *Oreochromis mossambicus, Oreochromis niloticus, Clarias gariepinus, Cyprinus carpio, Poecilia reticulate, Gambusia affinis* and *Trichopodus trichopterus* also established feral populations in the state. The Mozambique tilapia *O. mossambicus* (Peters) is reported as the widespread invasive fish in the region. The study also documented for the first time replacement of indigenous Tor sp. held as sacred species in Kulathupuzha river by the alien common carp, *Cyprinus carpio* Linnaeus. Further, alien North African catfish *Clarias gariepinus* (Burchel) has established good population in Protected Areas harbouring rich diversity of endemic fish fauna, besides replacing indigenous catfishes in many freshwater ecosystems. *Poecilia* reticulata invaded streams at around 2,500 m above sea level in the protected areas, posing threat to the endemic fish in the region. The paper discusses strategies to deal with alien invasive alien species in the Western Ghats biodiversity hotspot.

NOTES

Predicting Invasive Species Impacts under Context-dependencies

Jaimie T.A. Dick[1], James W.E. Dickey[1]
[1]Queen's University Belfast

Invasive species impacts are notoriously unpredictable, or at least highly context-dependent, making ecological impact prediction difficult. Our new metric of invader impact, "Relative Impact Potential" (RIP) blends: (1) the classic Functional Response (FR; consumer per capita effect) and Numerical Response (NR; consumer population response), that is, the Total Response (TR = FR × NR), with; (2) the "Parker equation", where Impact = Range × Abundance × Effect, to give; (3) RIP = FR × Abundance. The RIP metric is an invader/native ratio, values >1 predicting that invader ecological impact will occur, and increasing values above 1 indicating increasing impact. Across a diverse range of trophic and taxonomic groups, including predators, herbivores, animals and plants (22 invader/native systems, 47 individual comparisons), high impact invaders were significantly associated with higher FRs compared to native trophic analogues. However, the RIP metric substantially improves this association, with 100% predictive power of high impact invaders. Further, RIP scores were significantly and positively correlated with two independent ecological impact scores for invaders, allowing prediction of the degree of impact of invasive species with the RIP metric. Since both *per capita* effects and abundances of invaders can be measured across abiotic and biotic contexts, the RIP metric could substantially improve invader impact prediction. For example, we show that FRs are sensitive to temperature, oxygen, salinity, parasitic infection and multiple predator effects (MPEs). We also present a framework for the use of RIP in other contexts, particularly spatio-temporal patterns of invader replacement of native analogues. Since invaders may initially add to the existing ecological impacts of native species prior to replacing those species, and then increase in abundance rapidly after native species replacement, ecological impacts may follow multi-modal spatio-temporal patterns, which RIP can resolve. RIP thus provides an explanatory and predictive tool for scientists, managers, practitioners and legislators.

NOTES

Vulnerability of Freshwater Biodiversity to Non-native Aquatic Species and other Anthropogenic Stressors across the Continental United States

Amy J.S. Davis[1], *Stephanie Panlasigui*[1], *Michael Mangiante*[1], *John A. Darling*[2]
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Non-native species pose one of the greatest threats to native biodiversity. We employed geospatial analyses to investigate the potential role of non-native aquatic species in driving the decline of native freshwater biodiversity across the continental United States by assessing correlations between non-native species richness and metrics associated with vulnerability of native biota. We mapped non-native species richness at the watershed scale (hydrologic unit code 8) utilizing existing publicly available databases on the spatial distribution of non-native aquatic plant and animal species. This distribution was compared to the distribution of native aquatic animal taxa (fish, amphibians, mollusks, and decapods) drawn from the International Union for the Conservation of Nature (IUCN) database. To assess native species vulnerability, we mapped species listed as threatened and endangered by IUCN, local and continent-wide extinctions, as well as an index of aquatic species rarity intended to identify watersheds that harbor diversity that may be particularly sensitive to future decline. Spatial overlays of these datasets indicate that non-native species likely pose a significant potential threat to native freshwater diversity in multiple regions, particularly in the southeastern US; investigation of the distribution of protected lands indicates that these regions may be poorly safeguarded by existing conservation mechanisms. To further explore the direct role of non-native species in driving loss of native aquatic diversity, we generated statistical models to investigate the power of multiple anthropogenic drivers (e.g. non-native species, hydrologic alteration, habitat loss, pollution, and urbanization) to predict patterns in native species decline at the continental scale.

NOTES

Effects of Invasive Species on Native Populations of Aquatic Organisms in the San Francisco Bay-Delta and Freshwater Tributaries: A Review

Bryson Finch[1] *and Jeffrey Giddings*[1]
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Aquatic invasive species are considered an important causative factor in the declines of native species diversity and populations in the San Francisco (SF) Bay-Delta. The SF Bay-Delta is one of the largest estuarine and freshwater ecosystems in North America and harbors an abundant and diverse range of aquatic species including endangered species and several commercially and recreationally important species. The SF Bay-Delta is also a major port for trade and is heavily urbanized. Native species in the SF Bay-Delta and freshwater tributaries have declined precipitously, likely due to a myriad of factors including invasive species, changes in water flow, water diversions, habitat modifications, fishing practices, cyanobacteria blooms, and toxicants. The number of aquatic species invasions in the SF Bay-Delta has continued to increase over the last century and may be a key component to native species declines. The objective of this review is to identify aquatic invasive species present in the SF Bay-Delta and tributaries and determine the consequences of their introduction on indigenous species. Analysis of aquatic species in the SF Bay-Delta and associated tributaries revealed that invasive species have competitive advantages that result in impacts throughout the food web, resulting in trophic cascades and changes in species composition in both invertebrate and vertebrate populations. The phenotypic plasticity of organisms may play a key role in their susceptibility to displacement by invasive aquatic species. Native species with a diverse range of habitat preferences and food items (i.e. trophic adaptability) are more likely to adapt to changing conditions and are better equipped to withstand ecosystem changes originating from aquatic species invasions. Several case reviews demonstrate the dynamics between native and introduced aquatic species and reveal the interrelationships that lead to the continued persistence or the decline of native species.

NOTES

Predatory Impacts of the Invasive Portunid Crab, *Charybdis Japonica*, in New Zealand: Implication for Functional Change, Risk Assessment and Ecosystem Goods and Services

Michael Townsend[1], *Andrew M. Lohrer*[1], *Judi E. Hewitt*[1]; *Graeme J. Inglis*[1]
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Invasive portunid crabs have had adverse impacts worldwide resulting in serious ecological, social and economic costs. They remain on many countries "least wanted" species lists due to their ability to alter biodiversity and affect fisheries and aquaculture. In 2000 the Asian paddle crab, *Charybdis japonica*, was found in Waitemata Harbour, New Zealand, and has now established breeding populations across several hundred kilometers. Despite the predation potential, little is known of the impacts of *Charybdis* in New Zealand and the degree of risk posed to native ecosystems. Here we present findings from a series of field experiments, designed to elucidate the prey choices of *Charybdis* in the presence and absence of functionally important native species. We found that *Charybdis* negated the positive influence of native bivalves on the abundance and richness of the surrounding soft sediment macrofauna. By targeting burrowing urchins, *Charybdis* also influenced the rates of ecosystem processing through reductions in bioturbation and biogenic disturbance. We discuss the potential for functional changes as a result of the invasion of *Charybdis* and the broader findings in relation to risk assessment, invasion resistance and impacts on ecosystem goods and services, including customary harvest by Maori.

NOTES

Got Mussels? Work Your Quaggals

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Lakes are living systems with many players shaping the lake from the inside out. Occasionally, invasive species such as quagga mussels are accidentally introduced and begin to encapsulate the entire lake ecosystem. Due to their ability to spread rapidly and colonize most available substrates, quagga mussels are an increasing threat to native species in our waters. Early identification, specialized treatment, along with frequent monitoring must be implemented in order to gain control and prevent these invasive populations from spreading further. In a study located in Southern California, a small population of quagga mussels was discovered to be invading a recreational lake containing aquatic fauna, various fish, snails, crayfish, and turtles. Specialized treatments were calculated and applied in the target area where the mussels were identified. After treatment, the small quagga population was eradicated and additional spot treatments were recommended to minimize the chance of another quagga mussel outbreak. Special care must be taken for non-target species during these treatments so that overall lake health is kept in balance. Continuing regular site inspections in the future will help to reduce the chance of another quagga population from colonizing. If any more instances are discovered, early identification and immediate treatment is the best possible chance to keep these highly invasive species in check. This presentation will cover the details of this Southern California case study on quagga mussel monitoring and treatment.

NOTES

Assessing the applicability of the Aquatic Species Invasiveness Screening Kit (AS-ISK) across a Broad Range of Non-native Species and Risk Assessment Areas

Gordon H. Copp[1], *Lorenzo Vilizzi*[2], *and 50+ contributors*

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Risk-based identification and assessment of non-native species is an essential process for the implementation of legislation and regulatory controls to manage invasive species and avoid or mitigate their adverse impacts. This process is facilitated by electronic decision-support tools, and this study presents the outcome of initial trials of a recently-released decision-support tool for aquatic species, 'AS-ISK' (the Aquatic Species Invasiveness Screening Kit), which is available for free download at: www.cefas.co.uk/nns/tools/. Applicable to virtually all climatic zones and all aquatic plants and animals regardless of ecosystem, AS-ISK is compliant with the 'minimum requirements' for use with the new EU Regulation on invasive alien species of EU concern, including questions that require the assessor to evaluate the potential impact of predicted future climate conditions on the risk assessment. The aim of this study is to assess the applicability of AS-ISK across a broad taxonomic, geographic and climatic range of non-native species and aquatic RA areas. The trials comprise two groups of assessment, with a majority undertaken by delegates of the ICES Working Group on Introductions and Transfers of Marine Organisms (WGITMO): (i) single or duplicate assessments of a wide range of marine, fresh, brackish water species that are not native to the risk assessment (RA) areas selected by the assessors, including species and RA areas in Europe, North America and Asia; and (ii) multiple assessments of the Manila clam *Ruditapes philippinarum* for RA areas across the globe. The study outcomes will provide a basis upon which to consider the use of AS-ISK for identifying which non-native species require full risk assessment and thus assist and inform decision makers and environmental managers in the allocation of increasingly scarce resources in the battle against invasive species.

NOTES

A Rapid Assessment of Marine Non-native Species in Harbours and Marinas on the Southwest Coast of Norway and the Northeast Coast of Scotland and the Potential for Coastal Connectivity

Ian Campbell[1], *Elizabeth Cook*[1], *Jennifer Loxton*[2], *Andrew Blight*[3]
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The assembly, transportation and installation (ATI) process for floating wind turbines (FWT's) is significantly different to those, which are permanently fixed to the seabed and closer to shore, representing a number of unquantified vectors for the unintentional introduction of invasive non-native species (INNS). These vectors include, but are not limited to (i) attachment to the undersurface of heavy lifting vessels (HLV's) the only vessels capable of transporting key FWT components across different biogeographic regions (ii) attachment of 'hitch-hiking' species to the floating foundations during the 'wet-towed' journey from the port of assembly to the turbine deployment area (iii) fully deployed FWT's acting as 'stepping stones' for invasive non-native larvae across soft sediment habitats (iv) attachment to maintenance and decommission vessels. The recent development of floating wind technology means there is currently no research protocol for the early detection and monitoring of INNS during the ATI process. The industrial sponsor Statoil ASA is committed to building a knowledge base for the floating wind and wider marine sector by supporting a research protocol for Hywind Scotland, the world's first commercial floating wind farm. This will involve environmental monitoring during key stages of the ATI process and includes installing experiments on; pontoons at the port of assembly in Norway, the floating foundations of Hywind Scotland in Buchan Deep and the port for maintenance of the FWT in Peterhead, Scotland. This presentation will discuss the potential risks posed by each of these vectors for invasion, review the environmental monitoring techniques for assessing each stage and offer a research protocol for identifying the early introduction of INNS. The longer-term aim will be to translate these research findings into governance by preparing biosecurity advice for supporting and influencing the licensing conditions for future floating developments in Scotland and the wider marine sector.

NOTES

Evaluating the Use of a Novel Bayesian Risk Assessment Tool to Inform Regulatory Decisions for Aquatic Invasive Species in Ontario

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Ontario has developed a novel Bayesian risk assessment tool for aquatic invasive species that will be used to inform and support future regulatory decisions and management actions. The intent of the newly developed tool is to minimize assessor bias and increase the likelihood that risk assessments are objective, transparent, reproducible, and easily updatable in light of new information. The risk assessment tool follows a questionnaire-style format complete with detailed guidance and examples to comprehensively address all stages in the invasion process: arrival, survival, establishment, spread, and impacts. Answers follow a standardized rating system, require selection of an associated level of uncertainty, and must be justified by presenting existing scientific evidence. Responses to the questions and their associated uncertainty levels are then incorporated into a hierarchical model using Bayesian inference to derive the probability that the assessed species could become invasive and have impacts on the receiving environment. The modelling tool has been beta-tested and peer-reviewed, and will be used to provide a standardized, scientifically defensible, and objective means of evaluating the likelihood of invasion and adverse impacts for species of concern for the province. In addition, an inter-rater reliability study was conducted to evaluate consistency in risk rankings among assessors employing the tool, and to assess the sensitivity of the overall risk rankings to different levels of inter-rater variation. Here we present the results of risk assessments completed using the tool for several aquatic species, as well as the findings from the inter-rater reliability study-- highlighting areas for potential refinements to the tool.

NOTES

Evaluating the Effectiveness of Aquatic Animal Health Programs in Preventing Disease Introductions: A Canadian Case Study

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The introduction of aquatic invasive species in freshwater and marine ecosystems is a serious global issue. One of the often neglected risks of invasive species is the introduction of 'fellow travelers' (e.g. diseases, parasites) into freshwater and marine ecosystems. The goal of the World Organization for Animal Health's (OIE) call for the implementation of aquatic animal health programs across its 180 member countries is to improve farmed aquatic animal health and welfare globally, and to promote safe international trade. Canada's National Aquatic Animal Health Program (NAAHP) was developed in 2005 to protect Canadian wild and farmed finfishes (among other aquatic taxa) from international and domestic infectious aquatic animal diseases by mitigating the risk of introduction and spread. Based on risk assessments of freshwater fish diseases and trade pathways, we identified a number of concerns with this policy that impact the ability to effectively achieve these goals. These concerns include: the lack of risk assessment in a country-specific context; the exemption of some fishes and arrival pathways from import regulations; and, an overall lack of transparency and consistency in the policy. More specifically, these risk assessments concluded that, while most diseases were high risk, some were low risk and that risk varies greatly among trade pathways. Aquatic animal health programs should be based on risk assessments to determine the pathway(s) and probability of disease introductions specific to the country.

NOTES

Predicting the Large Scale and Long Term Distribution of Invasive Species using Habitat Suitability Models

Jeffrey Buckley[1], *Tim Johnson*[1], *Len Hunt*[1], *Andrew Drake*[2], *Allison Bannister*[1], *Simon Fung*[1], *Graham Mushet*[1], *Shannon Fera*[1]
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Invasive species threaten ecosystems worldwide. Predicting the introduction, establishment, and spread of invasive species will aide in monitoring and mitigating their effects. Habitat suitability analyses are frequently used to identify geographic areas mostly likely to be colonized. Climate change is likely to result in large changes to the habitat of aquatic species. As part of an aquatic invasive species risk assessment for the province of Ontario and the Great Lakes region, we investigated multiple methods using large-scale provincial and Great Lakes datasets to determine the suitability of future aquatic habitats for potential invasive species.

NOTES

The Nonindigenous Aquatic Species Flood and Storm Transport (NAS FAST) Mapper

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Storm surge and flood events can assist the expansion and distribution of introduced aquatic species (IAS) through a connection of adjacent watersheds, backflow of water upstream of impoundments, increased downstream flow, and creation of freshwater bridges along coastal regions. During these flooding conditions, IAS can spread to new areas, including to new drainages where they could otherwise not gain access. The USGS Nonindigenous Aquatic Species (NAS) program along with USGS's Advanced Applications Team have developed NAS Flood and Storm Transport (NAS FAST) mapper to allow managers to view which drainages, identified in HUC-8s, may have IAS spread due to flooding from adjacent drainages. The NAS FAST mapper can help natural resource managers determine potential new locations for individual species, or to develop a watchlist of potential new IAS within a watershed. Current NAS FAST maps include all flooded areas from Hurricane Harvey in east Texas and the Louisiana coast; flooded areas in peninsular Florida and coastal Georgia and South Carolina from Hurricane Irma; and flooded portions of Puerto Rico from Hurricane Maria. The NAS FAST maps were developed initially to show all potential HUC-8s that could have flooded but will be periodically updated with additional high water information to highlight which drainages have been connected. Individual maps and information on potential IAS spread will be created for all future storms or hurricanes that cause flooding conditions significant enough to breach drainage divides.

NOTES

Exotic Freshwater Fishes of Florida

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More exotic (i.e., introduced from another country) freshwater fish species have been reported from Florida than from any other state in the U.S. and this number continues to grow. The potential of these fishes to detrimentally affect native species has been a concern of the Florida Fish and Wildlife Commission (FWC) for over 50 years. FWC's objective is to eliminate all illegally introduced fishes wherever and whenever practical; however, when this is impractical, the goal is to assess the ecological and socioeconomic ramifications of these species, and to develop management strategies that minimize their deleterious effects. This paper will provide an overview of FWC's efforts to prevent, assess, and manage exotic fish.

NOTES

Assessment of UV Irradiation Effect on Downstream Settlement of the Colonial Hydroid, *Cordylophora caspia*

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Cordylophora caspia (Pallas, 1771) colonies have significant biofouling potential at hydropower facilities, which can increase maintenance and cause system failure. In 2015, *C. caspia* colonies were observed at dams along the Lower Colorado River system in Lake Powell UT, Lake Mead NV/AZ, Lake Mohave AZ/NV, and Lake Havasu AZ/CA. The goal of the current research was to determine if UV irradiation is an effective settlement prevention technique for this problematic invasive species. The research was conducted at Parker Dam, where all cooling water is being treated with Atlantium HOD-UV units to eliminate quagga mussel settlement. Bioboxes were installed on three cooling water units in order to measure *C. caspia* settlement reduction and overall site-specific biofouling reduction after UV treatment. Monthly dry weights and visual observations of post-treatment settlement plates indicated a reduction in overall biomass accumulation. *C. caspia* appears to be more tolerant of UV irradiation than quagga mussel larvae and higher doses were required for settlement reduction. Additionally, an anoxic layer of sediment was found only in control bioboxes, which is likely the result of microbial presence. The reduction of microbial mediated biofouling would be beneficial for many facilities. The results collected indicate UV exposure may significantly reduce colonial hydroid settlement along with other macro and micro biofouling issues in the cooling water systems at Parker Dam.

NOTES

Graminicide Development for Aquatic Invasive Grass Control in Florida

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Aquatic invasive grasses are an increasing problem throughout Florida and many areas of the United States. Aquatic and natural area managers frequently struggle to achieve long-term control of problem species such as torpedograss (*Panicum repens*), common reed (*Phragmites australis*), and para grass (*Urochloa mutica*). Additionally, emerging species such as West Indian marsh grass (*Hymenachne amplexicaulis*) and Tropical American watergrass (*Luziola subintegra*) are poised to become extensive problems if aggressive measures are not taken. One of the fundamental issues in aquatic grass management is a lack of selective control options. Glyphosate and imazapyr are the two principle tools used in Florida and much of the United States and can often provide twelve to thirty-six months of species specific control. However, non-target damage can be severe with both herbicides, which greatly hinders restoration efforts. In 2015 and 2016, the State of Florida received experimental use permits for two graminicides, sethoxydim and fluazifop-p-butyl to treat emergent, invasive grasses in aquatic systems. These grass-specific herbicides provide tremendous selectivity and could greatly assist aquatic managers in grass control programs. However, efficacy data for both is almost completely lacking in aquatic systems. This talk will focus on current research examining the biological and ecological aspects of aquatic grass control with these graminicides.

NOTES

The Performance of Band Non-biocide Coatings to Prevent Biofouling by Invasive and Non-native Species in Newfoundland

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Biofouling, the unwanted growth of aquatic organisms can characterize invasion hotspots and vectors for spread of non-native species with implications for industries (e.g. aquaculture). In shellfish aquaculture, fouling by invasive tunicates directly on the species can reduce oxygen and food acquisition, leading to slower growth. For example, biofouling by vase tunicate (*Ciona intestinalis*) in Prince Edward Island, Canada causes significant increases in time and labour to remove and process product, resulting in lower yields. Traditionally, antifouling coatings are used in aquaculture industry to limit fouling, but spread of non-indigenous species present novel threats to this industry in Atlantic Canada, and specifically, Newfoundland. Some coatings including self-polishing copolymer paints contain biocides, commonly copper, while other coatings rely on physical properties (e.g. smooth surfaces), to prevent fouling (i.e. foul-release coatings). Concerns of toxicity of biocides (e.g. copper) have led to development of new coatings. In our study, we deployed wood settlement panels to test eleven coatings (and two controls) at four sites that characterize Newfoundland fouling communities and included three invasive tunicate species (*C. intestinalis, Botrylloides violaceus*, and *Botryllus schlosseri*). Four coatings contained cuprous biocides, two used zinc biocides, one used zinc and Econea™ as biocides, two were foul-release coatings (non-biocide), and two were non-antifouling marine paints. We photographed panels monthly (May to December 2016) to determine changes in percent coverage of biofouling communities. Preliminary results suggest biocide coatings prevent growth of fouling organisms most effectively (as low as 0% coverage), while panels with non-antifouling marine paints exhibited up to 100% coverage, including invasive tunicates. Biofouling differed between foul-release coatings (up to 80 %), possibly indicative of differences in surface topography observed with scanning electron microscopy. Although, the most effective coatings contained biocides, one foul-release coating showed limited biofouling and may present a non-biocide alternative for use in the aquaculture industry.

NOTES

Effect of *Dreissena* on Benthos of the Laurentian Great Lakes

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The introduction of exotic dreissenids *Dreissena polymorpha* (zebra mussel) and *D. rostriformis bugensis* (quagga mussel) into theGreat Lakes in 1980s caused profound structural and functional consequences in their ecosystems. Both dreissenid species are ecosystem engineers that fundamentally change the flow of energy and nutrients and affect both the benthic and pelagic communities. We used benthic data collected by the U.S. EPA, Great Lakes National Program Office's Monitoring Program and data from 2014-2015 extensive surveys collected within the Cooperative Science and Monitoring Initiative to characterize changes in benthic communities over the last 16 years, and to identify the potential drivers of the changes. Our analysis distinguished main benthos assemblages across lakes that differed in terms of species composition, abundance, functional group diversity, and tolerances to organic pollution. Analyzing temporal trends we found the largest structural and quantitative changes in profundal communities, apparent in significant shifts in dominant taxa across all lakes except Lake Superior. The invasion of exotic dreissenids was among the most important drivers of temporal changes in native benthic communities.

NOTES

Understanding the Drivers and Impacts of *Cherax quadricarinatus* Invasion in Singapore

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In Southeast Asia, studies investigating the impacts of aquatic invasive species (AIS) are notably lacking, partly because AIS are largely restricted to artificial or highly modified environments that contain few (if any) native species of conservation concern. The Australian redclaw crayfish (*Cherax quadricarinatus*) is one species, however, that represents an increasingly worrisome threat owing to recent proliferation within the region, and ability to establish beyond artificial habitats, in natural forest streams. In Singapore, forest streams contain the majority of the country's native freshwater species, which broadens the potential impacts associated with the alien crayfish. This study focuses on recent efforts aimed at quantifying drivers and impacts associated with the spread of *C. quadricarinatus* in Singapore. Utilizing field studies and modeling techniques (e.g., structural equation models), environmental filtering was identified as the key factor driving crayfish spread. *Cherax quadricarinatus* was also revealed to have the potential to cause declines or displacements in the native lowland freshwater crab (*Parathelphusa maculata*) populations. To identify potential mechanisms of such species displacements, stable isotope analyses and behavioral experiments were additionally employed. These studies indicated that while *C. quadricarinatus* is unlikely to compete with *P. maculata* over a common food source, it can prey upon such native species. The identification of such impacts represents an important first step in the development of relevant management and conservation strategies.

NOTES

Determination of Invasive Round Goby (*Neogobius melanostomus*) Impact on Native Benthic Fishes in the Upper Allegheny Watershed

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Round Gobies, *Neogobius melanostomus*, were discovered in the Pennsylvanian waters of Lake Erie in 1990 and have become among the most abundant benthic fish species in all five Great Lakes. In August of 2014, Round Gobies were discovered in a tributary of the upper Allegheny River Watershed, which is the first documented inland introduction in Pennsylvania. French Creek holds the greatest diversity of both fishes and freshwater mussels in much of the Eastern United States. Preliminary research in 2015, determined that Round Gobies have moved from their introductory location into the main channel of French Creek, but the impacts of that introduction on native fishes is unknown. One hypothesis was that the immense diversity of benthic fishes in French Creek will control or retard its dispersal and colonization of the main channel. The objectives of the study, therefore,were to determine if Round Gobies have displaced native fishes from their preferred habitat and to determine diet overlap between Round Gobies and native benthic fishes. During 2016, fishes were collected via seine and macroinvertebrates were collected using a D-frame kicknet at nine locations throughout the French Creek watershed. Stomachs were removed from all fishes and contents identified to the lowest possible taxa. Sites in French Creek were also selected in 2016 and 2017 to snorkel and observe habitat occupancy of native benthic species and Round Gobies, when present. Principle component analysis was used to determine microhabitat and diet partitioning among darters (Percidae) in the presence/absence of Round Gobies. Preliminary results show that Round Gobies are colonizing downstream sections of stream through larval drift and consuming similar prey items as native fishes. We have also documented that Round Gobies are preying on unionid mussels. Larger impacts are still under investigation but the presence of freshwater mussels in stomach contents are of significant interest.

NOTES

Round Goby *Neogobius melanostomus* Expansion to European Rivers

Michal Janáč[1], *Zdeněk Adámek*[1], *Libor Mikl*[1], *Kevin Roche*[1], *Luděk Šlapanský*[1], *Pavel Jurajda*[1]
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The round goby *Neogobius melanostomus* has recently invaded several major freshwater systems in Europe and North America and is considered to be of high risk potential. All impact predictions, however, are either based on theoretical approaches or on impacts observed in the Laurentian Great Lakes, a system distinct from recently colonized European river basins. Here, we used long-term monitoring results to document progress of round goby expansion and its consequences on native fish fauna in three central European rivers (the middle Danube and two of its tributaries).

Similarly to Laurentian Great Lakes, round goby quickly dominated fish assemblages in these rivers, reaching relatively high abundances and becoming an important prey for native predators. In contrast to studies from the Laurentian Great Lakes, however, we have observed no predation on native fish eggs or juveniles, and only limited consumption of mollusks. Further, while observing significant dietary niche overlap, we have observed no microhabitat niche overlap with native fish. Thus far, there has been no apparent effect on native fish abundance and species richness from round goby introduction. Given the pronounced impact being reported elsewhere, including other European sites, these results document large variability of invader's impact, suggesting the impact being determined by the 'compatibility' of the invader and the recipient system.

NOTES

Is the "Killer Shrimp" Resistant to Non-consumptive Effects of Predators?

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Ponto-Caspian gammarids belong to the most effective aquatic invasive species. Especially Dikerogammarus villosus, also called the "killer shrimp", is recognized as one of the 100 worst alien species in Europe due to its negative impact on biodiversity. The success of Ponto-Caspian gammarids is related to their opportunistic feeding strategy including predation on other amphipod species, effective reproductive strategy, as well as high tolerance to salinity and environment degradation.

Available literature describes invasive gammarids as less susceptible to predation than their native counterparts due to better utilization of shelters, harder exoskeleton and effective chemoreception. Nevertheless, No research has been focused on the costs of predator-induced defense mechanisms (non-consumptive effects) in this group, which is crucial at the population scale.

To compare the anti-predator responses of species characterized by different predation susceptibility and invasive potential, we used *D. villosus* (extremely invasive) and *P. robustoides* (moderately invasive). The aim of our experiments was to answer the following questions: Does predator presence modify the consumption level of invasive gammarids? Does predation risk change the behavior related to searching for food resources? Does predator presence reduce the gammarid growth?

Experiments were conducted in aquaria in the presence or absence of predators (racer goby), in the presence or absence of a shelter, and over different durations.

Our results showed that the predator presence did not reduce the consumption level of invasive gammarids, but reduced the time spent on food searching (activity reduction). Also, the predator presence reduced the growth of *P. robustoides* but not that of *D. villosus*.

In conclusion, invasive potential of Ponto-Caspian gammarids may be related to the resistance to the non-consumptive effects of predators. We also showed that in an appropriate habitat, providing effective shelters and rich food resources, the predator impact was limited.

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NOTES

Binational Ecological Risk Assessment of Grass Carp in the Great Lakes Basin

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[5]*U.S. Fish and Wildlife Service*

Grass Carp, first introduced to North America in 1963 for vegetation control, is identified as an invasive species of concern for both Canada and the United States. Recent occurrence records of Grass Carp located in proximity to, and within, the Great Lakes basin, coupled with evidence of reproduction occurring in the basin indicates a perceived increased threat to the Great Lakes and an urgent need to better understand the current status and threat of Grass Carp in and to the Great Lakes basin.

In response to this threat and to help prevent the arrival, establishment, and spread of Grass Carp to the Great Lakes, a binational ecological risk assessment was undertaken. The purpose of this project was to determine the risk to the Great Lakes basin and to provide useful, scientifically defensible advice on prevention, monitoring, early detection, and management actions that are underway or could be taken. The key findings of the risk assessment will be presented.

NOTES

The Crayfish Invasiveness Risk Assessment Model (CIRAM): A Bayesian Belief Network for Assessing Risk Posed by Nonnative Crayfish

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Invasive crayfishes can substantively transform ecosystems through mechanisms including habitat disturbance, predation, competition, disease transmission, and hybridization. Economic and cultural effects of invasive crayfishes may also be considerable. Currently, the U.S. Fish and Wildlife Service (USFWS) uses a semi-quantitative, rapid risk screening to assess risk of invasiveness posed by nonnative crayfish; however, the screening tool poorly addresses uncertainty. To better quantify this uncertainty, the USFWS assembled a team of crayfish and policy experts to develop a stronger risk assessment tool for nonnative crayfishes. The Bayesian belief network structure of the new tool treats uncertainty as an integral component of the model, can be applied flexibly, and is accessible to individuals with a wide range of statistical abilities. Team members developed the model structure through discussion of the literature and individual experience. Key model elements included: historical or projected effects of the nonnative species on native species, ecosystems, and humans; potential for concurrent introduction of pathogens or commensals; potential for human and non-human transport; life history; and climate and habitat suitability. Team members independently supplied probability estimates that were combined to populate the model's preliminary probability tables. Crayfish species classified with high certainty as "high risk" or "low risk" were used to train and test the model structure. The resulting tool will provide the USFWS and its partners with a quantitative and flexible mechanism for assessing crayfish invasion risk.

NOTES

Climate Match Fails to Explain Variation in Establishment Success of Non-native Freshwater Fishes in a Warm Climate Region

Jeffrey E. Hill[1], *Quenton M. Tuckett*[1], *Katelyn M. Lawson*[1]
[1] *University of Florida, Tropical Aquaculture Laboratory*

Three factors seem to yield consistent associations with establishment success across taxa and regions: climate match, prior invasion success, and propagule pressure. Climate match is the most fundamental because some degree of habitat suitability is necessary for establishment. Recent research shows climate match is important worldwide for freshwater fishes and correctly categorizes 75-81% of introduced fishes in the Laurentian Great Lakes. Most studies focus on temperate or cold climates, potentially biasing our understanding of important processes. We therefore assessed the importance of climate match in differentiating successful versus failed freshwater fishes in the warm climate region of peninsular Florida (USA). We used CLIMATCH and followed a U.S. Fish and Wildlife Service protocol for 36 failed and 34 successful species. The protocol calls for using all native and established locations as source data resulting in *post hoc* determinations of climate match for successful species. We also estimated climate match with all Florida locations removed to determine *a priori* climate match, a more common scenario for risk assessment (i.e., determining if a species may establish). With Florida locations included, climate match of established species was significantly greater than for failed species (0.989 vs 0.587). Without Florida locations, climate match of successful species was 0.633 and was indistinguishable from failed species. Successful (*a priori*) and failed species both had a climate match range from 0 to 1. The protocol classifies values >0.103 as a high match—15% of successful and 19% of failed species fell below this threshold. Our results show that a priori climate match is not predictive of success or failure of non-native freshwater fishes in Florida and further suggest caution in using *post hoc* climate analysis as a basis for a predictive tool.

NOTES

The Use of Co-Spatial Modeling to Inform Aquatic Invasive Species Management

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[3]*Department of Veterinary Population Medicine, University of Minnesota*

Given the scope of the problem and limited resources, risk-based management of aquatic invasive species (AIS) is critical. Recognition of the areas at high risk of invasion through scientific evidence to facilitate early detection and the efficient allocation of limited resources to reduce AIS spread. This study uses co-spatial models to predict the risk of AIS establishment in Minnesota and, ultimately, to inform targeted surveillance and intervention activities. Co-kriging was used to estimate the plausible introduction of zebra mussels and Eurasian watermilfoil, using waterbody-specific variables available from selected waterbodies, whereas Maxent was used to determine the ecological susceptibility of the waterbodies. Thus, the combined interpretation of both models serves as a proxy of AIS establishment in waterbodies of Minnesota. Maxent results suggested that human population density was the most important environmental predictor for the suitability of zebra mussels (41.7%) and Eurasian watermilfoil (58%), followed by annual mean temperature (19.1%) and precipitation during the wettest month (17.6%) for zebra mussels and Eurasian watermilfoil, respectively. The zebra mussel co-kriging model included distance to the nearest zebra mussel-infested location, boater traffic, and road access, whereas the Eurasian watermilfoil model included distance to the nearest Eurasian watermilfoil-infested location, boater traffic, and connectivity to another infested waterbody. Combined results showed that ~15% of the waterbodies in Minnesota were at high risk of invasion by zebra mussels or Eurasian watermilfoil. Results suggest that targeted sampling of the high-risk waterbodies may facilitate the early detection and prevention of AIS spread in Minnesota.

NOTES

Possible Ballast Water Transfer of Lionfish to the Eastern Pacific Ocean

Emma M. De Roy[1], *Hugh J. MacIsaac*[1], *Brian Leung*[2], *Alice Grgicak-Mannion1, and Gregory M. Ruiz*[3]
[1]*Great Lakes Institute for Environmental Research, University of Windsor*
[2]*Department of Biology, McGill University*
[3]*Smithsonian Environmental Research Center*

Lionfish (*Pterois volitans/ miles* complex) are invasive species whose spread has sparked concern about the prospect of a subsequent invasion to the eastern Pacific Ocean. We attempted to determine the possibility of lionfish transport to western United States and their potential for establishment following arrival. We queried the National Ballast Information Clearinghouse for ballast water records. Included were ships whose source ports originated in lionfish-invaded regions in the Atlantic Ocean and whose destination ports received untreated ballast water along the US Pacific coast. From 2006 to 2013, ships made 27 vessel-trips to the eastern Pacific via the Panama Canal and discharged untreated ballast water. San Francisco Bay received the greatest number of vessel trips while the combined area of Los Angeles- Long Beach received the greatest number and volume of ballast discharges. Probability of establishment was estimated through a Species Distribution Model using readily available environmental variables and lionfish occurrence data across the invaded range. Temperature and salinity were the main drivers of establishment; areas in the western contiguous USA that receive ballast water are presently seemingly unsuitable for lionfish establishment. On the other hand, Mexico and parts of South America, in particular Peru and the Galapagos Islands, were at highest risk for lionfish establishment. Until ballast water treatment is in place, we recommend that 'risky' vessels transiting the Panama Canal exchange ballast water in Gatún Lake to reduce risk of introducing lionfish into the eastern Pacific Ocean.

NOTES

Reduction of Pesticide Applications using New Microsponge™ Technology

Lucía G.I. Marshall[1], Richard L. Lowe[1]; John Knezvic[2], Richard Renick[2], Brian Bailey, ***Scott Schermerhorn***[2]
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One of the main problems in pesticide application is the run-off or dilution of applied materials due to morning dew, rainfall or over-head irrigation. Traditionally, surfactants have been used to aid the spread of applications on vegetation surfaces; however, these surface-active molecules have a tendency to facilitate the dissolution of chemicals in water and wash the pesticides off the treatment area. New natural-based Microsponge™ technology is replacing surfactants in chemical and biological applications due to their absorption and adhesion properties. The cereal-based microsponge technology was invented for aquatic applications in weed and algae control, and for horticulture use in disease/insect control. Applicators, growers and farmers are using the rainfastness properties of the Biocar® microsponges to adhere treatments and not lose the application during rain events.

This talk will introduce the microsponge technology as compared to current surfactants analyzing:

1. Chemical and biological properties of treatments as they are applied to the surface of waxy cuticles of plants;
2. Toxicology and persistence of surfactants in aquatic/environmental conditions;
3. Biological efficacy of herbicide treatments with surfactants versus the microsponge system;
4. Implication to environmental fate and chemical accumulation in waterways due to run-off.

Adhesion properties of the Microsponge™ system as compared to standard surfactants will be demonstrated on invasive reeds and hanging vines of Southwest Florida.

NOTES

Evaluation of Chemical Biocides and Algaecides for Controlling Sprouting of *Nitellopsis obtusa* Bulbils

John H. Rodgers[1], *Tyler D. Geer*[1]
[1]*Department of Forest and Environmental Conservation, Clemson University*

Nitellopsis obtusa (starry stonewort) is an invasive species of Eurasian origin that was likely transported and introduced to the United States in ballast water. Since it was first identified along the St. Lawrence River, *N. obtusa* has spread rapidly and established itself among inland lakes across the Great Lakes region of the United States. Star-shaped bulbils of *N. obtusa* are important for sprouting and dispersal of this invasive species of macroalgae. In an attempt to limit transport and spread of this noxious alga, water resource managers can inspect and clean boats as they move from infested lakes. Decontamination procedures, including pressure washing or application of algaecides or biocides, may be employed as an additional layer of protection to prevent dispersal. For this study a commercial hydrogen peroxide/peracetic acid biocide (Oxonia Active®), a copper-ethanolamine algaecide (Cutrine-Plus®), and a sodium carbonate peroxyhydrate algaecide (Phycomycin® SCP) were evaluated for their effectiveness against *N. obtusa* bulbils from several sources. Bulbils were exposed to 0.5%, 1.0%, and 3.0% solutions of Oxonia Active (as Oxonia Active®), 1.0 mg Cu/L (as Cutrine Plus®) and 10.2 mg H_2O_2/L (as Phycomycin® SCP). After 7-d exposures, bulbils were transferred to untreated site water, and sprouting was evaluated weekly in terms of visual growth of algal filaments from bulbils. Both peroxide and copper formulations were effective in controlling sprouting and growth of *N. obtusa* bulbils with observation over a period of 6 weeks.

NOTES

PROCELLACOR™ – A Novel Herbicide Technology for Selective Management of Aquatic Invasive Plants

Mark A. Heilman[1], *Michael D. Netherland*[2], *Robert J. Richardson*[3], *Erika J. Haug*[3], *Jens P. Beets*[4], *Ben E. Willis*[1]
[1]*SePRO Corporation*
[2]*US Army Corps of Engineers*
[3]*North Carolina State University*
[4]*University of Florida*

Management of aquatic invasive plants is faced with increasing regulatory requirements and technical challenges such as herbicide resistance, new weed species introductions, risks to threatened and endangered species and infestations in higher exchange systems. New herbicide technology is much-needed to sustain the long-term success of past and current integrated management of aquatic invasive plants. PROCELLACOR™ is a novel reduced-risk herbicide technology under development for aquatic use and anticipated for USEPA approval in 2017. PROCELLACOR (a.i. benzyl 4-amino-3-chloro-6-(4-chloro-2-fluoro 3methoxyphenyl)-5-fluoropyridine-2-carboxylate) has unique, low-rate, short-exposure, systemic activity for selective control of major US submersed weeds including hydrilla (*Hydrilla verticillata*) and invasive watermilfoils such as Eurasian watermilfoil (*Myriophyllum spicatum*), Eurasian X Northern (*M. sibiricum*) hybrids and parrotfeather (*M. aquaticum*). Other anticipated target US submersed weeds include water chestnut (*Trapa natans*), rotala (*Rotala* spp.), and hygrophila (*Hygrophila polysperma*). Relative to selectivity of control, PROCELLACOR has little to no effect on common US native submersed plants such as tapegrass (*Vallisneria americana*), common waterweed (*Elodea canadensis*), and pondweeds (*Potamogeton* spp.) as well as most common native emergent plants. The new herbicide also has selective in-water and foliar activity for treatment of certain emergent/floating US invasive aquatic plants such as water hyacinth (*Eichhornia crassipes*), crested floating heart (*Nymphoides cristata*), alligatorweed (*Alternanthera philoxeroides*), and primrose (*Ludwigia* spp.). In studies for registration, PROCELLACOR shows no mammalian toxicity and an excellent environmental profile for use in water. The technical properties of PROCELLACOR for its major aquatic weed control uses and outcomes of key studies in its development will be reviewed.

NOTES

Control of Colonial Hydroids using EarthTec QZ

David Hammond[1]
[1]*Earth Science Labs, Inc.*

EarthTec QZ is a formulation of liquid copper ions that is NSF-certified for drinking water and labeled since 2013 by EPA for use against zebra and quagga mussels that infest open waters or pipelines. In 2016-17 EarthTec QZ was used to control quagga mussels infesting the cooling system of a major water conveyance system in Arizona. The same cooling system was also infested with a freshwater species of colonial hydroid (*Cordylophora caspia*). The full-scale pilot study has shown in the field that EarthTec QZ can reliably and successfully control *Cordylophora* at unprecedentedly low doses, in the range of <0.1 mg/L as copper. The same and even lower doses were also effective against invasive quagga mussels. Dose-mortality and economic data will be shared from this case study and compared to other historical data from tests of copper chelates and conventional copper sulfate in the control of biofouling pests.

NOTES

Functional Feeding Traits as Predictors of Competitiveness of Alien Freshwater Fishes

Leopold Nagelkerke[1], *Rob Leuven*[2]
[1]*Wageningen University & Research, Aquaculture & Fisheries Group*
[2]*Institute for Water and Wetland Research, Radboud University, Nijmegen*

Invasive fish species are a major threat to the biodiversity of inland waters. Alien fish can be more effective predators than native species, thereby increasing the predation pressure on resident aquatic organisms. This may lead to shifts in the food web or even local extirpation of certain prey species. In addition to posing predatory dangers, alien fish species are potentially efficient food competitors of native species. In some cases such competitive interactions have been suggested to lead to the disappearance of native species, some of them with great biodiversity value. In the Netherlands, which has a relatively species-poor ichthyofauna, ca. 30% of the species are of alien origin. Competition for prey between alien and native species appears to occur to a varying degree. In a recent study on five species of Ponto-Caspian gobies, which form the most recent invasion wave, we investigated how such competitive interactions may depend on feeding-associated functional traits. We used an eco-morphological approach, which links the functional traits of the predator to the biomechanical, behavioral, and chemical characteristics of prey types. This resulted in a trophic profile of each fish species, describing its capacity for feeding on different prey types. Invasive gobies were found to widely differ in trophic profiles and thus in their potential competition with native species. Native species with trophic profiles overlapping with invasive species (such as native bullhead, *Cottus*, species, with alien Kessler's goby, *Ponticola kessleri*) appeared to be most sensitive for competitive feeding interactions. Given these results we therefore propose that functional feeding traits can be used in assessing the risk of competitive interactions between native and alien species. In this presentation we show how to construct trophic profiles, how to compare them, and discuss how competitive interaction can be deduced from them.

NOTES

Assessing the Impacts of the Invasive Channel Catfish *Ictalurus punctatus* in Central Italy

Phillip J. Haubrock[1,2], *Iva Johovic*[1], *Paride Balzani*[1], *Alberto Inghilesi*[2], *Annamaria Nocita*[3] & *Elena Tricarico*[1]
[1]*Department of Biology, University of Florence*
[2]*NEMO Ambiente s.r.l.*
[3]*Museum of Natural History, Zoology Section*

Although present in 32 European countries, the North American channel catfish *Ictalurus punctatus* has gained almost no scientific attention there. For this reason, any potential impacts and threats for recipient European environments are still unknown. In Italy, the introduction of alien species for recreational fishing has been a common problem. The river Arno, which is one of the two most important rivers in Central Italy, has been invaded by several invasive species of which the Channel Catfish is among the most widely abundant, with dense populations likely affecting other present native and invasive species. Previous monitoring studies showed that the catfish invasion started downstream close to Pisa and subsequently spread upstream. Furthermore, it was hypothesized that high population densities potentially affect the distribution of other top alien predators, e.g. the European catfish *Silurus glanis,* which is seemingly retreating and decreasing in its abundance following the establishment of channel catfish. To assess the impact of *I. punctatus*, we have been collecting specimens to analyze stomach contents, gonads and otoliths from several populations along the River Arno in order to determine its feeding habits, reproductive capability and population structure. Additionally, hybridization with another alien species, the North American blue catfish *Ictalurus furcatus*, has been hypothesized. As hybridization among invasive species poses an interesting case study for invasive species biology, the occurrence and impact of hybrids in comparison to parental species is also under study.

NOTES

Invasive Species and Plankton Dynamics of the Columbia River Estuary

Stephen Bollens[1], *Gretchen Rollwagen-Bollens*[1], *Julie Zimmerman*[1], *Eric Dexter*[1], *Jeffery Cordell*[2], *Timothy Counihan*[3]
[1]*School of the Environment & School of Biological Sciences, Washington State University*
[2]*School of Aquatic and Fishery Sciences*
[3]*Western Fisheries Research Center, Columbia River Research Laboratory*

We have been investigating the plankton dynamics of the Columbia River Estuary (CRE), with special emphasis on invasive species, for more than a decade. Several important findings have emerged from our field and experimental studies. First, that several species of Asian copepods have invaded the CRE, with one species in particular, the calanoid copepod *Pseudodiaptomus forbesi*, becoming extremely widespread (penetrating several hundred kilometers upriver) and very abundant in late summer and early autumn (it is the overwhelming dominant mesozooplankter at this time of the year). Second, *P. forbesi* feeds on diatoms, ciliates, flagellates, and dinoflagellates, and exhibits a general preference for diatoms and ciliates (which suggests potential competition with native copepods), and an avoidance of chlorophytes and cyanobacteria. Third, that *P. forbesi* can be preyed upon by a range of native CRE predators, including juvenile chinook salmon, three-spined stickleback, northern pikeminnow, and mysids, and that some (but not all) of these native predators select for native zooplankton over *P. forbesi*. Fourth, that an invasive Asian clam, *Corbicula fluminea*, is also extremely widespread and abundant. Fifth, that dreissenid (quagga and zebra) mussels have not yet (to our knowledge) invaded the Columbia River Basin, but that these mussels represent a major threat for future invasion. These results will be presented and discussed in the context of food web impacts and potential climate change effects.

NOTES

Potential Ecological Consequences of Grass Carp on Great Lakes Fish and Bird Communities

Erin Gertzen[1], *Marten Koops*[1], *Nichole Wiemann*[1], *and Becky Cudmore*[1]
[1]*Fisheries and Oceans Canada*

Grass Carp (*Ctenopharyngodon idella*) is currently widespread in parts of the United States and poses an imminent threat to the Great Lakes. As part of the binational Great Lakes Risk Assessment for Grass Carp, an evaluation of the potential impacts of Grass Carp introduction on the native fish and water bird communities of the Great Lakes is important. Predicting such impacts can help assess the level of risk anticipated if Grass Carp invade the Great Lakes. Grass Carp is a large, herbivorous fish that consume large amounts of aquatic vegetation and consequently may affect ecological communities that rely on such vegetation in the Great Lakes. The potential negative effect of Grass Carp on fishes was evaluated using spawning characteristics and habitat preferences for 136 fish species occurring in the Great Lakes Basin. The potential negative effect of Grass Carp on wetland birds was evaluated using feeding needs and nesting habitat for 47 bird species that were identified to use Great Lakes coastal wetlands in Canada as breeding habitat. In general, the predicted negative impacts of Grass Carp on fishes and birds are variable; however, the impacts may be extreme for certain sites and species in the Great Lakes.

NOTES

Interagency Coordination to Develop a Statewide Python Management Plan

Evan Freeman[1]
[1]*Florida Fish and Wildlife Conservation Commission*

The Burmese Python has established in the greater Everglades ecosystem in South Florida and impacts native wildlife through direct depredation and competition for resources. Due to the extent of python distribution in a relatively inaccessible landscape, multiple agencies and organizations share responsibility for control efforts, which can impart challenges for statewide management of this invasive species. While different land managers have cooperated to implement various control strategies in localized areas of known python distribution, no singular, cohesive python management plan exists for the state of Florida. The Florida Fish and Wildlife Conservation Commission (FWC) has taken the lead in cooperation with Everglades National Park (ENP) to develop an interagency, statewide python management plan. In coordination with additional partner agencies, which include numerous state, federal, tribal, county, university, and non-governmental entities, the FWC and ENP have organized a Workshop for Ongoing Python Research and will continue to facilitate coordination throughout the development of this management plan.

NOTES

Preliminary Characterization of Risk Posed by Aquatic Insect Bait to the Spread of AIS in the Great Lakes Region

Patrice Charlebois[1,2], *Martin Berg*[3], *Danielle Hilbrich*[1,2], *Mark J. Wetzel*[2]
[1]*Illinois-Indiana Sea Grant*
[2]*Illinois Natural History Survey, Prairie Research Institute*
[3]*Loyola University Chicago*

Although much is known about the potential invasiveness of earthworm and crayfish bait, information on the potential impact of aquatic insect bait is lacking. To address this knowledge gap, we sampled the availability of insect bait from ten high-volume bait shops in the Greater Chicago Metropolitan Area (GCMA). Organisms were identified to the lowest feasible taxonomic level and their native ranges determined. We then assessed whether each organism was being sold outside its native range but within an area of similar climate. Because information on invasiveness of most aquatic insect taxa is limited, this analysis provided insight into the possible invasiveness of each taxon. We also purchased and identified aquatic insects from non-GCMA bait shops throughout Illinois to determine the extent to which taxa available in bait shops varied within the state. Each retailer was interviewed to assess the popularity of each taxon to determine its relative usage. Additionally, we surveyed GCMA anglers who use aquatic insect bait about their bait use and disposal practices, which impact the overall risk of the aquatic insect bait pathway. Finally, we conducted an Internet search and native range analysis of insect bait available in the other Great Lakes states to determine the applicability of the information obtained in Illinois to the rest of the region. We will present the outcomes of these activities, which will augment our collective knowledge of the risk that this pathway presents to the spread of AIS in the Great Lakes region.

NOTES

A Hotspot for Aquatic Alien Species? Evidence for Recreational Angling as an International Invasion Pathway

Emily R.C. Smith[1], *Helen Bennion*[1], *Carl D. Sayer*[1]
[1]*Environmental Change Research Centre, Department of Geography, University College London*

An assessment of the relative importance of unintentional pathways of invasive alien species introduction is a key objective of the new EU Regulation of Invasive Alien Species (1134/2014). However, the risk posed by recreational angling, particularly at causing international scale introduction events remains relatively unknown. A survey for invasive species was conducted in 34 private fisheries in northern France in June and September 2016. These fisheries were all frequented by anglers from the UK, along with anglers from Western Europe. A total of 77% of the fisheries contained at least one invasive species. This included the mysid shrimp *Limnomysis benedeni* and ornamental plant *Ludwigia peploides*, both high- alert invasive species currently absent from the UK. Due to issues accessing private lakes, there is relatively limited information on the presence of invasive species in these systems. However, these findings indicate they may represent overlooked hotspot for invasive species within Europe. Furthermore, with an absence of biosecurity at the fisheries, invasive species are likely to survive in damp angling equipment, and hence these lakes could act as donor sites for the introduction of new invasive species or genetic strains to other countries. Further work is required to quantify the risk of this pathway. However, with an estimated 25 million anglers in Europe, the high volume and frequency of movement through this pathway, coupled with the high number of invasive species present in fishing lakes, indicates a greater risk of introduction than previously estimated. Biosecurity compliance is essential to minimising the risk of dispersal through this pathway. It is recommended that countries engage in public education programs to increase anglers' awareness of the importance of biosecurity, and relevant authorities work with fishery owners to implement biosecurity protocol and a reporting procedure for the occurrence of new invasive species in their lakes.

NOTES

Using Environmental DNA for Sea Lamprey Assessments in Great Lakes Tributaries

Christopher M. Merkes[1], *Nicholas A. Schloesser*[1], *Christopher B. Rees*[2], *Jon J. Amberg*[1]
[1]*U.S. Geological Survey, Upper Midwest Environmental Sciences Center*
[2]*U.S. Fish & Wildlife Service*

Since the crash of the fisheries in the Great Lakes in the late 1940s and early 1950s, the Great Lakes Fisheries Commission (GLFC; established in 1955) has been working to control invasive Sea Lamprey (*Petromyzon marinus*) populations. The GLFC takes an integrated approach to controlling Sea Lamprey using barriers to prevent upstream migration for spawning, traps to remove spawning adults, and lampricide treatments on larvae-infested streams to prevent recruitment. Because eradication is not feasible in the Great Lakes, larval Sea Lamprey population assessments are conducted to rank streams for cost-effective lampricide treatments. These assessments rely on many hours of electroshocking and field identification of native lampreys. Additionally, the assessments make stream population estimates based on surveys of only a few small areas, and not all suitable tributaries are assessed every year.

Using environmental DNA (eDNA) for Sea Lamprey assessments could augment the traditional methods for expanded and more accurate assessments leading to more efficient control strategies. We developed four qPCR markers for Sea Lamprey-specific detection, and used them to compare eDNA results to different densities of larval or adult Sea Lamprey in lab trials. We then applied them to field samples collected during the spring spawning migration and again in the fall when only larvae should be present. Field eDNA results were compared with concurrent adult trapping and larval traditional assessment data.

NOTES

Human-mediated and Natural Dispersal of an Invasive Fish in the Eastern Great Lakes

Mattias L. Johansson[1], *Bradley A. Dufour*[1], *Kyle W. Wellband*[1], *Lynda D. Corkum*[1], *Hugh J. MacIsaac*[1], *Daniel D. Heath*[1]
[1]*Great Lakes Institute for Environmental Research, University of Windsor*

The globally invasive Round Goby (*Neogobius melanostomus*) was introduced to the Great Lakes around 1990, spreading widely and becoming the dominant benthic fish in many areas. The speed and scope of this invasion is remarkable and calls into question conventional secondary spread models and scenarios. We utilized 9 microsatellites to identify large-scale genetic structure in Round Goby populations in the eastern Great Lakes, and assessed the role of initial colonization versus secondary transport and dispersal in developing this genetic structure. We identified three clusters, corresponding with Lake Huron, eastern Lake Erie, and western Lake Erie plus eastern Lake Ontario, along with three highly-divergent populations. Bottleneck analysis identified founder effects in two divergent populations. Regression analyses of isolation-by-distance and allelic richness vs. distance from the initial invasion site were consistent with limited migration. However, assignment tests and anomalous results in regression analyses suggested that some populations resulted from long-distance transport, potentially of large numbers of individuals. Genetic structure of Round Goby in the Great Lakes likely resulted from three factors: 1) introduction of large numbers of individuals from Eurasia; 2) long-distance secondary transport via ballast water and bait buckets; and 3) natural dispersal. The success of Round Gobies represents an interesting model for colonization characterization; however, those same attributes present significant challenges for conservation and fisheries management. Current management likely prevents many new species from arriving in the Great Lakes, but fails to address the transport of species within the lakes after they arrive; an issue of clear and pressing importance.

NOTES

Invited Keynote Presentation

Knowledge to Action on Aquatic Invasive Species: Island Biosecurity – the New Zealand and South Pacific Story

Paul Champion
National Institute of Water and Atmospheric Research (NIWA)

New Zealand and Australia are regarded as world leaders in the field of biosecurity, the management of invasive pests and weeds including aquatic species. This talk is the final in the series of plenary sessions on the theme "Global Action Against Aquatic Invasive Species", outlining biosecurity science and its application in these and other Pacific islands. Proactive management actions include:

- attempting to keep future pests off-shore
- evaluation of the risks posed by species either pre- or post-border
- managing their dispersal
- surveillance for incursion detection
- eradication programmes
- prevention of spread

The talk will also outline the unique set of circumstances, especially within New Zealand, that allow for the success of these initiatives.

Paul Champion
Principal Scientist - Freshwater Ecology, National Institute of Water and Atmospheric Research, New Zealand

Paul has specialist expertise in biosecurity, plant ecology and conservation of endangered plant species, especially in freshwater and wetland habitats. Focus research areas include assessment of weed potential of introduced plants, management of alien aquatic weeds (including surveillance, control techniques and strategies), assessment of environmental impacts of both freshwater pest invasions and weed control strategies and restoration of habitats impacted by invasive weeds. In addition to his research areas, He has effectively communicated his and others research in the development of policy and management directions with central and regional government agencies and other resource managers. Examples include providing the science behind national pest management strategies such as the National Pest Plant Accord and National Interest Pest Responses, and regional pest management plans and region-wide lake protection strategies. Paul has organised consortia of management agencies in order to introduce new control tools into New Zealand and ensured their usage complies with Environmental Protection Authority standards. Paul joined NIWA in 1994 and was appointed Program Leader – Freshwater Biosecurity in July 2015. He has been a Principal Scientist – Freshwater Ecology since 2004. He previously worked with the Ministry of Agriculture and Forestry coordinating eradication programs for nationally important weeds.

Data Aggregation: Data Goes in, Data Goes Out. You Can't Explain That!

Charles T. Bargeron[1] *and* ***Rebekah D. Wallace***[1]
[1] *University of Georgia, Center for Invasive Species and Ecosystem Health*

The University of Georgia's Center for Invasive Species and Ecosystem Health (Bugwood) has worked with programs and agencies nationwide to aggregate, visualize, publicize, and recruit invasive species data using the EDDMapS database and tools. Through the EDDMapS website and smartphone apps, users can report invasive species and local experts will verify reports. That data is then displayed on the EDDMapS websites and is available for download as well. After experiencing success with the Florida IveGot1 program, a joint project encompassing multiple agencies in Florida for documenting, verifying, and publicizing the invasive species issue, the Minnesota Department of Natural Resources reached out to Bugwood. Minnesota DNR uses EDDMapS tools for in-field reporting by their trained crews and then biologists and other experts can verify these reports, which has allowed for streamlining of their Infested Waters program. Reports of specific, highly-concerning aquatic invasive species are sent straight to the appropriate people in real-time, these reports can be verified by designated experts, the areas of infestation can be delineated, and in-state procedures can be enacted quickly. This makes early-detection, rapid response programs more effective and local awareness programs and cleaning procedures can be marketed to the public.

NOTES

Risk Assessment Database for the Great Lakes Region

David Nisbet[1], *Maria Al Zayat*[1]
[1]*Invasive Species Centre*

Risk assessments are essential tools for predicting the likelihood than an invasive species will enter, establish, and spread in a novel region or environment. The Invasive Species Centre (ISC) identified that much information on risk assessments was decentralized; a wide range of species had been assessed, and the methodologies for assessment varied greatly by jurisdiction and assessing body. In an effort to consolidate this information, the ISC developed a searchable risk assessment database for invasive species relevant to the Great Lakes Region. This database is a valuable tool enabling stakeholders to quickly access risk information to inform response. This presentation will discuss the development of the database, how to access and use the database, and expansion of the database to include additional jurisdictions.

NOTES

Noteworthy Distribution Changes to Non-native Aquatic Plants in the U.S. Since 2015

Ian Pfingsten[1], *Pam Fuller*[2]
[1]*Cherokee Nation Technologies, contracted to: U.S. Geological Survey*
[2]*U.S. Geological Survey*

The USGS Nonindigenous Aquatic Species (NAS) database (http://nas.er.usgs.gov) contains occurrence records, distribution maps, and fact sheets of aquatic, non-native plants and animals found in the United States, including Guam, Puerto Rico, and the U.S. Virgin Islands. Date and locality data are obtained from many sources including federal, state, and local monitoring programs, literature, museum and herbarium collections, on-line databases, websites, professional communications, and on-line reporting forms. The aquatic plant portion of the database was restored in 2015 after a ten-year hiatus. Since 2015, the NAS database has added more than 100,000 new plant occurrences for 200+ non-native or native transplanted aquatic plant species in the U.S. Of those new occurrences, 76 were first records of a species for a state, county, or drainage. These first occurrences represented 24 plant species. Managers need to know what is new to their area, or new to a nearby area, in order to respond quickly. Conversely, managers are encouraged to report their observations of new occurrences to the NAS database so the information can be disseminated to other managers, researchers, and the public. Here we summarize recent spread of major nonindigenous aquatic plant species in the U.S., such as *Butomus umbellatus, Eichhornia crassipes, Hydrilla verticillata, Myriophyllum aquaticum, M. spicatum, Nitellopsis obtusa, Nymphoides peltata, Pistia stratiotes, Potamogeton crispus, Salvinia molesta*, and *Trapa natans*. One aquatic plant species was new to the U.S. since 2015; *Scleria microcarpa* (tropical nutrush), a Central and South American native, was discovered in FL in 2016. More information can be found on our website (http://nas.er.usgs.gov), and sighting reports can be sent directly to us via our mobile app. Interested users may register to receive notifications of these new occurrences using the NAS Alert System – located on our web site above.

NOTES

Application of a Watch List of High Risk AIS to Inform Surveillance Site Selection and Sampling Methods in the Laurentian Great Lakes

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A Great Lakes Aquatic Invasive Species Interstate Surveillance Framework (the Framework) has been drafted to address the regional goal of establishing a comprehensive program for detecting and tracking newly identified aquatic invasive species (AIS) in the United States' waters of the Laurentian Great Lakes. As part of the Framework, a Great Lakes surveillance watch list based on pathway-, vector-, and taxon-specific risk assessments was completed using the Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS). Here we discuss how data from the watch list species' risk assessments were used to identify and quantify the relative risk of introduction from pathways associated with high and moderate risk AIS, and how the information was applied to prioritize locations where surveillance efforts are most likely to detect these or similar high risk species. The watch list risk assessment data can also be used to inform decisions around which habitats need to be sampled and what sampling methods should be deployed to maximize detection sensitivity and the probability that new introductions of high risk AIS are detected early. Finally, we discuss how the data provide a resource that can be used to inform response efforts should a watch list species be detected.

NOTES

From Bad to Worse: Update on the Non-native Freshwater Fishes in Flanders (Belgium)

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Considering the new EU regulation 1143/2014 on the prevention, early detection and rapid eradication, and management of invasive alien species (EC, 2015) it is important that all member states, after non-native organisms have been discovered, follow up the invasive populations. Reporting on the non-native species' presence, spread and also pathways is an important part of regulation's obligations. Verreycken *et al.* (2007) reviewed the non-native freshwater fish species in Flanders (North Belgium) and described the status, pathways and trends of the 14 non-native freshwater fish species present at that time. Now, a decade onwards, already 25 non-indigenous freshwater fishes have been recorded in this small area (13 522 km²). Although some species are represented by one discovery only (e.g. *Ictalurus punctatus*), other species have become widespread and very abundant in the last five years (e.g. *Neogobius melanostomus*). We will discuss all the non-native freshwater fishes present and highlight their distribution, origin and pathways but also their impact and invasiveness. Also non-indigenous fish species present in neighbouring areas, expected to arrive in Flanders in the coming years, will be taken into account.

NOTES

Postglacial Colonizer or Cryptic Invader? Case of *Gammarus roeselii* (Crustacea Amphipoda) in Europe

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Gammarus roeselii Gervais, 1835 is an epigean species commonly found in rivers and lakes of Europe. The species has Balkan origin and most probably colonise the rest of Europe in historical times. In our study we aimed to test this hypothesis i.e. to define the origin of populations from western and central Europe and if these populations fit the model of demographic/spatial expansion. We amplified a 533 bp long portion of the mitochondrial cytochrome oxidase I (COI) marker from 866 specimens collected from 66 locations all over Europe, including 26 locations from the Balkan Peninsula. Relationships between haplotypes in populations from the presumably newly colonized part of Europe were illustrated with Minimum Spanning Network (MSN). Demographic changes in time were plotted using Bayesian Skyline Plot (BSP) analysis in BEAST, and Mismatch Distribution in Arlequin. Our results reveal that populations of *G. roeselii* inhabiting western and central Europe derive from the northernmost part of the Balkan Peninsula and from the Pannonian Plain i.e. from the Danube catchment. MSN shows existence of two haplotype groups widely spread in western and central Europe. The obtained star-like topology of MSN for these two groups as well as results of the MD analysis suggest that western and central European populations of *G. roeselii* are in the state of both demographic and spatial expansion. BSP shows that the demographic expansion have started at ca. 10 kya and accelerated at ca. 6 kya for one haplotype group and at ca. 2 kya for the other one. Thus, we may suspect that, already in early Holocene, the species has started its colonization up the Danube system. On the other side, its current distribution suggests that the species crossed the main watersheds only after large navigable canals were built and joined the Black, Mediterranean, North and Baltic Sea basins.

NOTES

Early Invasion Dynamics of New Zealand Mudsnails in Michigan Rivers

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New Zealand mudsnails are a recent invader to the state of Michigan, and have generated considerable concern among resource managers. New Zealand mudsnails were initially detected in non-targeted surveys in the Pere Marquette River in 2015, and have since been found in the Au Sable and Boardman Rivers. Our first goal was to determine the spatial extent of this species in these rivers, and to determine how much the range has expanded in the Pere Marquette between 2015 and 2016 using targeted qualitative surveys. The 2015 surveys show that the distribution in the Pere Marquette River encompassed at least 9.8 river miles. Preliminary surveys indicate that the range has expanded in 2016, but further sampling in the fall will refine estimates of the range. The distribution in the Au Sable River shows a disjoint distribution, with patches occurring in the East Branch as well as the South Branch and mainstream of the river. Information from a local conservation group suggests that the infestation in the Boardman River likely dates back to at least 2012. This infestation, however, went unreported until "unknown" snails in 2016 reached densities high enough to cause concern and ultimately lead the group to request confirmation of identification from taxonomic experts, which resulted in confirmation of New Zealand mudsnails. In implementing these surveys, a natural question is, how efficient are qualitative searches in detecting mudsnails when present. As such, our second goal was to estimate the detection probability for qualitative surveys. We implemented a split-plot type of sampling design, and found that when mudsnails were found in one sub-plot, they were also generally found in the other sub-plot, and rarely were there cases where they were found in only one sub-plot.

NOTES

Alien Freshwater Fish in Italy Have Over Passed the Native One as Number of Species and Locally Also as Biomass and Number of Specimens

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Freshwater fish are taken in little considerations for the preservation of biodiversity in Italy. In spite of the very ancient origins of freshwater fish, especially cyprinids, which make Italy a spot of unique biodiversity, and recent literature published in International Journals, and the IUCN list were most species are endangered and one, *Scardinus scardafa,* recently extinct, this was not enough to draw attention by conservationist and public authorities to the preservation of biodiversity of this animal category. The result of this situation, in due course, is either by legally stockings in every rivers for peninsular and insular regions of Italy with fish from others transalpine countries, and transfer of native fishes from one freshwater districts to another or by the inadequate old literature used for fish identification. About 51 species are of alien origins against the 50 natives. In larger northern Italy rivers the biomass of aliens may represents up 97% of total. Species as topmouth gudgeon, *Pseudorasbora parva*, present as impurity in stocked materials, now was spread in nearly every river of peninsular and several river of insular Italy. The giant wels, *Silurus glanis*, have been recorded in every river of northern, central and now also in River Crati in southern Italy. The spread of this species is probably by release in public waters by owner of private pounds when they realize the danger of this species as predator in restricted environment as ponds. Another dominant alien species, the Danubian roach, *Rutilus rutilus,* caused the reduction or the local extinction of endemic *R. pigus*, *Leucos aula* and *Sarmarutilus rubilio*.

NOTES

Starry Stonewort in Michigan (USA)

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Goal directed lake management programs are challenged when lake ecosystems are disturbed by invasive and opportunistic species that compromise biological diversity, habitat complexity, and ecosystem stability. Starry stonewort has a profound effect on the lakes where it is found and presents a very significant challenge to northern lake managers. The most predictable characteristic of starry stonewort (*Nitellopsis obsusa*) is that it is incredibly unpredictable. As an opportunistic invasive species it is known to bloom and crash but it is nearly impossible to predict when this might happen. This unpredictability seems to be related to the reasons that this nuisance alga can become so weedy and why it can be so difficult to control. It is critical to understand how a non-vascular plant can grow 8 ft tall or more? Why do starry stonewort meadows boom and crash? And, when they do crash, why is all other plant growth frequently eliminated from the crash zone? Is it possible to predict when and where starry stonewort will grow to nuisance levels? Why is it so easy to kill but so difficult to treat. Is it possible to selectively control starry stonewort and what are realistic expectations for the outcomes associated with selective control strategies? Data and videos will be presented that provide a strong argument to support the role of temperature gradients in the support and collapse of starry stonewort populations. It will also become clear why it may be so difficult to control starry stonewort in some situations.

NOTES

But it's So Pretty… Florida's Lovely Invasive Aquatic Plants

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South Floridians with free time on their hands often develop an interest in outdoor activities because temperatures in the region rarely climb above freezing, even in the dead of winter. A yearning to be outside, where they can enjoy nature year-round, drives residents to take up hobbies that include yardwork, landscaping and water gardening. The mild climate that residents enjoy extends to Florida's aquatic environment as well, and the state's warm, nutrient-rich waters are among the most highly invaded aquatic systems in the world. In this presentation I will outline the history and identifying characteristics of some of the water garden and aquarium escapes that have invaded Florida's waters.

NOTES

Slowing the Spread of Invasive Alien Species: Biosecurity Best Practice and Stakeholder Engagement

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Invasive Alien Species (IAS) are one of the greatest threats to biodiversity worldwide, with estimated global costs of US$1.4 trillion per year (Pimentel *et al.* 2001). Biosecurity is key to preventing the introduction and spread of IAS into new areas. Researchers represent an important group of stakeholders in relation to IAS. Researchers from a range of disciplines (e.g. ecology, conservation) undertake activities in the field that could potentially bring them into contact with/facilitate the spread of IAS. Information campaigns target awareness and risk perception around an issue aiming to indirectly influence behaviors.

The aim of this study was to investigate stakeholders' perception of risk in relation to their field activities and whether risk perceptions influenced behavior. Our study group was researchers from UK universities and research institutes. The study was timely as the UK government introduced the Check Clean Dry campaign in 2010 which aimed to raise awareness among water users about IAS and biosecurity. We gathered quantitative data on perceptions of risk and biosecurity practices using an online questionnaire (n = 65).

Only 35% of all respondents considered their field activities to pose some risk in terms of spreading IAS. Higher risk perception was found in those who have experience working in high risk environments or where IAS were known/expected to be present. Those with experience of IAS in the field were more likely to report employing biosecurity, unfortunately, whilst respondents reported consciously employing biosecurity in the field they did not in fact display better actual biosecurity practices.

We conclude that there is a need to raise awareness about IAS and the risks posed by fieldwork. There appears to be a disconnect between an individuals' perception of risk and undertaking biosecurity practices in the field and a lack of understanding about what constitutes good biosecurity practice.

NOTES

Population Genetics Characterization of Silver and Bighead Carps Invasion Fronts Approaching the Great Lakes

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Invasive populations of silver (*Hypophthalmichthys molitrix*) and bighead (*H. nobilis*) carps escaped from captivity in the 1970s to become widespread throughout the Mississippi River basin and now pose imminent invasion threats to the Great Lakes. These large, voracious, and prolific planktivorous filter-feeders are projected to severely impact native food chains and threaten fisheries. Almost nothing is known of their fundamental population genetic variability, which we evaluate using nuclear DNA microsatellite variation and mtDNA sequences at the two most likely invasion entry sites outside Chicago, Lake Michigan and (2) the Wabash River, leading to western Lake Erie through the Maumee River, in comparison to longer-established core populations in the Mississippi River. Microsatellite and mtDNA sequences reveal considerable genetic diversity across the invasions, which may aid adaptation and success. Sequencing results for silver carp reveal predominant haplotypes as well as unique (private) ones at each invasion front area. There is some significant divergence between the Illinois River front versus the established Mississippi River core population. This research will provide managers with important genetic baseline tools towards combatting the invasions and mitigating their effects.

NOTES

Tributary Use and Large-Scale Movement of Grass Carp: Patterns to Inform Control Efforts in Western Lake Erie

Cleyo Harris[1], *Travis Brenden*[1], *Charles Krueger*[1], *Seth Herbst*[2], *and Chris Vandergoot*[3]
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Grass carp (*Ctenopharyngodon idella*) were first imported to the U.S. in the early 1960s and by the 1970s were being widely introduced as a means for vegetation control. Over the past 20 years, grass carp have been detected at low densities in Lake Erie, but were deemed a low threat because most were assumed to be triploid individuals and consequently reproductively sterile. Recent evidence suggests that wild recruitment of grass carp in Lake Erie is occurring, which has elevated concerns about population expansion and spread. Grass carp life history and behavioral aspects in the Great Lakes are unknown and these knowledge gaps hinder design of effective control strategies. The objectives of this study were to determine tributary use, locations of potential fish aggregations, and the extent of inter-basin movements in Lake Erie and the potential for expansion into other Great Lakes areas. To date, 32 grass carp have been collected and tagged with acoustic transmitters. Movement and tributary use of tagged fish is being monitored with strategically placed, passive acoustic receivers in combination with mobile tracking methods through collaboration with the Great Lakes Acoustic Telemetry Observation System (GLATOS). Based on location data collected in 2015 and 2016, tagged grass carp appeared to selectively use larger tributaries. Although some tagged grass carp moved fairly long distances, to date no movement out of Lake Erie has been detected. The results of this study are increasing the understanding of grass carp seasonal movement patterns in Lake Erie and will help inform science-based management approaches for control.

NOTES

Multi-Jurisdictional Collaborations and Structured Approach for Grass Carp Control in Lake Erie

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Grass carp have been sporadically captured in the four lower Laurentian Great Lakes dating back to the early 1980s. More recently, grass carp captures have become more frequent in the western basin of Lake Erie, which has increased concerns of population expansion among managers. Lake Erie captures were initially thought to have originated from either accidental releases or immigration of sterile individuals stocked for macrophyte control in adjacent waters. These concerns led to the formation of a collaborative grass carp workgroup between the Michigan and Ohio Department of Natural Resources. Since the workgroup formed they invested in research projects to address key knowledge gaps that limited the effectiveness of control actions, which have also improved the overall understanding of the status of the Lake Erie grass carp population. These recent studies refuted the original assumption that most captures were sterile. In fact, the majority (~86%) of Lake Erie grass carp captured and analyzed for ploidy in recent years have been fertile. Moreover, successful spawning and reproduction has been documented in the Sandusky River and further evidence indicates that the natal origin among feral captures is not linked to one tributary. The workgroup, armed with this new information, completed a structured decision making (SDM) process to help guide management decisions related to controlling these invasive fish in Lake Erie. During the SDM process the group invited regional managers and subject experts to help define the problem, determine objectives, brainstorm control actions related to achieving objectives, identify key uncertainties associated with performing those management actions, evaluate the effectiveness of control alternatives, and managers decided upon the potential strategies for grass carp control. Additionally, the group reflected upon policy options for preventing future contributions and associated risks of fertile fish to Lake Erie. The agencies' incorporation of current Great Lakes governance processes, a solid commitment to collaboration and regular dialogue is key to identifying appropriate strategies to reduce future risks presented by grass carp in Lake Erie.

NOTES

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Each day, pressure mounts on the unique ecosystems that produce the fresh water vital to all life.

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Technological improvements can only be achieved through competent and sustainable research and development (R&D) programs. In the past, the federal government has played the prominent role in maintaining a coalition of research scientists, natural resource agencies, academic institutions, and private sector interests for studying and managing nuisance aquatic and wetland

vegetation. However, significant reductions in agency funded R&D programs have created a technological void while invasive aquatic and riparian weeds continue to spread and cause grave environmental damage.

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Biosorb, Inc. was founded in 1998 as bioscience based company providing natural-based products for horticultural, aquatic, turf, ornamental, golf course, landscape, agricultural, and environmental industries. The company owns proprietary patented technology based on Microsponge™ delivery systems called Biocar® made from cereal grain and oil-seed by-products. The natural product technology allows new proprietary products to be made that are safer for the environment due to the absorption, coating and adherence properties of grain materials.

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Diversified Waterscapes' mission is to provide exceptional quality of products and services for the protection of surface waters. DWI has an extensive knowledge base that includes experienced personnel and seasoned professionals in the management of lakes and ponds throughout the entire country for the last 29 years. We see annual growth in our business primarily through referrals and repeat customers and are equipped and staffed to service any size account. To maintain expertise and status as an industry leader, we are consistently expanding our knowledge by investigating industry trends, laws and regulations – ensuring our products and services are always the most updated and efficient in the industry. Our competitive advantage rests in awareness of all cutting-edge solutions that can be leveraged to solve your aquatic problems with superior efficiency. Our philosophy is to impart total quality, constantly exceeding the expectations of our distributors and consumers alike. We are dedicated to continually improve our technical and distributor support service, attitude, communication and innovative development of new products.

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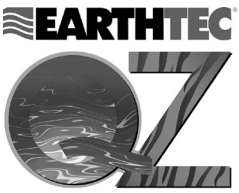

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Earth Science Labs (ESL) is a U.S. company that manufactures EarthTec® algaecide and other water treatment products, including Earthtec QZ for control of invasive mussels, and the PristineBlue® line of pool and spa chemicals. Earth Science Labs treats the water we use, drink and play in.

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- History of effective use with no negative impacts on fish and other non-targets.

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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.

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The International Joint Commission prevents and resolves disputes between the United States of America and Canada under the 1909 Boundary Waters Treaty and pursues the common good of both countries as an independent and objective advisor to the two governments.

In particular, the Commission rules upon applications for approval of projects affecting boundary or transboundary waters and may regulate the operation of these projects; it assists the two countries in the protection of the transboundary environment, including evaluating the governments progress toward restoring and maintaining the chemical, physical and biological integrity of the waters under the Great Lakes Water Quality Agreement and the improvement of transboundary air quality; and it alerts the governments to emerging issues along the boundary that may give rise to bilateral disputes.

In 1988, both the International Joint Commission (IJC) and the Great Lakes Fishery Commission (GLFC) alerted the governments of the United States and Canada that aquatic alien invasive species (AIS) in ballast water posed a significant threat to the Great Lakes. The two commissions urged the nations' Coast Guards to take immediate steps to end the ongoing introduction of exotic organisms via ballast water discharge, and having been reporting on AIS issues since.

Invasive Species Centre

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www.invasivespeciescentre.ca

The Invasive Species Centre is a not-for-profit organization that prevents and reduces the spread of invasive species by connecting with a broad array of stakeholders to catalyze invasive species management and communicate policy and science knowledge in Canada and beyond.

In addition to acting as the secretariat for ICAIS, current aquatic invasive species projects include:

- expanding a risk assessment database, writing ecological and socio-economic risk assessments and facilitating peer-review workshops, investigating tools available for emergency pesticide use registration with a view to improving access to aquatic herbicides, hosting and facilitating an aquatic invasive species response framework workshop for Ontario, and funding research on water soldier biology and herbicide efficacy;
- partnering with Fisheries and Oceans Canada on the Asian Carp Canada program which increases Canada's ability to prevent, detect and rapidly respond to Asian carps by providing Canadians with information about the most recent prevention technologies, early warning measures, response efforts, and the overall threat of Asian carps to the Great Lakes and beyond; and
- partnering with the Ontario Federation of Anglers and Hunters and Ontario Invasive Plant Council on the Early Detection and Rapid Response Network to train communities to fight invasive species by equipping a network of citizen scientists with the skills and tools to identify, detect, monitor, and control invasive species.

Marrone® Bio Innovations

Marrone Bio Innovations Inc.

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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 economic and ecological impact of invasive aquatic mussels. The company is also developing solutions for the control of algae and aquatic weeds.

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Zequanox is registered by the U.S. EPA for use in enclosed or semi-enclosed systems, such as service water and irrigation systems, and in open water settings like lakes and streams. In Canada, Zequanox is registered for hydroelectric facilities with planned expansion into other enclosed systems, as well as open water. Registration is also underway for use in enclosed and open water systems in the EU. No special precautions are required for employees working near Zequanox treatment areas. Zequanox is non-corrosive, and causes no accelerated deterioration of pipes, valves, and other infrastructure as can happen with other chemicals. There are minimal regulatory restrictions on the use of Zequanox, and MBI staff is comfortable and experienced working with regulatory authorities to support obtaining any necessary permits for those wishing to use Zequanox.

Ontario Federation of Anglers and Hunters
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The Ontario Federation of Anglers and Hunters was founded in 1928 due to concern over the future of Ontario's natural resources. It is Ontario's largest, non-profit, conservation-based organization, representing 100,000 members, subscribers and supporters, and 740 member 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 89 years, the OFAH has supported programs to conserve and restore fish and wildlife habitat, as well as to help protect our fishing and hunting heritage.

Recognizing the impacts of invasive species and the role of outdoor enthusiasts in their introduction and spread, in 1992 the OFAH initiated the Invading Species Awareness Program in partnership with the Ministry of Natural Resources and Forestry, with the objective to raise public awareness of invasive species and to engage 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 online reporting system (www.eddmaps.org/ontario). Through our partnership with the Government of Ontario to deliver this province-wide program, the ISAP has become a leader in invasive species education and awareness in Ontario, and has achieved 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 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 and Forestry

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The Ministry of Natural Resources and Forestry (MNRF) is responsible for protecting and sustainably managing the province's diverse natural resources, and supporting Ontario's economic prosperity, environmental sustainability and quality of life. MNRF manages our natural resources in an ecologically sustainable way to ensure that they are available for the enjoyment and use of future generations. The ministry fulfils its mandate through a broad range of legislation, policies and programs that reflect its diverse responsibilities. The ministry also works with a wide variety of partners and other ministries to meet current resource-based needs while at the same time ensuring that natural resources will be available for future generations.

To achieve its mandate, commitments and deliver its diverse programs, the ministry:

- monitors, researches and plans the management and use of Ontario's natural resources;
- develops legislation, policies and programs to regulate the conservation or sustainable use of Ontario's natural resources;
- delivers direct services to the public and industry; and
- protects the public from natural disasters or occurrences, such as floods and forest fire.

As part of its diverse mandate, MNRF has the lead provincial role to prevent the introduction, establishment and spread of invasive species and the negative effects they have on Ontario's environment, economy and society. This includes:

- leadership and coordination of inter-agency activities to prevent, detect, respond and manage the threat of 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

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Ontario Power Generation (OPG) is Ontario's largest clean electricity generator. In 2014, OPG stopped using coal to make electricity. It was North America's largest single action to combat climate change. Today, the company's diversified generating portfolio, which is 99.7 per cent free of smog and greenhouse gas emissions, consists of two nuclear, 65 hydroelectric, and three thermal generating stations. We're dedicated to making sure our generating stations continue to provide clean, reliable power at about half the cost of other generators.

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.

RESEARCH INSTITUTE
NATURE AND FOREST

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The Research Institute for Nature and Forest (INBO) is the Flemish research and knowledge centre for nature and its sustainable management and use. INBO conducts research and supplies knowledge to all those who prepare or make the policies or are interested in them.

As a leading scientific institute, INBO works for the Flemish government primarily, but also supplies information for international reporting and deals with questions from local authorities. In addition, INBO supports organisations for nature management, forestry, agriculture, hunting and fisheries. INBO is a member of national and European research networks. It makes its findings available to the general public.

INBO employs some 250 staff, mainly researchers and technicians.

With regard to aquatic invasive species (AIS) INBO plays a lead role in research, monitoring and management of these invasives in the northern part of Belgium. Current AIS research topics include: monitoring of spread and impact of Ponto-Caspian gobies, management of American bullfrog, drafting and reviewing risk assessments for invasive alien species, horizon scanning of new AIS, monitoring and surveillance of AIS, the publication of open data on invasives as well as the development of registries and data warehouses. The institute is a key player in implementing the recently approved European Union Regulation on the prevention and management of invasive alien species list.

INBO scientists liaise with European and other international experts on AIS to tackle the issue on a pan-European or worldwide scale. Results of these collaboration can be found in reports to managers and stakeholders and in numerous peer reviewed papers. The institute was involved in several outreach activities such as the Interreg project Invexo (http://www.invexo.be/), RINSE (http://www.rinse-europe.eu/, Reducing the Impacts of Non-native Species in Europe) and SEFINS (Safeguarding the Environment from Invasive non-native Species) which seek to improve awareness on the invasive species issue, and to develop methods to address them.

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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.

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As part of its mission to provide impartial information on the health of our ecosystems and environment, the natural hazards that threaten us, the natural resources we rely on, the impacts of climate and land-use change, the U.S. Geological Survey conducts science to support sound management and conservation of our Nation's biological resources. It does this through research, technical assistance, and education conducted by Cooperative Research Units and Science Centers located in nearly every State. In the Invasive Species and Wildlife Disease Program, USGS scientists work with Federal, State, local, and other partners to prevent, detect, and identify invasive species and wildlife disease using advanced technologies. USGS biologists also predict potential distribution and impact of invaders, develop and test methods of containing and controlling them, work with partners to determine effective restoration measures after control has been applied, and make data and data visualization tools broadly available. Examples of current USGS aquatic invasive species research include a research program to prevent Asian carp from becoming established in the Great Lakes (http://cida.usgs.gov/glri/#/Home/AsianCarp), co-leadership of a collaborative in the Great Lakes to control Common Reed (Phragmites) (http://greatlakesphragmites.net/); data delivery and visualization of aquatic invasive species occurrences (http://nas.er.usgs.gov); co-leadership of an invasive mussel collaborative (http://glc.org/projects/invasive/mussel/).

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The University of Florida is one of the nation's leading public land-grant universities, and the Institute of Food and Agricultural Sciences (UF/IFAS) is the UF agriculture and natural resources program. UF/IFAS is operated via federal, state and county partnerships and has three main units, dedicated to teaching, research and Extension outreach. Besides educating undergraduate and graduate students, UF/IFAS provides research and development, Extension education and technical assistance to Florida's agricultural, natural resources and related food industries, which had total value-added impacts of $127.34 billion for Florida's economy in calendar year 2014, the most recent year analyzed. UF/IFAS has presence statewide, including the College of Agricultural and Life Sciences on the main UF campus in Gainesville, 18 off-campus research facilities and UF/IFAS Extension offices in all 67 Florida counties. UF/IFAS also administers the Florida Sea Grant program, the UF/IFAS Global engagement program, the Florida 4-H Youth Development Program and aspects of the UF College of Veterinary Medicine.

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