2007

ICAIS

15th International Conference on Aquatic Invasive Species

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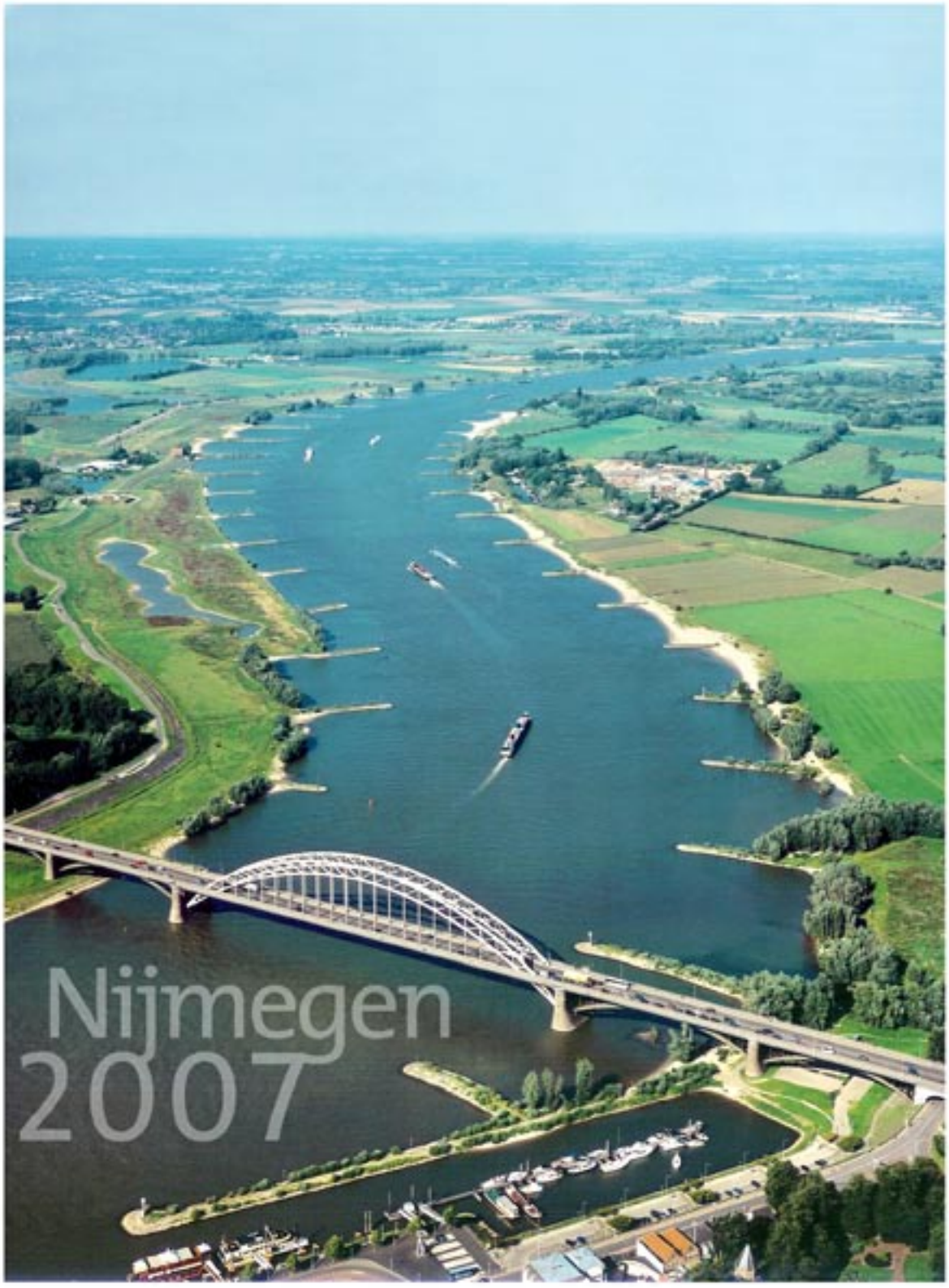

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The introduction and spread of invasive species in freshwater and marine environments is a worldwide problem that is increasing in frequency. There are various pathways by which non-indigenous invertebrate, fish, and plant species are introduced, becoming established and causing significant damage to coastal and freshwater ecosystems, and to the economies that depend upon them.

The Institute for Inland Water Management and Wastewater Treatment (RIZA) is hosting the 15th International Conference on Aquatic Invasive Species (ICAIS) that will be held in Nijmegen, The Netherlands from September 23 to 26, 2007

This conference series has evolved over the last decade into the most comprehensive international forum for the review of accumulated scientific knowledge; presentation of the latest field research; introduction of new technological developments for prevention, monitoring and control; and discussion of policy, legislation, public education and outreach initiatives to raise awareness of the impacts of aquatic invasive species and prevent new introductions. The conference typically involves participants representing academia, industry, government agencies, NGOs and other stakeholders seeking opportunities for cooperation and collaboration to address the issues of aquatic invasive species.

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Conference at a Glance

Sunday, September 23

12:00 PM to 6:00 PM
Conference Registration Check-in

1:00 PM to 4:30 PM
Workshop
Invasive Bivalves: A refresher on biology, fouling potential and available control strategies
(no additional fee, but pre-registration required)

1:00 PM to 5:00 PM
Excursion in the Forelands of the River Waal
(no additional fee, but pre-registration required)

7:30 PM to 10:00 PM
Invited Reception for Authors of Presentations and Posters

Monday, September 24

8:30 AM to 12:00 PM
Plenary Session

12:00 PM to 1:30 PM
Lunch (Provided)

1:30 PM to 6:00 PM
Concurrent Sessions

5:30 PM to 7:30 PM
Poster Session and Networking Mixer

Evening Free

Tuesday, September 25

8:30 AM to 12:00 PM
Concurrent Sessions

12:00 PM to 1:30 PM
Lunch (Provided)

1:30 PM to 5:30 PM
Concurrent Sessions

6:30 PM to 10:00 PM
Optional Special Event (additional fee)

Wednesday, September 26

8:30 AM to 12:00 PM
Concurrent Sessions

12:00 PM to 1:30 PM
Lunch (Provided)

1:30 PM to 5:30 PM
Concurrent Sessions

Evening Free

Thursday, September 27

9:00 AM to 5:00 PM
Port of Rotterdam Technical Tour (additional fee)

Sunday, September 23

1:00 PM to 4:30 PM

Workshop

Invasive Bivalves: A refresher on biology, fouling potential and available control strategies

This workshop is aimed at first-time attendees of the conference who are dealing with recent invasions of zebra, quagga and golden mussels. The workshop will provide an overview of biology and physiology of these fouling organisms, what areas of industrial cooling systems are vulnerable to primary and secondary fouling, and will cover successful physical and chemical control strategies. One segment of the workshop will focus on appropriate design of chlorination systems.

The workshop will include concise presentations on the above topics and a lengthy question and discussion period after each presentation.

The workshop is intended to provide an overview of existing knowledge and experience so that those who are dealing with new bivalve infestations can aim any further research into areas that have not yet been explored.

Monday, September 24 Morning

Plenary Session

Session Chair: Maarten Hofstra, RIZA

8:30 AM
Welcome and Introductory Remarks
G.B. Raaphorst, Director, Nature Department, Ministry of Agriculture, Nature and Food Quality, The Netherlands

9:00 AM
The River Rhine: A Global Highway for Dispersal of Aquatic Invasive Species
Rob S.E.W. Leuven, Radboud University Nijmegen, Institute for Wetland and Water Research, The Netherlands

9:20 AM
The Baltic: A Melting Pot for Aquatic Invasive Species
Erkki Leppäkoski, Åbo Akademi University, Finland

9:40 AM
The European Union Water Framework Directive: Status and Initiatives
Phil Boon, Scottish Natural Heritage, UK

10:00 AM **Break**

10:30 AM
Invasion Biology Put into Mathematical Terms
Rob Hengeveld, Institute for Forestry and Nature Research, The Netherlands

10:50 AM
Moving Toward Common International Policies
Timothy R.E. Keeney, Deputy Assistant Secretary for Oceans and Atmosphere, US Department of Commerce, USA

11:10 AM
Where Does the Effort to Resolve the Worldwide Problem of Aquatic Invasive Species Stand as We Begin the 15th International Conference on Aquatic Invasive Species? I Believe We Can, We Must, Do Better
The Rt. Hon. Herb Gray, Chair, Canadian Section, International Joint Commission, Canada

11:30 AM
Questions and Discussion

12:00 **Luncheon**

Monday, September 24 Afternoon

Concurrent Session A

Amphipods and Cladocera

Session Chair: Gerard van der Velde, Radboud University, Nijmegen

1:30 PM
Detailed Assessment of the Population Dynamics of the Non-native Amphipod, *Caprella mutica*, in Marinas in Scotland (UK): Implications for Secondary Dispersal
Elizabeth J. Cook, Scottish Association for Marine Science, UK

1:50 PM
Impact of Colonization of the IJsselmeer Area by *Chelicorophium curvispinum* and *Dikerogammarus villosus*
Ruurd Noordhuis, Institute of Inland Water Management and Wastewater Treatment, The Netherlands

2:10 PM
Preferences of Ponto-Caspian and European Gammarids for Zebra Mussel Shell Habitat
Jarosław Kobak, Nicolaus Copernicus University, Poland

2:30 PM
Success of the Invasive Ponto-Caspian Amphipod *Dikerogammarus villosus* by Life History Traits and Reproductive Capacity
Manfred Pöckl, University of Vienna, Vienna Ecology Centre and State Government of Lower Austria, Austria

2:50 PM **Break**

Concurrent Session B

Risk Assessment and Monitoring

Session Chair: Douglas Jensen, Minnesota Sea Grant

1:30 PM
Biological Invasions Via Inland Water Corridors: Developing a Risk Assessment Tool for European Inland Waterways
Vadim Panov, Zoological Institute of the Russian Academy of Sciences, Russia

1:50 PM
Predicting the Number of Ecologically Harmful Invaders in an Aquatic System
Anthony Ricciardi, McGill University, Redpath Museum, Canada

2:10 PM
Rapid Screening-Level Risk Assessment of Freshwater Fishes in Live Fish Trades in Canada
Becky Cudmore, Fisheries and Oceans Canada, Canada

2:30 PM
Risk Analysis for Non-indigenous Fish Species in Flanders (Belgium)
Hugo Verreycken, Research Institute for Nature and Forest, Belgium

2:50 PM **Break**

Concurrent Session C

Shipping: Policy

Session Chair: Richard Everett, US Coast Guard

1:30 PM
US Coast Guard's Programmatic Environmental Impact Statement in Support of the Ballast Water Discharge Standard Rulemaking
Bivan R. Patnaik, US Coast Guard, Environmental Standards Division, USA

1:50 PM
Canada's National Regulatory Approach to Ballast Water Management
David Yard, Transport Canada Marine, Canada

2:10 PM
Joint Ballast Water Inspection Program for Ocean Going Vessels Entering the Great Lakes
Christopher J. Wiley, Fisheries and Oceans Canada, Central and Arctic Region and Transport Canada, Ontario Region, Canada

2:30 PM
The Canadian Ballast Water Database Application
Sonya C. Santavy, Transport Canada, Ontario Region, Canada

2:50 PM **Break**

Monday, September 24 Afternoon

Concurrent Session A

Amphipods and Cladocera

Session Chair: Gerard van der Velde, Radboud University, Nijmegen

3:20 PM
Factors Influencing Predatory Behaviour in an Invasive Gammaridean Species, *Dikerogammarus villosus*
Gerard van der Velde, Radboud University Nijmegen, The Netherlands

3:40 PM
Small-scale Heterogeneity in the Physico-chemical Environment Limits the Local Dominance of an Aquatic Invader
Asa Kestrup, McGill University, Redpath Museum, Canada

4:00 PM
Phylogeography of *Crangonyx pseudogracilis*: Modelling an Alien Species' Progressive Invasion of British Waterways
Elise Michele Heinz, Middlesex University, Institute of Social and Health Research, UK

4:20 PM
Modelling the Migration and Ecological Impact by Alien Macroinvertebrates in Flanders: Case Study of Crustaceans in the Bocholt-Herentals Canal
Marjolein Messiaen, Ghent University, Laboratory of Environmental Toxicology and Aquatic Ecology, Belgium

4:40 PM
Established *Gammarus roeseli* Withstands Invasive *Dikerogammarus villosus* in Lake Constance: Experimental Evidence
John Hesselschwerdt, University of Konstanz, Limnological Institute, Germany

5:00 PM
Why are *Pontogammarus robustoides* and *Dikerogammarus haemobaphes* (Crustacea, Amphipoda) Such Successful Invaders?
Karolina Bacela, University of Lodz, Department of Invertebrate Zoology and Hydrobiology, Poland

5:20 PM
Ecological Patterns of Distribution in Alien Amphipods: A Case Study in Poland
Alicja Konopacka, University of Lodz, Department of Invertebrate Zooloy and Hydrobiology, Poland

5:40 PM
Parasitism and Biological Invasion: How Manipulator Parasites Could Promote a Gammarid Species Replacement
Vincent Médoc, Université Paul Verlaine, Metz, France

6:00 PM
Controlling Non-indigenous Crustaceans: A Case Study for *Charybdis japonica* in New Zealand
Daniel McClary, Golder Associates (NZ) Ltd., New Zealand

Concurrent Session B

Risk Assessment and Monitoring

Session Chair: Linda Shaw, National Marine Fisheries Service, Alaska Region

3:20 PM
Assessment of Zebra Mussel (*Dreissena polymorpha*) Infestation Risk Using GIS for Water Basins in Northwest Bulgaria
Teodora Trichkova, Bulgarian Academy of Sciences, Institute of Zoology, Bulgaria

3:40 PM
Risk Assessment of Infestation by Zebra Mussel (*Dreissena polymorpha*) and Quagga Mussel (*Dreissena bugensis*) and Conservation of Endangered Native Mussels, Higgins Eye Pearly Mussel (*Lampsilis higginsii*) and Winged Mapleleaf (*Quadrula fragosa*), in the St. Croix River Basin, Minnesota and Wisconsin, USA
Daniel Kelner, US Army Corps of Engineers, St. Paul District, USA

4:00 PM
European Water Framework Directive, Ecological Quality Indicators and Alien Species
Sergej Olenin, Klaipeda University, Coastal Research and Planning Institute, Lithuania

4:20 PM
A Dreissenid Rapid Response Plan for the Columbia River Basin, USA
Stephen H. Phillips, Pacific States Marine Fisheries Commission, USA

4:40 PM
Aquatic Exotic Invertebrates in Belarus: Past, Current, and Future Invasions
Alexander Y. Karatayev, Stephen F. Austin State University, Department of Biology, USA

5:00 PM
Rapid Assessment Surveys: Different Strokes for Different Folks
Dan Minchin, Marine Organism Investigations, Ireland

5:20 PM
Possible Introduction of Marine Species by Long Distance Drift: An Example with a Crustacean from USA to France
Pierre Y. Noel, Muséum national d'Histoire naturelle, France

Concurrent Session C

Shipping: Policy

Session Chair: Bivan Patnaik, US Coast Guard

3:20 PM
US Coast Guard's Ballast Water Management Program: Development of Technical Capabilities for Testing and Evaluating Ballast Water Management Methods
Richard A. Everett, US Coast Guard, Environmental Standards Division, USA

3:40 pm
The Management of the Risk of Non-indigenous Species Introduction Through Ship's Ballast Water and Biofouling – An Administration's Perspective
Brian Elliott, Maritime and Coastguard Agency, UK

4:00 pm
Managing Ballast Water – A Multi-Disciplinary Challenge
Dandu Pughiuc, Marine Biosafety Section, International Maritime Organization, UK

4:20 PM
A Journey Through Contemporary Australian Ballast Water Management
Rowan Ward, Australian Department of Agriculture, Fisheries and Forestry, Australia

4:40 PM
An Overview of Australia's Proposed Biofouling Management Requirements
Peter Neimanis, Australian Quarantine and Inspection Service, Australia

5:00 PM
Ocean Shipping in North America's Great Lakes: Invasive Species Costs vs. Transportation Cost Savings
John C. Taylor, Grand Valley State University, Seidman College of Business, USA

Monday, September 24, 6:00 PM to 7:30 PM

Poster Session

Spatial and Temporal Distribution of Zebra Mussel (*Dreissena polymorpha*) Veliger Larvae in the Lower Ebro River (NE Spain)
Jorge Alcázar, University of Lleida, Department of Environment and Soil Science, Spain

Some Approaches to Prediction of New Invasions in Aquatic Ecosystems
Borys Aleksandrov, National Academy of Sciences of Ukraine, Institute of Biology of Southern Seas, Ukraine

Successful Colonization of *Palaemon elegans* Rathke in the Gulf of Gdańsk – Diet and Reproduction
Anna Barańska, University of Gdańsk, Institute of Oceanography, Poland

Recent Invasion of European Estuaries by the Asian Shrimp *Palaemon macrodactylus* Rathbun, 1902: The Case of the Gironde Estuary
Mélanie Béguer, EDF/Cemagref, France

***Limnomysis benedeni* Czerniavsky (Crustacea, Mysidae) – A New Species in the Fauna of Croatia**
Irella Bogut, J.J. Strossmayer University, Department of Biology, Croatia

Non-indigenous Species and Plankton Dynamics of the Lower Columbia River Estuary
Stephen M. Bollens, Washington State University, USA

Evaluating the Biological Efficacy of NaCl Brine as a Ballast Water Treatment Technology for Transoceanic Vessels Entering the Great Lakes
Johanna Bradie, University of Windsor, Great Lakes Institute for Environmental Research, Canada

Gametogenesis and Population Dynamics of Alien Bivalves in Brazilian Wetland
Cláudia T. Callil, University of Mato Grosso, Biology and Zoology Department, Brazil

The Alteration of Lake Ecosystems by Invasive Alien Species. A Case Study on a Potential Keystone Species: *Orconectes limosus*
Ana Cristina Cardoso, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Italy

INCOFISH: From Local Knowledge to Global Understanding of Sustainable Coastal Management Strategies
Christine Marie V. Casal, FishBase, WorldFish Center

An Analysis of the Diffusion of Selected Federal Policies Relating to the Coordination of Aquatic Invasive Species Management Efforts Among States Within the Chesapeake Bay Watershed, USA
John F. Christmas, Jr., George Mason University, Environmental Science and Policy Department, USA

Navigational Buoy Survey of Invasive and Native Benthic Invertebrates of the St. Lawrence River, Lake Ontario, and the Welland Canal
David Bruce Conn, Berry College, School of Mathematical and Natural Sciences, USA

Is the Diversity of Aquatic Invertebrates Affected by the Red Swamp Crayfish?
Alexandra M. Correia, Universidade de Lisboa, Portugal

Golden Mussel Abundance After Eight Years of Invasion in the Paraguay River, Brazil
Márcia Divina de Oliveira, Embrapa Pantanal, Brazil

The Invasion of *Gammarus tigrinus* Sexton, 1939 in the Gulf of Gdańsk (Southern Baltic) and its Adaptive Pattern of Osmoregulation
Aldona Dobrzycka-Krahel, University of Gdańsk, Department of Experimental Ecology of Marine Organisms, Poland

***Balanus improvisus* (Darwin 1854) in the Gulf of Gdańsk (Poland) – An Important Component of Macrobenthic Community**
Anna Dziubińska, University of Gdańsk, Department of Experimental Ecology of Marine Organisms, Poland

The Impact of the Invasive Ponto-Caspian Hydroid, *Cordylophora caspia*, on Benthic Macroinvertebrate Communities in Southern Lake Michigan: Effects on Fish Prey Availability
Nadine Folino-Rorem, Wheaton College, Biology Department, USA

Inventory and Mapping of Aquatic Invasive Plants in Kenya
Patrick Gang, Department of Resource Surveys and Remote Sensing, Kenya

The Introduced Clam *Ensis americanus:* Ecological Aspects and Genetic Diversity as Revealed by Nuclear and Mitochondrial Genes
Ana González-Tizón, Universidade da Coruña, Department of Cell and Molecular Biology, Spain

Habitat Preference of Alien vs. Native Gammarid Species in a Lowland Lake, Poland
Michal Grabowski, University of Lodz, Department of Invertebrate Zoology and Hydrobiology, Poland

High Phytoplankton Densities Reduces Feeding Rate of Ctenophores
Jamileh Javidpour, Leibniz Institute of Marine Science, Germany

Global Advances in the Ecology and Management of Golden Apple Snails
Ravindra C. Joshi, Philippine Rice Research Institute, Philippines

Distribution and Hatching Success of Resting Eggs of *Cercopagis pengoi* in the Gulf of Finland
Tarja Katajisto, Leena Karjala and Maiju Lehtiniemi, Finnish Institute of Marine Research

Selective Behaviour of *Procambarus clarkii* in the Channel Under Different Light Conditions
Pavel Kozák, University of South Bohemia in České Budějovice, Czech Republic

Impacts of Introduced Fish on the Feeding Habits of the Ichthyofauna in a Caribbean Estuary
Jenny Leal-Flórez, Center for Marine Tropical Ecology, Germany.

Canada's Centre of Expertise for Aquatic Risk Assessment
Nicholas E. Mandrak, Fisheries and Oceans Canada, Centre of Expertise for Aquatic Risk Assessment, Canada

Eliminating Bacteria in Ballast Water by a Compact System of Utraviolet Radiation
Lucía F. Martínez, University of Oviedo, Spain

Too Hot to Handle: Evaluation of Steam Sterilization as an Aquatic Biosecurity Response Tool
Daniel McClary, Golder Associates (NZ) Ltd., New Zealand

Shipwreck Ahoy! Incursion Response to the Semi-Submerged Wreck of a Fishing Vessel from Southeast Asia in New Zealand Waters
Daniel McClary, Golder Associates (NZ) Ltd., New Zealand

Reproductive Periodicity of the Invasive Tunicate *Styela clava* in Auckland, New Zealand
Daniel McClary, Golder Associates (NZ) Ltd., New Zealand

Distribution and Expansion of Two Ornamental Aquatic Plants in an Irish Lake
Dan Minchin, Marine Organism Investigations, Ireland

Monday, September 24, 6:00 PM to 7:30 PM

Poster Session

Microparasites of Alien and Native Gammarids (Crustacea, Amphipoda) in Poland with First Record of Hyperparasitic Infection in the Invasive Amphipod *Pontogammarus robustoides*
Mykola Ovcharenko, W. Stefanski Institute of Parasitology, Polish Academy of Sciences, Poland

Impact of the Planktonic Larvae of the Invasive Asian Bivalve *Limnoperna fortunei* on the Growth of Larvae of the "Sábalo", *Prochilodus lineatus* (Pisces) in South America
Esteban Marcelo Paolucci, Museo Argentino de Ciencias Naturales "Bernardino Rivadavia"

The New European On-line Journal "Aquatic Invasions" as an Effective Early Warning Tool
Vadim Panov, Zoological Institute of the Russian Academy of Sciences, Russia

Free Choice Learning Initiatives to Mobilize Community Action Against Aquatic Invasions
Alan Power, University of Georgia, Marine Extension Service, USA

Developing a Policy on Invasive Aquatic Plants at the Canadian Food Inspection Agency
Élizabeth Powles, Canadian Food Inspection Agency, Canada

Learning Time Versus Prey Capture: How Does Learning Time Affect Successful Prey (Red Swamp Crayfish: *Procambarus clarkii*) Capture by Largemouth Black Bass (*Micropterus salmoides*)?
Ricardo O. Ramalho, University of Évora, Institute of Marine Research, Portugal

Integrating Economics into Invasive Aquatic Plants (IAP) Management in Sri Lanka: Alien Aquatic Plants, is this an Economic Problem?
Leel Randeni, Ministry of Environment, Promotion and Environmental Education Division, Sri Lanka

Control of Golden Mussel by Ozonation of Cooling Water in Power Plants
Matthias Rothe, ProMinent ProMaqua GmbH, Germany

Eradication of Common Carp (*Cyprinus carpio*) with Rotenone in Laguna De Zonar, Spain
Sigmund Sevatdal, Centre for Veterinary Contract Research and Comercial Services Ltd. (VESO), Norway

Modeling Habitat Capability for Invasive Species Using the ShoreZone Mapping System
Linda Shaw, National Marine Fisheries Service, Alaska Region, USA

The Global Invasive Species Information Network
Annie Simpson, US Geological Survey, National Biological Information Infrastructure, USA

***Orconectes virilis:* a North American Crayfish Conquering The Netherlands**
Menno Soes, Bureau Waardenburg bv, The Netherlands

Distribution of American Crayfish *Orconectes limosus* (Raf., 1817) in European Waters
Anna Szaniawska, University of Gdańsk, Institute of Oceanography, Poland

Bactericidal Effects of Lime Stabilization and Recarbonation to Bacterial Fish Pathogens and Aquatic-Environmental Bacteria
Barnaby J. Watten, US Geological Survey, Leetown Science Center, USA

Toxicity of CO_2 to New Zealand Mudsnails *(Potamopyrgus antipodarum)*: Implications for Control
Barnaby J. Watten, US Geological Survey, Leetown Science Center, USA

The Baltic Sea Alien Species Database: Ten Years Online
Anastasija Zaiko, Klaipeda University, Coastal Research and Planning Institute, Lithuania

Tuesday, September 25 Morning

Concurrent Session A

Marine Invasions

Session Chair: Geoff Hicks, New Zealand Department of Conservation

8:30 AM
Byssogenesis of Invasive Marine Mussels *Perna viridis* and *Perna perna*: Implications for Their Invasion Race
Sanjeevi Rajagopal, Radboud University Nijmegen, Institute for Water and Wetland Research, The Netherlands

8:50 AM
The Ecological Role of the Invading Species *Cercopagis pengoi* (Crustacea, Cladocera) in the Gulf of Finland and in the Baltic Proper
Larisa F. Litvinchuk, Zoological Institute of the Russian Academy of Sciences, Russia

9:10 AM
Natural Currents: A Pathway for the Spread of Marine NIS in Tasman and Golden Bays, New Zealand
Hernando Acosta, Auckland University of Technology, Earth and Oceanic Research Institute, New Zealand

9:30 AM
Changes in Macrozoobenthos of the Eastern Gulf of Finland After Introduction of Alien Annelids
Alexey A. Maximov, Zoological Institute of the Russian Academy of Sciences, Russia

9:50 AM **Break**

Invasive Crayfish

Session Chair: Joe Caffrey, Central Fisheries Board

10:20 AM
Aquatic Invasive Invertebrates in the United States: Rusty Crayfish as a Case Study
Angela M. Bobeldyk, University of Notre Dame, Department of Biological Sciences, USA

10:40 AM
Dispersal of Red Swamp Crayfish (*Procambarus clarkii*, Girard), Does Population Density Matter?
Ricardo O. Ramalho, University of Évora, Institute of Marine Research, Portugal

11:00 AM
Reproduction and Growth of *Orconectes limosus* Raf. in Baltic Brackish Waters – Is it Possible?
Joanna Jaszczołt, University of Gdańsk, Institute of Oceanography, Poland

11:20 AM
The Effect of Water Temperature on Number of Moults and Growth for Invasive Crayfish *Pacifastacus leniusculus* D. During the First Three Months of their Life
Pavel Kozák, University of South Bohemia in České Budějovice, Czech Republic

11:40 AM
Evaluating Recruitment Dynamics of the Chinese Mitten Crab, *Eriocheir sinensis*: Methods for Early Detection, Monitoring and Determining Year Class Strength
Carolynn S. Culver, University of California Cooperative Extension Program and Marine Science Institute, University of California Santa Barbara, USA

12:00 PM **Luncheon**

Concurrent Session B

Population Genetics and Invasion

Session Chair: Nicholas Mandrak, Fisheries and Oceans Canada

8:30 AM
Appraisal of Molecular Detection Methodologies for Identifying and Enumerating Aquatic Pests
Kirsty Smith, Cawthron Institute, New Zealand

8:50 AM
Phylogeny and Population Genetics of Invasive Asiatic Clams (*Corbicula* spp.) in the Meuse
Lise-Marie Pigneur, Facultés Universitaires Notre-Dame de la Paix, Unité de Recherche en Biologie des Organismes, Belgium

9:10 AM
Identifying the Origin of the Cryptogenic Ascidian *Molgula manhattensis* (De Kay, 1843)
Deniz Haydar, University of Groningen, Centre for Ecological and Evolutionary Studies, The Netherlands

9:30 AM
Genetic Structure of a Invasive Species *Dreissena polymorpha* in Ebro River, Spain: Results of PCR Based AFLP-Fingerprinting
Sanjeevi Rajagopal, Radboud University Nijmegen, Institute for Water and Wetland Research, The Netherlands

9:50 AM **Break**

Tracking Aliens

Session Chair: Hugh MacIsaac, University of Windsor, Great Lakes Institute for Environmental Research

10:20 AM
Aquatic Invaders in the European Alien Species Database
Sergej Olenin, Klaipeda University, Coastal Research and Planning Institute, Lithuania

10:40 AM
The Most Invasive and Impacting Introduced Aquatic Species in Europe
Stephan Gollasch, GoConsult, Germany

11:00 AM
Alien Species in European Seas: Regions at Risk
Bella S. Galil, National Institute of Oceanography, Israel Oceanographic and Limnological Research, Israel

11:20 AM
Online Database "Aquatic Invaders of Belarus": Goals and Structure
Sergey E. Mastitsky, Belarusian State University, Belarus

11:40 AM
***Harmonia*, an Information System Dedicated to Non-native Invasive Species in Belgium**
Etienne Branquart, Belgian Biodiversity Platform/ Research Centre for Nature, Forest and Wood, Belgium

12:00 PM **Luncheon**

Concurrent Session C

Shipping: Research

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

8:30 AM
A Computational and Experimental Approach to Prediction of the Effectiveness of Flow-through Ballast Water Exchange
Peter A. Chang, Naval Surface Warfare Center, Carderock Division, USA

8:50 AM
Biological Effectiveness of Open-ocean Ballast Exchange for Preventing Invertebrate Invasions Between Freshwater Ports
David F. Reid, National Oceanic and Atmospheric Administration, USA

9:10 AM
Estimating Probability of Establishment for Parthenogenetic Taxa with Small Founding Populations: An Assessment of the Proposed IMO Ballast Water Treatment Standards
Sarah Bailey, Fisheries & Oceans Canada, Great Lakes Laboratory for Fisheries & Aquatic Sciences, Canada

9:30 AM
Assessing the Importance of Biological Uncertainty in the Management of Species Introductions Via Ballast Water
Joana F. Tavares, University of Delaware, College of Marine Studies, USA

9:50 AM **Break**

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

10:20 PM
Results and Lessons Learned from the ETV Beta Test
Jonathan F. Grant, Naval Research Laboratory, USA

10:40 AM
Automated Methods for Planktonic Enumeration and Viability Analysis
Bruce N. Nelson, Naval Research Laboratory, USA

11:00 AM
Counting Viable Phytoplankton and Bacteria in Ballast Water
Marcel J. W Veldhuis, Royal Netherlands Institute for Sea Research, The Netherlands

11:20 AM
Using a Continuous Imaging Particle Analyzer (FlowCAM®) as an Integrated System for Ballast Water Analysis and Regulatory Compliance
Kent A. Peterson, Fluid Imaging Technologies, USA

11:40 AM
Microzooplankton Response to Variable UV Treatment in Ballast Water Mesocosms
Gretchen Rollwagen-Bollens, Washington State University, School of Earth & Environmental Sciences & School of Biological Sciences, USA

12:00 PM **Luncheon**

Tuesday, September 25 Afternoon

Concurrent Session A

Dreissenology

Session Chair: Abraham bij de Vaate, Waterfauna Hydrobiologisch Adviesbureau

1:30 PM
From Lakes to Rivers – the Downstream Larval Distribution of *Dreissena* in Irish River Basins
Frances E. Lucy, Institute of Technology, Sligo, School of Science, Ireland

1:50 PM
***Dreissena polymorpha* (Zebra Mussels) Versus *Dreissena rostriformis bugensis* (Quagga Mussels): A Review of Their Different Invasion Dynamics**
Daniel P. Molloy, New York State Museum, Division of Research and Collections, USA

2:10 PM
The Invasive Zebra Mussel *Dreissena polymorpha* as a Habitat Engineer in a Boreal Coastal Lagoon
Anastasija Zaiko, Klaipeda University, Coastal Research and Planning Institute, Lithuania

2:30 PM
The Zebra Mussel Shells as a Substrate for Periphyton
Sergey E. Mastitsky, Belarussian State University, Belarus

2:50 PM **Break**

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

3:20 PM
Physiological and Ecological Traits in Invasive Zebra Mussel and Local Unionids
Marina Orlova, Zoological Institute, Russian Academy of Sciences, Russia

3:40 PM
Impact of the Zebra Mussel *Dreissena polymorpha* on the Ecological Integrity of Lough Sheelin
Michael Millane, University College Dublin, School of Biology and Environmental Science, Ireland

4:00 PM
First Report of a High Prevalence and Intensity of Parasitic Infection in North American Zebra Mussels: What's the Significance?
Daniel P. Molloy, New York State Museum, Division of Research and Collections, USA

4:20 PM
Assessment of Waterborne Parasites in Irish River Basin Districts – Use of Zebra Mussels (*Dreissena polymorpha*) as Bioindicators
Thaddeus K. Graczyk, Johns Hopkins Bloomberg School of Public Health, USA

4:40 PM
Recent Invasion of the Zebra Mussel: The Spanish Experience
Concha Durán Lalaguna, Ministerio de Medio Ambiente, Confederación Hidrográfica de Ebro, Spain

5:00 PM
Does the Biofouling by *Dreissena polymorpha* in Waterways Impact *Rhodeus sericeus* Reproductive Success? A Potential Competitive Interaction Between Two Common Aquatic Invaders in Europe
Philine zu Ermgassen, University of Cambridge, Department of Zoology, UK

Concurrent Session B

Education and Outreach: The Information Highway

Session Chair: Marc Gaden, Great Lakes Fishery Commission

1:30 PM
Evaluating the *Stop Aquatic Hitchhikers!* Campaign to Prevent the Spread of Aquatic Invasive Species by Recreational Boaters in Three States
Douglas A. Jensen, University of Minnesota Sea Grant Program, USA

1:50 PM
***Hydrilla*: From Rapid Response Planning to Reality**
Carol Swinehart, Michigan Sea Grant, Michigan State University, USA

2:10 PM
Alaska Green Crab Monitoring Project
Dan Gilson, Prince William Sound Regional Citizens' Advisory Council, USA

2:30 PM
Of Gods and Government: What Can *Cherax quadricarinatus* in Black River, Jamaica Teach Us About Invasive Species Communication and Management?
Wei Ying Wong, Brown University, Center for Environmental Studies, USA

2:50 PM **Break**

Session Chair: Marc Gaden, Great Lakes Fishery Commission

3:20 PM
NISbase and GISIN: Building a Pilot System to Cross Search Invasive Species Online Databases
Pam Fuller, US Geological Survey, Florida Integrated Science Center

3:40 PM
Invaders of the United States National Parks: Using Film as an Education Tool to Conserve Resources
Linda Drees, National Park Service, Natural Resource Program Center, USA

Concurrent Session C

Shipping: Technology

Session Chair: Ray Krick, Transport Canada Marine Safety

1:30 PM
Understanding the Realities of a Private Sector Technology Provider in the Ballast Water Treatment (BWT) Market
Mike Hasson, Echoclor Inc., USA

1:50 PM
Treatment of Ballast Water with Chlorine Dioxide to Control Invasive Species Under Actual Shipping Conditions
Lucie Maranda, University of Rhode Island, Graduate School of Oceanography, USA

2:10 PM
Shipboard Testing of Seakleen® as a Ballast Water Treatment to Eliminate Non-indigenous Species Aboard a Working Tanker in Pacific Waters
David A. Wright, University of Maryland Center for Environmental Science, USA

2:30 PM
New Method for Treating Ship Ballast Solids to Prevent Future Introductions of Aquatic Invasive Species: Effect of Lime Stabilizaton/ Recarbonation on Survivorship, Water Chemistry and Process Economics
Barnaby J. Watten, US Geological Survey, Leetown Science Center, USA

2:50 PM **Break**

Session Chair: Ray Krick, Transport Canada Marine Safety

3:20 PM
Peraclean® Ocean for Ballast Water Treatment: Onboard Ship Evaluation in Very Cold Temperatures
Yves de Lafontaine, Environment Canada, St. Lawrence Centre, Canada

3:40 PM
Offshore Oil Platforms and Aquatic Invasive Species: Implications of Recent Discoveries in California
Carolynn S. Culver, University of California Cooperative Extension Program and Marine Science Institute, University of California Santa Barbara, USA

4:00 PM
Vessel Biofouling as a Vector for Invasive Marine Species: Biosecurity New Zealand's Research Programme
Daniel Kluza, Biosecurity New Zealand, Ministry of Agriculture and Forestry, New Zealand

4:20 PM
How to Gift-Wrap a Frigate: Hull Encapsulation as a Potential Incursion Response Tool for Large Vessels
Daniel McClary, Golder Associates (NZ) Ltd., New Zealand

Wednesday, September 26 Morning

Concurrent Session A

Invasive Plants: Macrophytes on the Move

Session Chair: Charles W. Boylen, Darrin Fresh Water Institute, Rensselaer Polytechnic Institute

8:30 AM
Chokeberry (*Aronia* spec.), an Invasive Species in the Marshlands of The Netherlands?
Wil L.M. Tamis, Leiden University, Institute of Environmental Sciences, The Netherlands

8:50 AM
Understanding Eurasian Watermilfoil: Nutrients, Growth and Invasion
Mark W. Swinton, Darrin Fresh Water Institute and Rensselaer Polytechnic Institute, Department of Biology, USA

9:10 AM
Lessons from Four Freshwater Invasive Plants in New Zealand
John Clayton, National Institute of Water and Atmospheric Research, New Zealand

9:30 AM
The Quantitative Abundance of *Lagarosiphon major* in Lough Corrib Ireland
Liam Gavin, Western Regional Fisheries Board, Ireland

9:50 AM **Break**

Session Chair: Charles W. Boylen, Darrin Fresh Water Institute, Rensselaer Polytechnic Institute

10:20 AM
***Lagarosiphon major* in Irish Watercourses – Awareness and Control**
Joseph M. Caffrey, Central Fisheries Board, Swords Business Campus, Ireland

10:40 AM
The Invasion of the Water Hycinth *(Eichhornia crassipes)* in SW Europe
Trinidad Ruiz Téllez, University of Extremadura, Faculty of Sciences, Spain

11:00 AM
Pond Apple *(Annona glabra)* Economic Prospecting: Opportunities for Meeting Challenges of Alien Invasive Plant Infested Ecosystems in Sri Lanka
Leel Randeni, Ministry of Environment, Promotion and Environmental Education Division, Sri Lanka

11:20 AM
Physiological Age-Grading Techniques to Assess Reproductive Status of Insect Biocontrol Agents of Aquatic Plants
Jennifer Lenz, US Army Engineer Research and Development Center, Germany

11:40 AM
An Ecological Approach to Aquatic Plant Management
R. Michael Smart, US Army Engineer Research and Development Center, USA

12:00 PM **Luncheon**

Concurrent Session B

Invasion Impacts

Session Chair: Kay H. Austin, United States Section, International Joint Commission

8:30 AM
Predicting Lake Vulnerability to Species Invasion Using a Hierarchical Approach
Hugh MacIsaac, University of Windsor, Great Lakes Institute for Environmental Research, Canada

8:50 AM
Phenology and Population Dynamics of the Invasive Ctenophore *Mnemiopsis leidyi* in Recipient Areas of the Eurasian Seas - Changes Linked with Environmental Variability and Climate Forcing
Tamara Shiganova, P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences, Russia

9:10 AM
Invading Ecosystem Engineer Dramatically Alters Benthic Communities In and Out of Marine Reserves
Dianna K. Padilla, Stony Brook University, Department of Ecology and Evolution, USA

9:30 AM
The Economic Impact of Aquatic Nuisance Species
Alfred F. Cofrancesco, Jr., US Army Engineer Research and Development Center, USA

9:50 AM **Break**

Session Chair: Kay H. Austin, United States Section, International Joint Commission

10:20 AM
Introduced Marine Crustacea Decapoda and Stomatopoda in Syria: An Overview and Recent Data
Hassan Hasan, Muséum national d'Histoire naturelle, France

10:40 AM
Non-indigenous Species Invading Italian Inland Waters: Distribution, Case Studies and Threats
Francesca Gherardi, Università di Firenze, Dipartimento di Biologia Animale e Genetica, Italy

11:00 AM
Environmental Modulation of the Reproductive Activity of the Invasive Mussel *Limnoperna fortunei* in South America
Francisco Sylvester, Universidad de Buenos Aires, Argentina

11:20 AM
Effects of Nile Perch on the Ecology of the Spot-Necked Otter and Competition with Fishermen in Lake Victoria, Kenya
Mordecai Ogada, National Museums of Kenya, Department of Ichthyology, Kenya

11:40 AM
Invasion of the Asian Clam *Corbicula fluminea* in Lake Constance
Stefan Werner, University of Konstanz, Limnological Institute, Germany

12:00 PM **Luncheon**

Concurrent Session C

Biofouling: Keeping Aliens in Check

Session Chair: Henk Jenner, KEMA Power Generation and Sustainables

8:30 AM
Successful Control of Zebra Mussels in a Fouled Waterworks Using Microencapsulated BioBullets
David C. Aldridge, University of Cambridge, Department of Zoology, UK

8:50 AM
Update on *Pseudomonas fluorescens* Strain CL145A as a Zebra Mussel Control Agent
Daniel P. Molloy, New York State Museum, Division of Research and Collections, USA

9:10 AM
A Comparative Study of Zebra Mussel Control Methodologies in the Lake Ontario Region
Amit Bhatt, ProMinent Fluid Controls Ltd., Canada

9:30 AM
The Use of Ozone to Control Zebra Mussels, Ontario Power Generation, Lennox Generating Station
Terry Brady, Ontario Power Generation, Canada

9:50 AM **Break**

Session Chair: Henk Jenner, KEMA Power Generation and Sustainables

10:20 AM
Control of Golden Mussel by Ozonation of Cooling Water in Power Plants
Matthias Rothe, ProMinent ProMaqua GmbH, Germany

10:40 AM
Proactive Approach to Zebra Mussel Treatment at a Spanish Nuclear Power Plant: A Case Study
Miguel Angel Cortes Cabanero, Santa Maria de Garona Nuclear Plant, Spain

11:00 AM
On-site Evaluation of Fouling Release Coatings for the Protection of Cooling Circuits Against Macro-organisms
Lieve Verelst, Laborelec, Belgium

11:20 AM
Zebra Mussels in Russia: Past, Present and Towards its Control in Service Water Systems
Marina I. Orlova, Zoological Institute of the Russian Academy of Sciences, Russia

11:40 AM
An Electric Barrier to Prevent Aquatic Invasive Species Dispersal in a Commercial Navigation Canal
Philip B. Moy, University of Wisconsin Sea Grant, USA

12:00 PM **Luncheon**

Wednesday, September 26 Afternoon

Concurrent Session A

Fish and Gobies

Session Chair: Philip B. Moy, University of Wisconsin Sea Grant

1:30 PM
Non-native Armored Catfishes in Florida: Description of Nest Burrows and Burrow Colonies with Preliminary Assessment of Shoreline Impacts
Leo G. Nico, US Geological Survey – Florida Integrated Science Center, USA

1:50 PM
Do Introduced Pumpkinseed Sunfish Have an Impact on Native Species in European Streams?
Gordon H. Copp, CEFAS, Salmon and Freshwater Team, UK

2:10 PM
Aspects of Successful Invasion of English Inland Waters by Introduced Topmouth Gudgeon, *Pseudorasbora parva*
Kathleen Beyer, Centre for Ecology and Hydrology, Dorset, Natural Environment Research Council, UK

2:30 PM
Distribution of Racer Goby *Neogobius gymnotrachelus* Along the Cross Section of a Dam Reservoir on the Lower Vistula River (Central Poland)
Tomasz Kakareko, Nicolaus Copernicus University, Poland

2:50 PM **Break**

Session Chair: Philip B. Moy, University of Wisconsin Sea Grant

3:20 PM
Modification in the Reproduction Strategy – Reason for the Round Goby (*Neogobius melanostomus*) Invasion Success in the Gulf of Gdańsk?
Mariusz R. Sapota, University of Gdańsk, Institute of Oceanography, Poland

3:40 PM
Alien Fish Species in Southeast Asia: Pathways, Biological Characteristics, Establishment and Invasiveness
Christine Marie V. Casal, FishBase Project, WorldFish Center, Philippines

4:00 PM
Invasive Fishes and their Effects on the Native Fish Fauna of the Upper Rio Grande Basin, USA
Bob Calamusso, Tonto National Forest, USA

Concurrent Session B

Invasion Impacts

Session Chair: Jim Houston, Canada Section, International Joint Commission

1:30 PM
Predicting the Impacts of Introduced Mussels on Aquatic Communities
Jessica M. Ward, McGill University, Redpath Museum, Canada

1:50 PM
Drastic Change of Peracaridan Assemblage in Lake Dusia, Lithuania, After the Introduction of Ponto-Caspian Aliens
Kęstutis Arbačiauskas, Vilnius University, Institute of Ecology, Lithuania

2:10 PM
Invaders Are Not a Random Selection of Species
Alexander Y. Karatayev, Stephen F. Austin State University, Department of Biology, USA

2:30 PM
Invasibility of Small Lakes and Impact on a Non-indigenous Plant
Helena Berglund, Lund University, Department of Ecology, Sweden

2:50 PM **Break**

Policy

Session Chair: Carol Swinehart, Michigan Sea Grant

3:20 PM
Invasive Species in Ireland: Risk Assessments, Policy Development and International Co-operation
Caitriona M. Maguire, EnviroCentre, Northern Ireland

3:40 PM
Beyond the Lacey Act: Improving the Enforcement of Aquatic Invasive Species Regulations
Jill Finster, Great Lakes Fishery Commission, USA

4:00 PM
Assessment of Sea Lamprey (*Petromyzon marinus*) Populations in the Laurentian Great Lakes Basin
Todd B. Steeves, Fisheries and Oceans Canada, Sea Lamprey Control Centre, Canada

4:20 PM
Fighting the Sea Lamprey in the Great Lakes: 50 years of AIS Management
W. Paul Sullivan, Fisheries and Oceans Canada, Sea Lamprey Control Centre, Canada

Concurrent Session C

Biofouling: Keeping Aliens in Check

Session Chair: Bob Hester, Ontario Power Generation

1:30 PM
A Study of an Unidentified Energy Field to Determine its Potential Value in Excluding Fish from Water-Intakes, Ship Canals, etc.
A. Garry Smythe, Shaw Environmental Inc., USA

1:50 PM
Use of Rotenone to Eradicate the Round Goby *(Neogobius melanostomus)* in Pefferlaw Brook
Brian E. Stephens, Fisheries and Oceans Canada, Central and Arctic Region, Canada

2:10 PM
Potential Economic Impacts of Zebra Mussels on the Hydropower Facilities in the Columbia River Basin
Stephen Phillips, Pacific States Marine Fisheries Commission, USA

2:30 PM
Technology, Psychology and Bullfrog Eradication
Stan A. Orchard, BullfrogControl.com Inc., Canada

2:50 PM **Break**

Session Chair: Bob Hester, Ontario Power Generation

3:20 PM
Distribution, Density, and Population Dynamics of Invasive Applesnail Pomacea Insularum in Southeast Texas
Lyubov E. Burlakova, Stephen F. Austin State University, Department of Biology, USA

3:40 PM
Biological Control of Invasive Aquatic Weed *Eichhornia crassipes* in Tamiraparani River Basin (India)
R. Ramanibai, University of Madras, Department of Zoology, India

4:00 PM
Prevention of Dispersion Strategy of Golden Mussel in Central Part of South America
Cláudia T. Callil, University of Mato Grosso, Biology and Zoology Department, Brazil

4:20 PM
Golden Apple Snail: Global Invasion and Management
Ravindra C. Joshi, Philippine Rice Research Institute, Philippines

The River Rhine: A Global Highway for Dispersal of Aquatic Invasive Species

Rob S.E.W. Leuven, *I. Baijens, J. Snijders, C. van der Zwart and H.J.R. Lenders*
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Oostrandpark 30, 8212 AP Lelystad, The Netherlands

The river Rhine is heavily influenced by human activities and suffers from a series of constraints, which hamper a complete return to natural species composition. These constraints have often included problems, such as navigation, pollution and loss of habitats. Improving water quality while these constraints remained in place has led to increased colonization by invasive species. This tendency has been accelerated by new canals connecting river basins (such as the Rhine-Main-Danube canal). Over the last two centuries, the total surface area of river basins connected to the river Rhine has been increased by a factor of 20. An extensive network of shipping fairways via canals and rivers has allowed (endemic) faunas from rivers in various bio-geographical regions to mix, changing communities, occupying the food web and forming new constraints on the return of the original fauna.

In total 65 invasive species have been recorded in the Rhine river branches in the Netherlands. The average number of invasions shows a strong increase over the period 1800-2006 (from less than 1 species per decade to 1-2 species per year) due to anthropogenic introductions, transport via ballast water and dispersal via shipping fairways. Biological traits analyses reveal that invasive species are often adapted to high water flow, temperature and salt content. Spatial-temporal analysis of the geographical distribution reveals that the dispersal rates of invasive species vary between 14 and 461 km year^{-1}. These values are relatively high in comparison with dispersal rates recorded for other large rivers. Environmental factors significantly explaining intra- and inter-species variation of dispersal rates will be discussed.

NOTES

The Baltic: A Melting Pot for Aquatic Invasive Species

Erkki Leppäkoski
Åbo Akademi University, Environmental and Marine Biology
FIN-20500 Turku/Åbo, Finland

The brackish inland seas of Europe, i.e., the Black (including the Sea of Azov), Caspian and Baltic Seas, are of special interest to invasion biology. Their long history of research and ongoing monitoring programmes make it possible to detect newcomers with only a reasonable delay.

In the Baltic Sea, horizontal and vertical gradients provide aquatic invasive species (AIS) of different origin an extended repertoire of hospitable abiotic conditions within a salinity range from 0 to > 20 psu (the Kattegat included). Consequently most highly euryhaline and eurythermal species are potential invaders.

The peculiar mixture of Atlantic and freshwater species living in the Baltic, and its low number of native species, have been altered through human-mediated introduction of alien species. Much of the Baltic Sea's present structural and functional diversity is now of foreign origin: during the last two centuries, more than 120 AIS have been recorded here. They originate from all continents but South America and Antarctica. Ongoing Americanisation appears to be one of the most important processes that contribute to the xenodiversity of all (semi-)enclosed European seas. In the Baltic Sea, 23 species of Ponto-Caspian and North American origin each have been able to establish self-reproducing populations. Ponto-Caspian invaders are common in the sheltered, low-salinity coastal lagoons and in the eastern Gulf of Finland, while the share of North American invaders increases south-westward.

Vectors for intentional introduction of AIS directly into the Baltic Sea or indirectly via its catchment include those for stocking and aquaculture (43 species) while unintentional introductions have been associated with aquaculture (14) and ornamental purposes (3) or carried by ships (55); for 8 species the vector remains unknown. During the last two decades all most important invasions have been associated with shipping and ballast waters discharges, evidenced by the recent appearance of species native to the Ponto-Caspian region (e.g., the round goby *Neogobius melanostomus*, and the predatory cladoceran *Cercopagis pengoi*) and North America (the polychaetes *Marenzelleria* spp. and most recently (2006) the comb jelly *Mnemiopsis leidyi*). Range extensions of Ponto-Caspian species, native to the Black and Caspian Sea areas, are facilitated by the interconnection of river basins through man-made canals.

Today the biota of brackish water bodies are exposed to each other because of the breakdown of geographical barriers due to ship traffic, leading to an exchange of species between continents and seas and further homogenization of aquatic animal and plant life worldwide.

In the European brackish seas, species introductions have been longitudinal rather than latitudinal. However, increased movement to higher latitudes of species as the result of global warming is expected in the near future.

NOTES

The European Union Water Framework Directive: Status and Initiatives

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The Water Framework Directive (WFD), adopted in 2000, is the single most significant piece of legislation covering aquatic environments ever enacted in Europe. The WFD takes a holistic approach to water management, and applies to all surface waters (rivers, lakes, estuaries, coastal waters) as well as to groundwater. It aims to prevent further deterioration of aquatic ecosystems and to protect and enhance their status. At the heart of the Directive is a requirement to produce river basin management plans, with the aim of achieving 'good surface water status' by 2015.

Surface water status (classified into five levels from 'high' to 'bad') comprises 'chemical status' and 'ecological status', the latter defined according to the quality of 'biological elements' such as macrophytes, benthic invertebrates and fish. Ecological status also takes account of 'physico-chemical quality elements' (e.g., nutrient concentrations and pH) and 'hydromorphological quality elements' (e.g., substrate composition and riparian structure). The classification of surface water status applies to 'water bodies', which may constitute, for example, whole lakes, or stretches of river.

What does the WFD say about alien species?

The WFD brought with it a requirement to assess the human pressures affecting surface waters. Whilst the text of the Directive does not explicitly mention alien species, it is clear that they may at times constitute a pressure on other aquatic species as well as detracting from the 'naturalness' of a water body – a fundamental concept that underpins the WFD. The need to address these issues under the WFD has been recognised in some of the guidance developed by the European Commission, including 'REFCOND', 'IMPRESS' and 'COAST'.

The UK (through the Alien Species Group of the WFD UK Technical Advisory Group) has led the way in proposing how alien species might be assessed as a 'pressure' under the WFD. In addition to discussion and consultation within the UK, work is beginning under the auspices of the Commission's ECOSTAT group to develop a consensus on how aquatic alien species should be tackled under the Directive.

How should alien species affect the classification of ecological status?

There are no water bodies within Europe that have escaped human impacts entirely; thus, even 'high status' water bodies have some degree of 'departure from naturalness'. The key questions for debate include:

What constitutes an alien species? What about species that have become naturalized over time?

Should we include native species that have been translocated to other regions of the same country?

Should a water body be classed at 'high ecological status' if an alien species is present?

How should alien species affect the classification of 'good ecological status'? Should this be related exclusively to the *impact* of alien species on other biota, rather than their presence?

Is the *presence* of an alien species the important factor, or should assessments be made only for species that are *established*?

These issues are currently under debate in the UK as progress is made towards classifying water bodies for the first cycle of river basin management under the WFD.

How should alien species problems be addressed through WFD programmes of measures?

The WFD 'programmes of measures' provide a real focus for dealing with threats and impacts to aquatic systems, and they will provide its principal mechanism for improving the state of the aquatic environment. It is therefore important to use these opportunities to address some of the critical ecological and economic problems caused by aquatic alien species.

The same principles that underlie successful alien species management in general need to be applied in WFD programmes of measures. These include:

- Preventing future problems – this involves detailed risk assessment.
- Early and urgent action on new outbreaks, identifying and controlling external sources of potential recolonization.
- Long-term management using appropriate tools and techniques, rather than 'one-off' eradication of existing problems.
- Linking funding to long-term management.
- Involving a wide range of interested parties, defining clear roles and responsibilities.
- Underpinning the process by monitoring.

NOTES

Invasion Biology Put into Mathematical Terms

Rob Hengeveld
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Much of invasion biology is studied using statistical descriptions and tests. This means that the parameters determining the process, such as dispersal and reproduction, are becoming known, but not the way they operate. However, without insight into their mechanism of operation, it is not feasible to take adequate measures if these are needed. The obvious disadvantage of this approach does not exist in analytical modelling, which is specifically concerned with this mechanism. Apart from technical difficulties concerning possible practical measures of eradication or conservation to be taken, knowing the mechanism of operation typically concerns the biology of the process; this brings the invasion process into direct contact with other biological disciplines.

In this talk, I shall explain the differences between the two approaches, and suggest impacts knowledge about invasions has on bio-geographical and ecological understanding when it is obtained in this analytical way.

NOTES

Moving Toward Common International Policies

Timothy R.E. Keeney
Deputy Assistant Secretary for Oceans and Atmosphere
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By its very definition, the invasive species issue is international in scope and cannot be addressed solely with domestic laws. All of us at this conference are certainly aware of efforts within the International Maritime Organization to address the ballast water issue, but, increasingly, NOAA has found that the issues associated with invasives are being raised in the context of a variety of other international agreements. Further, as international trade increases in volume, the United States government has found it necessary to take cognizance of potential invasive species problems.

To some extent, our colleagues dealing with terrestrial plant pests are ahead of us with Sanitary and Phytosanitary provisions under the International Plant Protection Convention. Although it may be premature to take similar steps with aquatic organisms, there are initial steps that can be taken in moving toward an international consensus on appropriate actions. There are four areas in which this is feasible. First, we can make an effort to move toward common methods and processes in assessing problems. Second, we should formalize methods of sharing scientific information so that biological and life history information are readily available. Third, similar to the provisions for plant pests, we should explore the possibility of regional cooperation. Finally, we need to give renewed emphasis to preventing the movement of diseases and other organisms that may be associated with deliberate movements of species.

NOTES

Where Does the Effort to Resolve the Worldwide Problem of Aquatic Invasive Species Stand as We Begin the 15th International Conference on Aquatic Invasive Species? I Believe We Can, We Must, Do Better

The Rt. Hon. Herb Gray
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From its genesis in 1991 as a Great Lakes regional meeting where scientific studies on the invasion of the zebra mussel in North America were presented and debated, this conference on aquatic invasive species has evolved to become a comprehensive international forum for the review of scientific information on the impacts of aquatic invasive species, technological and engineering advances, modeling, information management, education and public outreach, and policy and legal issues.

The intent of my talk today is to stimulate further dialogue on how this conference can do more to press governments worldwide to take truly effective concerted action to contain the existing AIS problem, prevent new invasions from shipping activities in both fresh and salt waters, and also on ways to eliminate newly-recognized threats from other vectors such as migration through canals, aquaculture escapement, intentional or accidental releases of bait, aquarium fish; or live fish sold for human consumption.

NOTES

Detailed Assessment of the Population Dynamics of the Non-native Amphipod, *Caprella mutica* in Marinas in Scotland (UK): Implications for Secondary Dispersal

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In August 2006, the ten largest marinas in Scotland were surveyed for the presence of the non-native amphipod *Caprella mutica*. A variety of structures, including pontoon floats, chains and harbour walls were inspected to a depth of 0.5 m for the presence of this non-native species. Replicated 0.25 m^2 scrape samples were removed from the pontoon floats in three locations within each marina including: i) inner (i.e., closest to the foreshore) ii) middle, and iii) outer (i.e., nearest to the marina entrance/exit and typically furthest from the foreshore). The presence/absence, abundance, sex ratio and age of *C. mutica* were recorded for each marina and location. *C. mutica* was found in seven of the 10 marinas and occurred on the west and east coasts of Scotland. The population dynamics of *C. mutica* within each of these sites, the potential for marinas to act as a refuge and for recreational boating to disperse this species will be discussed.

NOTES

Impact of Colonization of the IJsselmeer Area by *Chelicorophium curvispinum* and *Dikerogammarus villosus*

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Lake IJsselmeer, Markermeer and the border lakes in The Netherlands were gradually colonized by *Chelicorophium curvispinum* during the 1990s, and stormingly in 1997 by *Dikerogammarus villosus*. Both were accused of having a negative impact on the local *Dreissena* population. A significant impact on the filtration capacity of the bivalve community would result in negative effects on local aquatic ecology and water quality, in which filter feeders play a key role. However, the occurrence of both invading species is heavily concentrated in the dynamic border zones of the lakes, while densities in the mussel beds on the lake bottom are relatively low (*Chelicorophium*) or even negligible (*Dikerogammarus*). On the other hand, *Chelicorophium* largely replaced the indigenous *Corophium lacustre*, while colonization by *Dikerogammarus* in 1997 coincided with a sharp drop in densities of a large number of other species. Among these were in particular Huridinea, Turbellaria, *Gammarus* and *Asellus*. Populations of the mollusc *Theodoxus fluviatilis* disappeared completely. In conclusion, effects on water quality and lake ecosystems as a whole seem to be limited, but effects on invertebrate diversity are considerable.

NOTES

Preferences of Ponto-Caspian and European Gammarids for Zebra Mussel Shell Habitat

Jarosław Kobak *and Jarosław Żytkowicz*
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We investigated associations between two invasive, Ponto-Caspian gammarids (*Dikerogammarus haemobaphes* and *Pontogammarus robustoides*) and one native European species (*Gammarus fossarum*) with zebra mussel (*Dreissena polymorpha*) shell habitat in a series of laboratory experiments.

We tested gammarid preferences for the following objects: 1) living mussels, 2) empty mussel shells (clean or coated with nail varnish) glued together using aquarium silicone sealant to imitate a living mussel, 3) stones (clean or varnished), and 4) empty plates.

Ten objects of one type were glued to a plastic plate (100 x 100 x 5 mm) with fast-binding methyl acrylic glue. Drops of glue were also put on the empty plates to control for its effects. The plates were placed in tanks (bottom: 220 x 220 mm in Experiment 1 and 110 x 220 mm in Experiments 2-6; height: 200 mm) in the following combinations:

Experiment 1 (the test of substratum preferences): mussels, clean shells, clean stones and empty plates

Experiment 2 (the effect of stones): stones and empty plates

Experiment 3 (the effect of varnish): varnished and clean stones

Experiment 4 (the effect of shell surface properties): varnished and clean shells (the same shapes, different surfaces)

Experiment 5 (the effect of shell shape): varnished shells and varnished stones (the same surfaces, different shapes)

Experiment 6 (the effect of waterborne mussel exudates): mussels covered with mesh and empty substratum.

We put a single gammarid into the central part of the tank and determined its position after 24 h. From 28 to 115 individuals were tested in each experiment.

Gammarids preferred stones rather than empty plates (Experiment 2), showing that stones were a good shelter for them and could be used for comparison with shells in other experiments. They did not discriminate between varnished and clean stones (Experiment 3), confirming that the varnish did not affect animals and could be used to exclude the effect of object surface properties in other experiments.

D. haemobaphes preferred living mussels rather than their empty shells and these two habitats over stones and empty plates (Experiment 1). It responded to shell shape, selecting varnished shells rather than varnished stones (Experiment 5) as well as to shell surface properties, selecting clean shells rather than varnished shells (Experiment 4). It did not respond to waterborne mussel exudates (Experiment 6).

P. robustoides did not select any substrata in Experiment 1, so it was not included in the other experiments. It is probably associated with macrophytes and sandy bottom rather than with mussel shell habitat.

G. fossarum preferred empty mussel shells (but not living mussels) in Experiment 1. It responded only to their shape (difference in Experiment 5), but not to surface properties (no difference in Experiment 4). Thus, its affinity for zebra mussels was weaker than that of *D. haemobaphes*.

Zebra mussels are valuable habitat for gammarids, as well as for other benthic organisms, as they increase substratum heterogeneity, provide numerous shelters and rich food sources. Strong associations of *D. haemobaphes* with zebra mussels could stimulate its successful range expansion in Europe.

NOTES

Success of the Invasive Ponto-Caspian Amphipod *Dikerogammarus villosus* by Life History Traits and Reproductive Capacity

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State Government of Lower Austria, Experts for the Conservation of Nature
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Dikerogammarus villosus was not found in the Austrian stretch of the River Danube until 1989, and not before 1992 in the Bavarian Danube. This relatively large species was introduced into the Rhine catchments via the Main-Danube Canal. It quickly spread to adjacent areas in the Netherlands and France, and hence also used the southern corridor to spread into Western Continental Europe. It has successfully invaded the Rhône system and large rivers of northern Germany, as well as the Moselle and other French streams, rivers and canals. The species also occurs in several lakes, e.g., Traunsee, Lake Constance, Lake Garda.

A potentially high reproductive capacity expressed in the number of eggs and brood volume, comparatively small eggs, optimal timing to release the maximum number of neonates per female in April/May (maximising rapid growth at high summer temperatures and plentiful food), a long reproductive cycle, a privilege of mating only for larger individuals in winter and spring, a female-biased sex ratio, together with a rapid development of eggs, rapid growth to sexual maturation, short life span, tolerance to a wide range of environmental conditions, and exceptional predatory capabilities, all give the invasive Ponto-Caspian gammarid an opportunity to develop large populations in fresh and brackish waters of the temperate biome all over the world. In all life-history variables, *D. villosus* is competitively superior to many of the indigenous species in northwestern Europe and elsewhere.

NOTES

Biological Invasions Via Inland Water Corridors: Developing a Risk Assessment Tool for European Inland Waterways

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The complex European network of inland waterways is made up of >28,000 km of navigable rivers and canals, connecting 37 countries in Europe and beyond. This aquatic web now connects the previously isolated watersheds of the Caspian Lake, the southern European seas (Azov, Black and Mediterranean) and the northern European seas (Baltic, North and White), to provide corridors for aquatic invasive species (AIS). We conducted preliminary qualitative risk assessment of AIS for four main European inland invasion corridors: the largest, with 6,500 km of main waterways and 21 inland ports of international importance, the "northern corridor" (linking the Black and Azov seas with the Caspian Lake via the Azov-Caspian waterway including the Volga-Don Canal, and with the Baltic and White seas via the Volga-Baltic waterway including the Volga-Baltic Canal, and the White Sea-Baltic Sea waterway, including the White Sea-Baltic Sea Canal), "central corridor" (connecting the Black Sea with the Baltic Sea region via Dnieper and Bug-Pripyat Canal), the "southern corridor" (linking the Black Sea basin with the North Sea basin via the Danube-Main-Rhine waterway) and the "western corridor" (linking the Mediterranean with the North Sea via the Rhône and the Rhine-Rhône Canal). Our approach to a qualitative integrated risk assessment of AIS is combining environmental matching risk assessment and species-specific risk assessment and includes: the identification of principal recipient and donor areas of AIS (risk areas) along likely invasion routes; identification of the main vectors involved in AIS transmission; assessment of inoculation rates, ecosystem vulnerability to invasions and AIS invasiveness both in the recipient risk area and in potential donor areas. Qualitative estimations of inoculation rates, ecosystem vulnerability to invasions and species invasiveness, based on previous patterns, were used for an assessment of the integrated ecosystem risk level for main risk areas within the invasion corridors. For example, an initial predictive risk assessment of possible spread and establishment of 34 high-risk AIS in aquatic ecosystems along the "northern invasion corridor" has shown the Gulf of Finland (Baltic Sea) to be the most vulnerable ecosystem for invasions. Recommended management options include treatment of ballast water and sediments and removal of hull fouling which should be undertaken before entering the main inland waterways. Control and reduction of the dispersal of AIS along inland waterways may also entail installation of barriers such as deterrent electrical systems, chloride or pH-altered locks. Our qualitative approach to risk assessment of aquatic invasions may be a useful tool for the management of AIS introductions in the European inland waterways.

This study has been supported by the European Commission 6th Framework Integrated Project ALARM (contract GOCE-CT-2003-506675) and Strategic Targeted Research Project DAISIE (contract SSPI-CT-2003-511202).

Predicting the Number of Ecologically Harmful Invaders in an Aquatic System

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Although most introduced species do not have strong impacts on biodiversity, a small proportion cause substantial declines or extinctions of native species populations. But such impacts may vary greatly across systems and regions. As a first step toward examining why some systems appear more susceptible to impacts, we determined whether the number of invaders that cause substantial declines in native species in a given system can be predicted from the total number of invaders in the system.

We compiled a data set of 16 aquatic systems that differ broadly in area, location, numbers of native species historically present, and numbers of invaders. These systems were located by a search of the scientific literature for lakes, river basins, estuaries and marine coastal regions with well-documented invasion histories. For each system, we categorized all established exotic fishes, invertebrates, algae and vascular plants according to their ecological impact. Invaders were classified as 'high-impact' if there was a published reference to them having been associated with the displacement, near extirpation or severe reduction of a native population. A second data set was similarly compiled for freshwater fishes in 149 countries.

In both data sets, after correcting for the species-area effect, the number of high-impact invaders was positively correlated with the total number of invaders. These relationships were best fitted with simple linear functions; thus, there was no evidence of non-linear (synergistic or antagonistic) effects of invaders at system-wide or regional scales, contrary to invasional meltdown and biotic resistance hypotheses. High-impact invaders comprised a mean 8% of the total number of invaders across aquatic systems and 12% of the total number of fish invaders across countries, remarkably consistent with the Tens Rule. Although the mechanism driving this correlation is most likely a sampling effect, it is not merely the effect of proportional sampling of a constant number of repeat offenders; most of these invaders are not reported to have strong impacts on native biodiversity in the majority of regions in which they invade.

NOTES

Rapid Screening-level Risk Assessment of Freshwater Fishes in Live Fish Trades in Canada

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Hundreds of species, and thousands of kilograms, of live freshwater fishes enter Canada annually through various vectors including the food and aquarium trades. Fishes originating from these trades have been collected in the wild in Canada; therefore, these vectors, and the species found in them, present a potential risk to Canada's aquatic ecosystems. To better direct policy and management actions to minimize this risk, it is important to differentiate those species with a high risk of having a significant negative impact if released into the wild from those species with a low risk. To determine the risk of the hundreds of species in these vectors, Fisheries and Oceans Canada's Centre of Expertise for Aquatic Risk Assessment (CEARA) is currently developing a three-step process for assessing risk: 1) Initial Screening; 2) Screening-level Risk Assessment; and, 3) Detailed-level Risk Assessment. An initial screening to determine the priority of species to be screened further will be undertaken by evaluating two criteria: 1) the presence and abundance of the species in a high risk vector; and, 2) the ability of the species to survive in Canada. Vectors will be assessed to determine the risk of species released into the wild through them. The presence and abundance of species in high-risk vectors will be determined by examining import records compiled in partnership with the Canada Border Services Agency. The ability of species to survive in Canada will be evaluated using environmental niche modeling. Rather than model the potential distribution of each species, a time and resource consuming process, global environmental variables known to be important to freshwater fishes will be used in an ordination analysis to identify areas of the world with similar environments to Canada. The native distribution of each species screened will then be overlaid onto the resultant global environmental niche map to determine if the species is found in environments similar to those found in Canada. Species found in abundance in a high-risk vector and predicted to be able to survive in Canada will be subjected to a Screening-level Risk Assessment (SLRA). The SLRA will evaluate the known and predicted impacts of the species identified from a literature search on the species from its introduced range and on its closely related species. Species with known or predicted negative impacts where introduced will then be subjected to Detailed-level Risk Assessments (DLRA) based on National Guidelines developed by CEARA.

NOTES

Risk Analysis for Non-indigenous Fish Species in Flanders (Belgium)

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Katleen Vandenbergh and Frans Ollevier
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Belgium has known many fish introductions during the last centuries. Louette *et al.* (2001) describe 47 considered, attempted and/or successful introductions with freshwater fish species since 1200. First introductions concern the common carp *Cyprinus carpio* and later gibel carp *Carassius gibelio* and goldfish *Carassius auratus*. Recently introduced non-indigenous fish species (since 1980s) are fathead minnow *Pimephales promelas,* asp *Aspius aspius* and the highly invasive topmouth gudgeon *Pseudorasbora parva.* Many other species (*Neogobies* sp., *Romanogobio albipinnatus*, *Proterorhinus marmoratus*, ...) are expected to appear soon in Belgian waters as they are already present in adjacent river basins in our neighbouring countries, The Netherlands and Germany.

In Flanders (Belgium) no risk analysis protocol exists to judge non-indigenous fish species on their invasiveness, risk of introduction and risk of establishment. A risk analysis, based e.g., on "risk identification and assessment of non-native freshwater fishes: concepts and perspectives on protocols for the UK" (Copp *et al.*, 2002) is now being developed. An extensive literature search about the above mentioned non-indigenous fish species was carried out. A large database resulting from fish monitoring programmes of the Research Institute for Nature and Forest was analysed to detect existing trends in the presence and abundance of non-indigenous species over the last 10 years in Flanders.

This inventory and existing trends are used to construct a hazard identification and assessment protocol. The results from this risk analysis will allow to advice policy makers to take measures in order to prevent and control deliberate and accidental introductions of freshwater fish species.

NOTES

US Coast Guard's Programmatic Environmental Impact Statement in Support of the Ballast Water Discharge Standard Rulemaking

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The United States Coast Guard is authorized by Congress to develop a national regulatory program to reduce, and eventually prevent, introductions of aquatic non-indigenous species (NIS) into US waters via vessel operations. As such, the US Coast Guard established a mandatory ballast water management program which specifically requires the US Coast Guard to approve alternative ballast water management methods that are found to be at least as effective as ballast water exchange (BWE) in preventing NIS introductions. As the effectiveness of BWE varies from vessel to vessel, and most vessels cannot conduct BWE due to voyage constraints or safety concerns, we are developing a regulatory standard for the discharge of ballast water. Once these systems meet the standard and are approved by the US Coast Guard, vessels can use them in lieu of conducting BWE. As with the promulgation of any Federal regulation, we are bound by the National Environmental Policy Act (NEPA) to analyze the environmental impacts of implementing the ballast water discharge standard. In the fall of 2003, we held public workshops across the nation to engage the public in scoping out the possible environmental impacts the US Coast Guard should consider. The US Coast Guard contracted the services of the Department of Transportation's John A. Volpe National Transportation Systems Center to conduct the environmental impacts analyses. Also, the Environmental Protection Agency, the National Oceanic and Atmospheric Administration, and the US Fish and Wildlife Service agreed to assist us and became cooperating agencies. The results of our environmental impacts analyses have been prepared in a Draft Programmatic Environmental Impact Statement (DPEIS), which was made available to the public on [insert date] 2007. This presentation will: provide a brief review of the US Coast Guard's regulatory process; discuss elements of the DPEIS; discuss next steps to finalize the DPEIS; and offer insight on the direction of the development of the ballast water discharge standard regulation.

NOTES

Canada's National Regulatory Approach to Ballast Water Management

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Canada has been active in regulating ballast water discharge from ships for the last 26 years. In 1982, the perceived threat to the aquaculture industry in the Grand Entrée Lagoon of the Isles de la Madeleine from toxic phytoplankton, prompted the Canadian Coast Guard to issue a Notice to Mariners prohibiting ships from discharging their ballast water within ten miles of the islands unless it had been exchanged.

Much has happened on the ballast water and regulatory front in those 26 years. The understanding of the science of invasions, marine engineering and ship operations aspect of ballast water management has been the subject of much research. The invasion of the ruffe and the zebra mussel into the Great Lakes caused Canada to promulgate the Voluntary Guidelines for the Control of Ships proceeding to the Great Lakes and St. Lawrence River in 1989. In 1998 the Canada Shipping Act was amended to allow a full regulatory regime for ballast water management. By 2000 National Guidelines were in place based on both international guidance provided by the International Maritime Organization (of which organization Canada was an Active participant in the Ballast Water Working Groups of the Marine Environmental Protection Committee) and reflecting regional differences for the reality of shipping in different parts of the country.

In June 2005 the Ballast Water Management Regulations were published in the Canada gazette. Incorporating the pertinent regional realities of Canada and many of the provisions of the 'International Convention for the Control and Management of Ships Ballast Water' these regulations will form the basis of Canada's response to the unintended discharge of aquatic invasive species into waters under Canadian jurisdiction. The Regulations came into force in June 2006 and are currently being enforced.

NOTES

Joint Ballast Water Inspection Program for Ocean Going Vessels Entering the Great Lakes

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The fresh waters of the Great Lakes are currently home to over 180 identified aquatic invasive species. Scientists suggest that greater than 70% of successful invasions are associated with ocean-going ships since the 1959 opening of the St. Lawrence Seaway. The introduction of the ruffe, goby and zebra mussel in the late 1980s brought various regulatory responses from the governments of the United States and Canada starting in 1989 with Voluntary Guidelines. Today both countries have exchange regulations for vessels entering the Great Lakes in ballast. Both counties require that unpumpable residual water and sediment in ballast tanks be exposed to a salinity equivalent to ballast exchange by flushing; though this requirement is currently only mandatory for vessels planning to discharge in waters under Canadian jurisdiction. The St. Lawrence Seaway has a regulatory requirement regarding ballast water for ships entering the system as well. To ensure compliance with the various compatible (but differing) regulatory requirements from each agency, and to facilitate the continued use of the Seaway, (which is of considerable economic benefit to both countries) Transport Canada, the United States Coast Guard, the St. Lawrence Seaway Management Corporation and the St. Lawrence Seaway Development Corporation have entered into a innovative joint ballast water inspection program. Initiated in 2005, and refined during the 2006 shipping season, joint teams of Transport Canada and United States Coast Guard have been boarding vessels, with primarily unpumpable residuals onboard, in the Quebec City to Montreal portion of the St. Lawrence River, prior to entry into the Seaway. These boardings are in addition to the long-standing program undertaken by Seaway and the United States Coast Guard, targeting ships in ballast while in the Seaway. The joint program has been continuously refined to provide a unified and consistent message to the ships entering the system.

NOTES

The Canadian Ballast Water Database Application

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Ballast water is the primary vector for the transport of aquatic and invasive species to Canadian freshwater and marine ecosystems. Some studies estimate that as many as 70% of invasive species established in the Great Lakes ecosystem arrived there via ballast water discharges since the opening of the St. Lawrence Seaway. It is therefore crucial to closely examine the reality of ballast discharges in order to prevent future unwanted introductions through this conduit.

A Joint Fisheries and Oceans Canada (DFO)/Transport Canada (TC) database is ambitiously and proactively addressing the issue of ballast water discharges and the establishment of aquatic species in Canadian waters by supporting real-time scientific analyses of aquatic and invasive species and enforcement of ballast regulations. Current, up-to-the-minute data can be entered either manually or electronically, to receive instantaneous quality-assured information that drives the enforcement of regulations and guidelines protecting Canadian freshwater and marine ecosystems. This is a vital approach to not only assess risks but also select the most appropriate treatment methods to apply to a ship that has failed to perform ballast water exchange.

This innovative tool will be the authority that guides decisions aimed at effectively preventing future introductions of aquatic organisms via ballast water operations. Ballast water reporting forms, GloBallast Risk Assessment tools, biological and salinity sampling of ballast water and joint boarding enforcement information are all recorded in the database. The compilation of all the data supports ballast water and invasive species analyses; the determination of factors which might influence the establishment success of invasive species; and the construction, through GIS mapping, of risk assessment models that can identify areas of concern in order to direct future prevention and management policies.

Designed to harmonize with the United States Coast Guard's National Ballast Information Clearinghouse (NBIC), the Canadian Ballast Water Database Application (CBDA) will influence Port State Control (after ratification of the International Maritime Organization [IMO] 2004 Convention) and TC Enforcement procedures. The CBDA will also provide reputable resources for GIS mapping, scientific research and public consultations.

The database will serve as the primary resource for government agencies, industry, the scientific community and other concerned stakeholders to make decisions that effectively protect the ecosystem from the impacts of aquatic invasive species.

NOTES

Factors Influencing Predatory Behaviour in an Invasive Gammaridean Species, *Dikerogammarus villosus*

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The Ponto-Caspian amphipod *Dikerogammarus villosus* appeared to be an omnivore with predatory activity, and with a high impact on newly invaded communities. It can be questioned which factors influence this typical predatory behaviour in an invasive gammaridean amphipod. By aquarium experiments the influence of several factors such as size, sex, temperature and types of prey and shelter are tested in order to explain observations on community changes in the River Rhine and Lake Gouwzee after invasion of this species. All these factors seemed to influence the predatory behaviour of *D. villosus*. Low temperatures slowed down its activity, which means that cold water communities of tributaries of the River Rhine are not threatened by this 'killer shrimp'. Furthermore, other species can recover from predation by *D. villosus* in winter time in the Rhine as well in the Gouwzee.

NOTES

Small-scale Heterogeneity in the Physico-Chemical Environment Limits the Local Dominance of an Aquatic Invader

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The impacts of an exotic species on native species may vary along environmental gradients. We tested the hypothesis that heterogeneity in the physico-chemical environment over small spatial scales alters the dominance of two competing amphipods: *Gammarus fasciatus*, the most common native species in the upper St. Lawrence River, and *Echinogammarus ischnus*, a euryhaline Ponto-Caspian species that invaded the river in the late 1990s. *Echinogammarus* has replaced *Gammarus* as the dominant amphipod at some sites. Using experiments in the laboratory and in the field, we tested the effect of conductivity on the outcome of interspecific interactions between these two species. The field experiment was conducted using amphipods of both species transplanted to different sites along a strong gradient of conductivity within Lac Saint-Louis. Our lab experiments used water collected from these sites. The lab experiments revealed that both species were interspecific predators whose rate of predation varied with conductivity. *Echinogammarus* was the dominant predator at higher conductivity, while *Gammarus* was the dominant predator at lower conductivity. The field experiment supported these results at high conductivity, but not at low conductivity – where the presence of *Gammarus* had no effect on *Echinogammarus* survival. *Echinogammarus* survivorship in experimental enclosures was found to be more sensitive to variation in conductivity than was *Gammarus*. These environmental constraints limit the invader's ability to replace the native species. Therefore, chemical variables might be useful for predicting the impact of *Echinogammarus* on benthic communities.

NOTES

Phylogeography of *Crangonyx pseudogracilis:* Modelling an Alien Species' Progressive Invasion of British Waterways

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Crangonyx pseudogracilis (Bousfield 1958) is one of several freshwater amphipod species currently invading slow-flowing and lentic waterbodies throughout Europe associated with widespread ecosystem deterioration. Since its initial UK colonisation in the 1930s its spread has been neither deliberately promoted nor curtailed, so this species presents an opportunity to examine phylogeographic consequences associated with invasion of an isolated but heterogeneous neutral aquatic milieu.

This study makes use of microsatellite markers to reconstruct a genealogy and infer historical patterns of gene flow between populations and meta-populations. Phylogenetic trees are constructed to determine rate and extent of genomic differentiation occurring in relation to spatial and temporal isolation and specific environmental factors. GIS mapping, in conjunction with multivariate analyses, are being employed to produce predictive models of likely future spread of *C. pseudogracilis* with its associated genomic consequences. Such models should enable detailed and effective predictions regarding invasive amphipod spread within British and, by inference, European waterways, permitting quantified assessment of future colonisation risk and the targeting of management towards preservation of native species and ecosystem integrity.

NOTES

Modelling the Migration and Ecological Impact by Alien Macroinvertebrates in Flanders: Case Study of Crustaceans in the Bocholt-Herentals Canal

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Since the last century, more and more exotic species have become established in rivers and canals. Although the knowledge about the presence of invasive macroinvertebrates in Flanders is still limited, one can state that at least 23 species, mainly belonging to mollusca and crustacea, have invaded the Flemish watercourses. In Flanders, there is an urgent need to analyse the dispersal and impacts of those invaders. Therefore, samples taken yearly by the VMM in the Bocholt-Herentals canal (between 1991 and 2005) were analysed and identified at species level and a model framework was established. Primarily results state that *Dikerogammarus villosus*, which is present in Flanders since 1997, becomes the dominant crustacean species after its invasion and that native species like *Gammarus pulex* have disappeared. Moreover, this species is rapidly invading other watercourses.

The dispersal of invasive species is nowadays mainly altered by man through canalisation and ship transport (e.g., ballast water). Ecological models can help to predict the colonisation and migration of invasive species. Based on monitoring data and expert knowledge on the relationship between biota, environmental variables and habitat characteristics, habitat preference and GIS migration models are established to predict the migration as well as the impact of the invasive species on the occurrence of native species like *Asellus aquaticus* and *Gammarus pulex*. In this way the major invasion routes and new habitats can be determined and optimal measures can be taken to prevent further migration. Within the context of the Water Framework Directive, this risk analysis can play an essential role in developing prevention measures limiting the risk of large-scale invasion by these species.

NOTES

Established *Gammarus roeseli* Withstand Invasive *Dikerogammarus villosus* in Lake Constance: Experimental Evidence

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In the last decades, the pontocaspian gammarid *Dikerogammarus villosus* has invaded the large rivers of Europe, thereby displacing nearly all native gammarid species. *D. villosus* has a larger body size and a more predatory feeding behavior than most other gammarid species that are shredders to omnivores. Since 2002, *D. villosus* occurs in Lake Constance. We expected that it would quickly outcompete the smaller *Gammarus roeseli*, which has dominated the gammarid fauna so far. As expected, the abundances of *G. roeseli* in Lake Constance declined very fast, however they remained on a lower level than before. Especially during winter *G. roeseli* reveals high densities. Therefore we analyzed several aspects of this coexistence.

1) Interactions between gammarids: One potential reason for the displacement is intra-guild-predation (IGP) among gammarids. IGP was found in micro-scaled experiments with freshly molted individuals. In order to provide data that are closer to the natural situation, we analyzed the predation rate between *D. villosus* and *G. roeseli* in meso-scaled experiments using several substrates commonly found in Lake Constance: a) hard substrates (pebbles, pebbles overgrown with *Dreissena polymorpha*, gravel), b) soft substrates (sand and sand covered with characean macroalgae). In each replicate, we used ten hard-shelled (not freshly molted) individuals of each species and observed the predation rate over three days. *G. roeseli* showed no predation on *D. villosus*. On the hard substrates and on sand we found predation rates between 20% to 50% by *D. villosus* on *G. roeseli*. We found no IGP at all on the macroalgae *Chara sp.*, which is widespread in Lake Constance. So it seems that the extensive characean stands act as a refuge for *G. roeseli* that support the resistance of *G. roeseli* against *D. villosus*.

2) Gammarid–crayfish interactions: We investigated the influence of the exotic crayfish *Orconectes limosus*, a top-predator in the littoral zone. This species was presumably introduced in Lake Constance in the 1950s and accounts for – besides molluscs – the highest invertebrate biomass in the littoral zone. Since the habitats of this crayfish overlap with most of the gammarid habitats, we examined the predation rates on both gammarid species on gravel as substrate, using the set-up described above. Predation of *O. limosus* was nearly two times higher on *G. roeseli* than on *D. villosus*. This further reduces chances for coexistence of both gammarid species on gravel substrate.

3) Olfactory cues: An important influence on predation is the active enemy avoidance behavior, e.g., by reacting to olfactory traces of the predator. Therefore we investigated the influence of water containing crustacean kairomons on the site choice behavior by gammarids (either *D. villosus* or *G. roeseli*) in a Y-maze. In one experiment we tested the reaction to kairomones of *O. limosus*. Both gammarid species avoided the kairomone-containing water. In a further experiment we analyzed the reactions of both gammarids among each other. As expected *G. roeseli* avoided the scent of *D. villosus*. Surprisingly *D. villosus* also avoided the water incubated with *G. roeseli*, although *D. villosus* preys normally on *G. roeseli*.

In summary, our experiments show that *G. roeseli* appears to withstand *D. villosus* in structure-rich habitats formed by characean algae. As the crayfish *O. limosus* are rare in this habitat and the characeans are currently spreading in Lake Constance due to the re-oligotrophication of the water, we expect a coexistence of these crustaceen species in the future.

NOTES

Why Are *Pontogammarus robustoides* and *Dikerogammarus haemobaphes* (Crustacea, Amphipoda) Such Successful Invaders?

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Pontogammarus robustoides (G.O. Sars, 1894) and *Dikerogammarus haemobaphes* (Eichwald, 1841) are species of Ponto-Caspian origin occurring in Polish waters. They have spread very quickly and now are common in the lower and middle section of the Vistula River as well as in other rivers (Oder and Bug), and in lakes (*D. haemobaphes* in Great Masurian Lakes, and both species in lakes of the Vistula River valley).

The aim of the study was to estimate if the life history traits and feeding preferences promote invasion of these two species in Polish inland waters. The present study was carried out in the middle Vistula section. Samples were collected throughout the year in monthly intervals from October 2003 till October 2004 and in spring, summer and autumn in 2005. Both gammarid species are multivoltine and have a typical Ponto-Caspian-type life history: three to four generations per year, reproductive break during winter, relatively short generation time, early sexual maturity, high fecundity.

Analyses of digestive tract contents and results from two sets of laboratory feeding experiments showed that the feeding strategy of above-mentioned invasive species is more oriented to predatory behavior, than that of the native gammarid *Gammarus fossarum*, taken for comparison. It can be concluded that life history traits and feeding preferences probably promoted the invasion of *P. robustoides* and *D. haemobaphes* in Polish rivers.

NOTES

Ecological Patterns of Distribution in Alien Amphipods: A Case Study in Poland

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During the last two decades, invasive amphipods of various origins have colonised a number of water basins in Poland. These colonisations have been mostly associated with the decline of native amphipod species. Our goal was to reveal the general colonisation pattern with respect to a set of physico-chemical characteristics and anthropogenic influences in the colonised vs. non-colonised waters.

During the years 2002-2006 our group performed extensive fieldwork to reveal the occurrence of gammarids in six large Polish rivers (Vistula, Oder, Bug, Narew, Notec, Warta) and in their 80 tributaries, as well as in Baltic lagoons, and along the open Baltic coast. Altogether we found seven species of alien amphipods (*Chelicorophium curvispinum*, *Gammarus tigrinus*, *Pontogammarus robustoides*, *Obesogammarus crassus*, *Dikerogammarus villosus*, *D. haemobaphes* and *Chaetogammarus ischnus*).

In inland waters alien species occurred only in large rivers, where natives were almost completely absent. In comparison, native amphipods thrived in tributaries, where aliens did not enter. The main factor associated with that pattern was water conductivity (ranging in large rivers from 420 uS to 1824 uS, and in affluents from 365 uS to 754 uS). Distribution of aliens was positively correlated with growing values, while in native species the trend was reversed. High conductivity is a result of industrial pollution and may be the main reason for decline of sensitive native fauna and the success of more euryoecious invaders. Aliens, preferring higher ionic content, do not spread in small rivers, which if undisturbed, may remain safe refugia for native amphipods.

In Baltic lagoons the aliens were also successful, eventually replacing native brackish water species. Along the Baltic coast alien species were present mostly in river mouths and in coastal lakes. Native fauna thrived well in littoral zones on the open coast. The data obtained suggest that alien amphipods successfully colonize such brackish water habitats that are under anthropogenic pressure. In higher salinities (6-7 ‰) on the open Baltic coast, the Ponto-Caspian species are not present. The only species occurring in such conditions is the North American *G. tigrinus,* however its abundance is marginal compared to native fauna.

NOTES

Parasitism and Biological Invasion: How Manipulator Parasites Could Promote a Gammarid Species Replacement

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In the current context of assemblages blending species without co-evolutionary history, the outcome of competing species results from their inter-specific relationships in the recipient ecosystem. Of the numerous invasive amphipods in Western Europe, the Ponto-Caspian gammarid *Dikerogammarus villosus* has become the dominant member of crustacean assemblages in the main drainage basins. In eastern France, *D. villosus* can be found in sympatry with *Gammarus roeseli*, another crstracean amphipod of Balkan-European origin introduced in France 150 years ago. *G. roeseli* serves as an intermediate host for the acanthocephalan parasite *Polymorphus minutus* which manipulates the amphipod's behaviour in order to favour trophic transmission to shore birds. We investigated this host-parasite interaction within communities dominated by exotic species such as *D. villosus*. Under laboratory conditions, the aggressiveness of *D. villosus* involved a vertical displacement and a prompt escape of infected *G. roeseli* towards the water's surface.

Three mechanisms underline a potential decline in the prey dynamic. First, the behavioural modification induced by *P. minutus* prevents parasites from dying in non-host predators and make infected hosts vulnerable to the predation by an appropriate final host. The resulting prevalence rate should thus increase. Second, the predation pressure of *D. villosus* on uninfected *G. roeseli* staying benthic increased with the overlap of their microdistribution. Third, the infection is assumed to decrease the reproductive potential of parasitized animals. Overall, the acanthocephalan infection could promote species replacement in a biological invasion context.

NOTES

Controlling Non-indigenous Crustaceans: A Case Study for *Charybdis japonica* in New Zealand

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Charybdis japonica, the Japanese rock crab, is a non-indigenous portunid crab species now resident in Waitemata Harbour, New Zealand. This species has the potential to become a significant competitor for the native paddle crab and a predator of important bivalve populations such as mussels, scallops and cockles. We undertook a review of potential methods for the control of invasive crab species, with assessments of efficacy, benefits, constraints, health and safety issues, and cost considerations. The review highlighted several options for control, including environmental modification, biological control, physical removal, sterilization and chemical control methods. Based on the conclusions of this review, it was evident that the best strategy would be the incorporation of multiple control options into an integrated pest management strategy.

Experimental trials evaluated a number of control options, including the use of contact poisons, poison baits and a range of barrier treatments, as part of an IPM strategy. Four chemical compounds were selected for laboratory experiments to ascertain their effectiveness as control treatments of portunid crabs. These were carbaryl, copper oxychloride, the molt disruptor emamectin benzoate and hydrated lime. Overall carbaryl provided the best effects on portunid mortality as an aqueous solution, mixed with bait and applied as a treated rope barrier. Barrier methods proved to be relatively ineffective overall, providing little longevity as a practical control option for the control of a portunid crab. On balance it was considered that trapping utilising carbaryl-laced baits would provide the most effective methods for controlling invasive crab populations.

A field trial of the final strategy was carried out a on a wild population of *C. japonica* in a semi-enclosed estuary in Auckland, New Zealand. The results of the trial and the benefits and limitations of implementing a fish-down control strategy on invasive crab species are discussed.

NOTES

Assessment of Zebra Mussel *(Dreissena polymorpha)* Infestation Risk Using GIS for Water Basins in Northwest Bulgaria

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In Bulgaria, zebra mussels (*Dreissena polymorpha*) occurred originally in the Danube River and its tributaries as well as in the Black Sea coastal lakes and rivers. During the last 10 years a rapid spread of zebra mussels in the Bulgarian inland water bodies has been observed. Several reservoirs were infested and this caused damages to thermoelectric power plant, irrigation and fish cage facilities. In the northwest region of Bulgaria, there are about 280 large and small reservoirs belonging to the Danube River basin. Two of them have already been reported as infested. The goal of this study was to determine the risk of zebra mussel infestation in water bodies in this region by combining available biological and environmental data and by subsequent processing and analyzing of these data using Geographic Information System (GIS). Assessing the risk of infestation will be the first step in developing an action plan in this and other vulnerable regions of Bulgaria.

The evaluation of physical and chemical characteristics of the water bodies in the region, and their suitability to the zebra mussel requirements, was made based on existing data from monitored river stations, spatial data and reservoir field survey. Fifteen reservoirs were sampled to determine which physicochemical variables explain the occurrence and abundance of zebra mussels. Based on the results of PCA and review of available information, the following habitat suitability parameters were selected: calcium concentration, pH and dissolved oxygen. The data about physiological tolerances of zebra mussels during their larval and early growth stages were retrieved from the literature. The chemical parameters selected were divided into three main categories that reflected the infestation potential of zebra mussel: High, Moderate and Low. The parameters that were in the range considered as optimal for zebra mussel infestation and that supported moderate and high population abundance were included in the category "High"; these in the range considered as appropriate for zebra mussel infestation but supporting moderate abundance in "Moderate"; and the parameters that were outside the range known to support zebra mussels in the category "Low". After all spatial and attributive data were collected, they were processed and analyzed in a GIS environment, which included GIS database development, spatial and geostatistical interpolation of limiting factors, reclassification and overlay.

The results showed that based on water chemistry, approximately 55% of the territory can be classified with high zebra mussel infestation potential, 20% with moderate infestation potential, and 25% with low infestation potential. In reservoirs, additional factors, which contribute to the increased risk of infestation are large surface area (over 90 ha), comparatively high depth, high substrate diversity, moderate amount of nutrients and easy accessibility to human users. Potential zebra mussel dispersal mechanisms were identified as the direct waterway connections with the Danube, as well as transport of larvae or adult individuals with fishing equipment (nets), boats and fish stocking material from the Danube and fish farms nearby; and from already infested water bodies.

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NOTES

Risk Assessment of Infestation by Zebra Mussels *(Dreissena polymorpha)* and Quagga Mussels *(Dreissena bugensis)* and Conservation of Endangered Native Mussels, Higgins Eye Pearlymussel *(Lampsilis higginsii)* and Winged Mapleleaf *(Quadrula fragosa)* in the St. Croix River Basin, Minnesota and Wisconsin, USA

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The European freshwater zebra mussel (*Dreissena polymorpha*) and quagga mussel (*Dreissena bugensis*) were first noted in North America in Lake St. Clair and Lake Ontario, respectively, during the mid to late 1980s. Zebra mussels rapidly spread throughout the Great Lakes. The connection of Lake Michigan to the Illinois River via the Chicago Ship and Sanitary Canal allowed downstream dispersal of larvae into the Illinois and Mississippi Rivers. Upstream transport was slower and probably enhanced by attachment of mussels to vessel hulls. Quagga mussels now occurs throughout the Great Lakes and the upper St. Lawrence River. The St. Croix River, a major tributary to the Mississippi River, is the focus of an ongoing study of zebra mussel control options and other management actions to minimize adverse effects on endangered native mussels.

Two endangered mussels, the Higgins eye pearlymussel (*Lampsilis higginsii*) and winged mapleleaf (*Quadrula fragosa*); occur in the St. Croix and Upper Mississippi Rivers. A three-year feasibility study was initiated in 2006 to identify cost effective and environmentally sustainable alternatives for controlling zebra and quagga mussel populations in the St. Croix River basin and adjacent Upper Mississippi River pools and conserving the endangered mussels. Thirty-nine species of mussels have been identified from the St. Croix River. Zebra mussels have only been found in the lower 40 km of the St. Croix River.

The St. Croix River is a sixth-order stream that drains 20,018 km^2 in east-central Minnesota and northwestern Wisconsin. This basin includes 1,700 tributaries, with 98 that connect directly to the St. Croix River. In that area, 628 lakes greater than 0.4 ha directly connect with the river and its tributaries. An additional 1,725 lakes are in the basin but do not have a surface water connection to the river system.

A risk model is being developed to evaluate likely pathways of zebra mussel spread and estimate infestation potential for lakes and stream segments in the St. Croix River basin. Habitat suitability for growth, survival, reproduction, persistence, proximity to infested waters, and opportunity for introduction determine risk. Habitat suitability estimates are based on published accounts of physiological and ecological requirements of adults and larvae. Suitability functions were developed for calcium, total hardness, conductivity, pH, chlorophyll *a*, salinity, potassium, ammonia, current velocity, water clarity, temperature, depth, and dissolved oxygen. Physical and chemical characteristics of water bodies in the region were estimated from existing data for monitored river, lake, and reservoir stations. A risk index was established for various water bodies to indicate establishment probability. Digital maps are being generated to show high-risk locations, rates of infestation, and projected patterns of invasion.

Development and evaluation of potential management actions will focus on risk reduction. Such actions may include large- and small-scale alterations of habitat, control of recreational and/or commercial traffic, cleaning and coating technologies, and barriers to zebra mussel transport. In addition to the risk model, a risk based decision framework is being developed to inform management and enhance the consistency and transparency of decisions for relocating or artificially propagating endangered mussels if zebra mussel control is not feasible or sufficiently protective.

European Water Framework Directive, Ecological Quality Indicators and Alien Species

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The concept of ecological quality indicators (EcoQ) is being developed in relation to the European Water Framework Directive (WFD) which aims to improve (or maintain the good status of) the water quality of rivers, lakes, transitional and coastal waters. In WFD there is no explicit mention of alien species (AS) and their potential impact on ecological quality, although in the instructive WFD Guidance Document the introduction of AS is given as an example of biological pressure and impact. Based on an extensive literature examination we assessed the mechanisms by which EcoQs developed within the WFD are influenced by alien species. The analysis shows that not only biological, but also physico-chemical and hydro-morphological parameters may be, in greater or lesser extent, modified by AS causing increasing or decreasing trends. Often the impact of AS may be interpreted as biological pollution or a decline in ecological quality due to changes in the biological, chemical and physical properties of invaded ecosystems. Based on literature analysis of distribution and abundance of alien species, their impact on native communities, habitat properties and ecosystem functioning, we propose a biopollution index helping to evaluate in which extent an aquatic ecosystem was altered by alien species and how this can effect overall assessment of ecological quality. We also discuss various aspects of use of the biopollution index in relation to temporal changes in aquatic ecosystems.

This study is supported by the EU FW6 Integrated Project 506675 ALARM "Assessing large-scale environmental risks with tested methods".

NOTES

A Dreissenid Rapid Response Plan for the Columbia River Basin, USA

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The recent discovery of quagga mussels (*Dreissena rostiformis bugensis*) in the Lower Colorado River Basin (Lake Mead and Lake Havasu) has sent shock waves through the aquatic invasive species (AIS) community. This event has highlighted the need for rapid response planning in other watersheds in the western United States.

The development of a zebra mussel rapid response plan for the Columbia River Basin began in 2005. Leading the effort has been the Columbia River Basin Team of the 100th Meridian Initiative – the US Fish and Wildlife Service (USFWS) and Pacific States Marine Fisheries Commission (PSMFC). This multi-agency team serves as a coordinating body for AIS activities (particularly zebra mussels) in the Columbia River Basin (CRB).

The goal of rapid response plan is to serve as a roadmap to actively guide rapid response activities if zebra mussels are detected in CRB waters. It is not intended to manage interception of contaminated watercraft prior to launching. Note that the word "rapid" is subject to interpretation, but for the purposes of this plan, the initial stages of rapid response are measured in hours and days, not in weeks. Some tasks identified in the plan are already ongoing, while others will need to be implemented expeditiously following their review and approval. The response plan is broken into 10 categories:

1. Verify Reported Detection
2. Make Initial Notifications to All Relevant Managers
3. Define Initial Extent of Colonization
4. Define Roles and Responsibilities; Set Up a Coordination Mechanism
5. Establish External Communications System
6. Organize Resources
7. Initiate Quarantine/Pathway Management to Avoid Further Spread
8. Launch Available/Relevant Control Actions
9. Institute Long-Term Monitoring
10. Evaluation

The draft plan contains technical documents including necessary responses at hydropower projects and hydropower fish facilities, potential mitigation responses, and documents that support compliance with environmental regulations, such as discharge permits. This presentation will review the development of the plan and review the successes and failures to date.

The draft plan can be found at http://www.100thmeridian.org/ColumbiaRT.asp

NOTES

Aquatic Exotic Invertebrates in Belarus: Past, Current, and Future Invasions

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The territory of what is now Belarus became critically important when early in the 19th century three interbasin canals connecting River Dnieper with several rivers from the Baltic Sea basin, were constructed for international trade. These canals were in operation until the beginning of the 20th century and provided important passages for the introduction of numerous exotic Ponto-Caspian species into the Baltic Sea basin including amphipod, *C. curvispinum,* two species of molluscs, *Lithoglyphus naticoides* and *Dreissena polymorpha,* and several species of oligochaetes.

For more than 100 years only Ponto-Caspian species colonized Belarus. Two reasons may be suggested as to why the Baltic Sea basin did not play an important role as a donor area for the colonization of Belarus: 1) low diversity of exotic species of other than Ponto-Caspian origin in the Baltic Sea basin at that time, and 2) pattern of ship traffic through interbasin canals. The major reason for construction of interbasin canals in the 19th century was the export of Russian timber to Western Europe, usually in rafts, which provided an excellent substrate for the attachment of many invertebrates, but this was one-way traffic because timber was exported but never imported to Russia. In the second half of the 20th century new vectors of spread became important in Belarus including the deliberate introduction of economically important invertebrates as well as accidental introductions. In addition, the rapid recent spread of exotic species was facilitated by the changes in the political and socio-economic regime of Belarus.

Currently 18 exotic aquatic invertebrates are known in Belarus including 13 of Ponto-Caspian origin, two from New Zealand and one from North America, Southern Europe and Southern Asia. The rate of spread of aquatic invasive species increased from 0.3 species per 10 years in the 19th to the beginning of the 20th century, to 2.2 species per 10 years in the second half of the 20th century. There is a significant correlation between the time since initial invasion and numbers of water bodies colonized (average rate of colonization by an invasive species about six water bodies per 10 years). This correlation could be used to predict the spread of recent invaders. We predict a further increase in the rate of colonization of Belarus by exotic invertebrates as well as an increase in the diversity of donor areas of alien species. We further predict that this process will accelerate with the reconstruction of the interbasin canals, when the hydrological connection between Black and Baltic Sea basins is re-established after nearly a century.

NOTES

Rapid Assessment Surveys: Different Strokes for Different Folks

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Different survey methods are employed for specific life stages of various aquatic invasive species (AIS). In mapping and monitoring AIS distributions, priority should be given to species with significant levels of impact, which are either expected or likely to occur in high numbers. Most high-impact AIS tend to be known. This account examines the utility of different survey methods directed at invasive freshwater and marine biota. Various Irish surveys have been undertaken and these include:

1. Surveys of zebra mussel larvae
2. Surveys of recently settled stages of zebra mussels
3. Surveys of settled stages of zebra mussels
4. Surveys of aquatic invasive 'ornamental' plants
5. Beach surveys for marine invasive species
6. Marina-based surveys for invasive species

Some of the survey methods utilised can provide semi-quantitative information on AIS. Rapid assessment methods have already been successful in detecting AIS and can facilitate the future detection of new species, some of which are expected to expand their range to Irish waters.

The combination of survey methods and sampling efforts employed since 2000, have revealed AIS previously unrecorded in the wild and have also demonstrated range expansion for cryptogenic species and AIS. It is estimated that this represents about 10% of Irish AIS records during this time period. In Ireland, the species with the greatest impacts, revealed by these surveys, and thus of most concern to environmental managers, have been: the tunicate *Didemnum* sp., the zebra mussel *Dreissena polymorpha,* Nuttall's pondweed *Elodea nuttallii* and the Japanese seaweed *Sargassum muticum.*

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Possible Introduction of Marine Species by Long Distance Drift: an Example with a Crustacean from USA to France

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Once upon a time, it happened that a buoy located on the USA coast between Florida and Georgia (30-59-39.562 N, 081-24-27.669 W, according to the US Coast Guard) broke its attachments and started a long journey across the Atlantic Ocean from April 2005 onwards. This buoy drifted for about 18 months and finally reached the French offshore zone near Concarneau Bay, Brittany, on October 2006.

The part of the buoy that emerged was covered with a variety of organisms. Samples were collected and sent to the Muséum national d'Histoire naturelle - Paris, for identification.

Three species of Crustacea were identified. The first two are classical hosts of floating objects (such as sea turtles, ships' hulls), the common gooseneck barnacle, *Lepas anatifera* (Linnaeus, 1758) (abundant, mean length of capitulum ca. 30-32 mm, peduncle length ca. 40-55 mm) and Columbus or Flotsam Crab *Planes minutus* (Linnaeus, 1758) (two large specimens: a brownish male of 28 x 26 mm and a reddish female of 23 x 22 mm in carapace width x carapace length).

Surprisingly, a Florida stone crab, *Menippe mercenaria* (Say, 1818) was also present. This was a female of 54 x 38 mm, presenting the reddish brown typical coloration of the species, including the carapace and claws, tan to medium gray, with small dark spots, while legs were dark brown with distinct white bands.

This finding indicates that intercontinental drift of floating objects can bring living specimens on shores that are far away from their native place, and contribute to the dissemination of organisms, and possibly the introduction of species.

NOTES

US Coast Guard's Ballast Water Management Program: Development of Technical Capabilities for Testing and Evaluating Ballast Water Management Methods

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The US Coast Guard is the United States agency authorized and directed by Congress to develop a national regulatory program to reduce, and eventually prevent, introductions of non-indigenous aquatic organisms into US waters via the operations of vessels. At the direction of Congress, the Coast Guard has established a mandatory ballast water management program for the US Current regulations allow vessels to use mid-ocean ballast water exchange as a management practice, and a regulation in development will establish a standard for the allowable concentration of organisms in discharged ballast water. Effective implementation of these regulations depends upon the development of a suite of technical capabilities for testing ballast water and ballast water management systems for the purposes of approval and compliance assessment. To support these regulations, the Coast Guard is developing methods and technologies for assessing the efficacy of mid-ocean exchange in replacing water, testing the performance of ballast water management systems, and assessing the number and viability of organisms in treated ballast water. The status of several of these efforts will be summarized in this presentation. This work is being conducted in collaboration with partners such as the US Environmental Protection Agency, the Naval Research Laboratory, the US Department of Transportation, and the Smithsonian Environmental Research Center. In addition to supporting the Coast Guard's regulatory program, this work should also facilitate the development of management practices and technologies by contributing to the development of improved and standardized methods of assessment.

NOTES

The Management of the Risk of Non-indigenous Species Introduction Through Ship's Ballast Water and Biofouling – An Administration's Perspective

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This abstract was not available at the time of printing

Managing Ballast Water – A Multi-Disciplinary Challenge

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Billions of tonnes of ballast water are being carried around the world by ships. The problem arises when ballast water, taken on by a ship for balance, stability and structural integrity reasons, contains unwanted marine organisms. When discharged into new environments, they may become invasive and severely disrupt the native ecology, affect the economic activities and cause major human health problems.

There are hundreds of examples of severe ecological, economical and human health impacts from invasive aquatic species around the world and the costs associated with invasions are in the range of hundreds of billion US$. Once established, it is virtually impossible to control an invasive species and the impacts are usually irreversible. The ballast water problem requires solutions that integrate biological and engineering aspects and is as complex as the biology of marine organisms can be.

The International Maritime Organization (IMO), and the shipping industry have joined forces to find ways to address this problem. IMO has been working on this matter for the last two decades developing several sets of Guidelines and devising a new, legally binding international regime to address this rather new challenge. In February 2004, IMO's efforts were rewarded with the adoption of the new International Convention for the Control and Management of Ships' Ballast Water and Sediments. The new Convention builds on the complementary roles of coastal, port and flag States as well as the shipping industry in protecting the marine environment and provides the much needed framework for developing an integrated approach to ballast water management.

Because its enormous environmental, economic and social implications the ballast water issue is far more complex than most of the other ship based categories of pollution and calls for advanced and fully integrated technological solutions. The Convention requires the implementation of a ballast water performance standard on a schedule of fixed dates, beginning in 2009 and provides for phasing out the practice of ballast water exchange. Existing ships will also be required to apply the performance standard after a phase-in period. A recent review by the IMO's Marine Environmental Protection Committee aimed at assessing the availability of ballast water treatment technologies concluded that they will be available to meet the first application date of the performance standard contained in the Convention, but remained concerned that a number of logistic problems and the slow pace of ratification may have negative effect on the process.

Countries exporting bulk commodities are among the largest "importers" of ballast water. Exports of oil, ore, phosphates and other bulk cargoes are in many cases the primary source of revenue and an important component of their national economies. On the other hand, these countries are frequently dependent on their marine environments as the main source of living for the coastal populations and as a major tourist attraction. A balance between these two related facts has, and can, be achieved if proper consideration is given to the sustainable development principle and if the interest of future generations is included in the equation now.

IMO has already, through the Integrated Technical Co-operation Programme, co-ordinated and managed a number of activities, aiming at assisting in the implementation of the Ballast Water Management Convention. During the GloBallast programme a number of 'centres of excellence' have been created around the world. Nevertheless, the problem of invasive species is of global nature and further support is needed. In recognition of the success of the pilot phase of GloBallast and as a response to the constantly increasing demand for technical assistance, the Global Environment Facility, which is probably the largest independent financial organization supporting environmental initiatives, has recently approved a new project called "**GloBallast Partnerships**". While continuing to focus on assisting developing countries, the new phase will seek innovative partnership opportunities with shipping industry, multilateral banks and industrialized countries as well as with the private sector in achieving its goals and in laying the foundation for sustainable mechanisms to address the issue of ballast water.

Considering the enormous scientific and technological challenges, and the highly complex and multi-disciplinary nature of the problem, the development of this new instrument is perhaps one of the most significant achievements of the shipping community during the last decade. However, uunless IMO Members and the shipping industry act together, proactively and with due sense of responsibility, the devastating impacts of aquatic bio-invasions will continue to remain one of the greatest threats to the ecological and economic well being of the planet.

A Journey Through Contemporary Australian Ballast Water Management

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The discharge of ballast water from vessels is recognised as a key factor contributing to the introduction and distribution of marine pests around the world. In 2001 the Australian Government introduced ballast water management requirements for vessels arriving from overseas, however, a number of major pests had already established, particularly in Melbourne's Port Phillip Bay. In recognising the need to prevent the further translocation of marine pests around Australia, the decision was made to develop a management strategy that included the movement of domestic ballast water taken up in Australian ports. The Australian Government looked to the development of a national system that would provide consistency in application for vessels carrying either foreign or domestic ballast water, while giving effect to the International Maritime Organization's (IMO) International Convention for the Control and Management of Ships' Ballast Water and Sediments (the Convention), adopted in February 2004.

All relevant Australian jurisdictions agreed in April 2005 to a joint commitment to managing the risk of further marine pest introduction in the form of an Intergovernmental Agreement. This high-level agreement sets out the objectives for the National System for the Prevention and Management of Marine Pest Incursions (the National System). Since then Australia's Department of Agriculture, Fisheries and Forestry has been coordinating the development of policy, using science, consultation and the Convention as the basis for direction.

The collective Australian governments are working within the provisions of the Convention and Australia has signed the treaty subject to ratification. Specific Convention guidelines have been used in identifying possible designated areas for ballast water exchange and the model for risk-based assessment of ballast water. A single contact point is being established for the convenience of the shipping industry. Under the proposed National System vessels would be required to exchange their port-sourced ballast water en-route to their next port of arrival, at a specified distance from nearest land, however, vessels may be granted an exemption for ballast water that is assessed as low risk to the environment via an automated on-line risk assessment tool.

Eventually the requirement for Masters to manage their ballast water via exchange at sea will be phased out as the IMO requirement for onboard ballast water treatment technology is phased in. The Australian Government will ensure the necessary regulations meet the Convention requirements and will continue to work cooperatively with other IMO member states and the shipping industry to maximise the protection of our natural marine resources.

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An Overview of Australia's Proposed Biofouling Management Requirements

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An estimated 250 exotic marine species have been introduced to Australian waters. For more than two decades, the discharge of ship's ballast water was considered the major vector for the translocation of marine pests around the world. However, recent research suggests that biofouling on vessel hulls, niche areas and internal sea water systems may be responsible for more marine pest introductions around the world than ballast water.

The Australian government has recognised the need to address this issue in a nationally coordinated manner; hence an Inter-governmental Agreement (IGA) on a National System for the Prevention and Management of Marine Pest Incursions was developed and signed by the Australian, State and Northern Territory governments. The IGA outlines the three core marine pest management strategies of 1) prevention, 2) emergency response and 3) ongoing management and control. Furthermore, the IGA outlines the specific responsibilities of the Australian, state and Northern Territory governments. The Australian Government is responsible for international border protection and, therefore, the management of biofouling and ballast water for all vessels arriving into Australia.

The Australian Quarantine and Inspection Service (AQIS) is the international border biosecurity agency of the Australian Government. AQIS has regulated the discharge of internationally sourced ballast water into Australia since 2001. The responsibility for international border management of the biofouling risk presented by all vessels entering Australian ports and waters is a natural extension of AQIS's role.

Australian receives approximately 13,500 vessel arrivals into 65 ports per annum. The variety of vessel arrivals into such a large number of geographically dispersed locations produces a number of challenges in developing a nationally consistent biofouling management approach. The diverse nature of the vessel arrivals is reflected in the unique biofouling risk each vessel class presents. The following biofouling risk and mitigation factors were central to the development of the protocol vessel classes – antifouling practises, period of foreign port residency, transit speed, proposed operations/movements within Australia.

AQIS is developing, with due consideration of the aforementioned factors, protocols for the following broad vessel classes: Trading commercial, non-trading commercial, yachts, Illegal Foreign Fishing Vessels, petroleum and exploratory infrastructure, cruise and Naval vessels.

AQIS is preparing the legislative and administrative arrangements to implement mandatory biofouling management requirements through the series of vessel class specific protocols.

An overview of the proposed biofouling protocols will be revealed in the presentation.

NOTES

Ocean Shipping in North America's Great Lakes: Invasive Species Costs vs. Transportation Cost Savings

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One of the largest aquatic invasive species problems in the world involves the Canadian and US Great Lakes waters. Together, the Great Lakes contain some 5,439 cubic miles of fresh water, making them the largest freshwater body in the world. However, the Lakes and their role in both the environment, and tourist economy, are increasingly threatened by invasive species. It is estimated that some 60% of these invasive species have entered the Lakes through ocean vessel ballast water. Ocean vessels reach the Lakes by traversing the St. Lawrence Seaway System, which allows vessels to rise some 600 feet into the mid-continent region. While the environmental and economic damage from invasives is hard to estimate, more conservative estimates are in the range of $300 million/year.

This presentation reports on the results of research aimed at determining the benefits of ocean shipping in the Great Lakes. The extent of any such benefit is an important piece of information for policymakers considering how to address regulation of ship borne invasive species. Such regulations include discussions about System operating modifications on access, ballast water treatment, etc. In order to study benefit levels the researchers made detailed calculations of the extent of transportation savings to shippers and receivers of goods moving by direct ocean vessel routings. These savings were estimated by studying the volumes of goods moving on the System by commodity and origin-destination (primarily steel in and grain out), and comparing the door-to-door total transportation/handling cost of the complete move with the alternative of moving the goods into and out of the Lakes by alternative modes such as lakers, rail, and barge.

The principal conclusion of this study is that a cessation of ocean shipping on the Great Lakes would result in a transportation cost penalty to Canadian and US users of just US$54.9 million per year at 2002 volumes. Conversely, it can be stated that the yearly benefit from ocean shipping is in fact US$54.9 million. The relatively small transportation benefit is due to the fact that just 12.3 million tonnes of ocean vessel cargo passed into and out of the Lakes in 2002 on 569 ship entries. It is also because the costs of the alternative modes, for coastal transfers with lakers, rail and barge primarily, are not substantially higher than the cost for ocean direct routings into Great Lakes ports. Overall, the conclusion is that ocean vessels on the Lakes make only a modest contribution to transportation cost savings. The calculated transportation benefit represents a 5.9% savings in the current door-to-door transportation cost for the goods currently moving via ocean shipping in the Great Lakes. However, when compared to the invasive cost estimates noted above, the research suggests a negative 6:1 cost benefit for ocean shipping. Policymakers should consider this ratio in assessing ship access rules, permitting and insurance requirements, and ballast water regulations and costs.

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Poster Session

Spatial and Temporal Distribution of Zebra Mussel (*Dreissena polymorpha*) Veliger Larvae in the Lower Ebro River (NE Spain)

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The zebra mussel *(Dreissena polymorpha* sp.*)* is undoubtedly one of the main reasons for intensive economic and ecological changes in rivers, lakes, channels and reservoirs within Europe and North America over the last decades.

In Spain, *D. polymorpha* was not detected until the middle of the year 2001, when it was found in several points of the lower Ebro River (NE Spain). In particular, during a survey of water intakes at the hydroelectric power station of Ribarroja Reservoir (Ebro River), a diver team detected in May 2001 the presence of high-density populations of zebra mussels attached to grills, up to 200,000 indiv/m^2, and a few months later (April of 2002) they detected spectacular concentrations of more than 300,000 indiv/m^2 in those grills. Currently, very important populations are present along the edge of the reservoir of Ribarroja as well as to a large extent of the Ebro River. Zebra mussels have been also detected in other large basins of Spain.

This study shows the firsts results of zebra mussel veligers spatial and temporal distribution in the lower Ebro River. A full hydrologic year was studied (October 2005 to October 2006) to show the vertical distribution of zebra mussels in the Ribarroja Reservoir and its ecological interpretation as an up-river source of larvae to the downstream populations of zebra mussels, as well as veliger densities in the lower part of the Ebro River downstream from the reservoir.

NOTES

Some Approaches to Prediction of New Invasions in Aquatic Ecosystems

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Eutrophication led to a major increase in both pelagic and benthic zone primary production. On example of the Black Sea was shown that difference between productivity of these habitats amount to >200 times. Marked changes to the predominant planktonic and benthic species led to major modifications of community composition, with the new dominant taxa showing a doubling of functional activity in comparison to the 1960-1970s. Introduced species characterized by maximal values of specific production were at the forefront of these mass-predominant taxa. The increased trophic conditions also caused a marked decline in biodiversity, which in turn led to ecosystem instability and created niches now occupied by highly productive species more adapted to the new conditions. Thus the increased ballast water transportation into the Black Sea over the same period (1970s to present) had enhanced the number of successful introductions, with the most invasive being highly-productive and hence "pre-adapted" taxa which could acclimatize and expand rapidly in the recently-formed niches. If the coastal waters of the Black Sea maintain their elevated trophic status, then it seems possible to predict the invasiveness (and hence thread) of newly-discovered or potential introductions using the average value of specific production of the mass species, that reflect the functional activity of the predominant pelagic and benthic native species inhabiting the recipient aquatic area. Preliminary calculations with the data from the northwestern part of the Black Sea gave the possibility to assume that when trophic conditions enhance, a further change in biodiversity will occur in the prevailing development of species with a specific production more than 2.4 fold in the composition of phytoplankton, 1.2 fold zooplankton and 0.012 fold macrophytobenthos. It will be possible to find a correlation between specific production of mass representatives of phyto-zooplankton, seaweeds, zoobenthos and trophic level of ecosystem. The trophic index may be calculated on the basis of chlorophyll a concentration, dissolved inorganic nitrogen, total phosphorus etc. (for example TRIX index).

NOTES

Successful Colonization of *Palaemon elegans* Rathke in the Gulf of Gdańsk – Diet and Reproduction

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Since 2001 a species new to the Polish part of the Baltic (*Palaemon elegans*) has been found there in large numbers. This species is the most abundant palaemonid prawn along the Polish Baltic coast. Inhabiting the littoral zone, it is usually found on stone, sandy bottom and vegetated areas. The aim of this work was to describe the diet of *P. elegans* from the Gulf of Gdańsk in relation to the place, season of year, sex and body length. Females' fecundity and breeding season were also assessed. The investigated material had been collected from a 1-metre water depth with a hand net at eight stations in the Gulf of Gdańsk from June to December 2004 and in May 2005, once a month. The importance of food component in the stomach was assessed on the basis of its frequency of occurrence and its percentage of filled space.

The analysis of prawns' stomachs revealed the occurrance of 16 taxa. Detritus and pine pollen also contributed to the diet. The main food components of *P. elegans* diet were: detritus and algae (mainly Cladophora sp. and Ectocarpaceae). Small benthic animals, i.e., Harpactocoida, Gammarus sp. and Chironomidae were of less importance. Diet was different depending on the place of living. The diet of prawns inhabiting shallows coastal waters was more varied than the diet of prawns collected in harbours. It contained benthic animals (i.e., *Hediste diversicolor*, Chironomidae). Pine pollen was dominant component in spring. In summer the importance of algae increased, in autumn detritus and crustaceans were the main components. No differences in the food composition in relation to sex were noted. The diet changes ralatively slightly with body length. With an increase in length of individuals the importance of Polychaeta and Gammarus sp. in the food ingested by *P. elegans* increased.

The breeding season of *P. elegans* is related to the water temperature. It starts at the end of May and the beginning of June and continues mid- September. The body length of ovigerous females was 32–59 mm. The number of eggs varied from 238 to 1954 per female, the quantity depending upon the prawn's size.

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Recent Invasion of European Estuaries by the Asian Shrimp *Palaemon macrodactylus* Rathbun, 1902: the Case of the Gironde Estuary

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The shrimp *Palaemon macrodactylus* Rathbun, 1902 is a native species of Asian waters. It was introduced into California (USA) in the 1950s and it had recently been recorded in Mar del Plata Harbor (Argentina) and in several European estuaries, such as the Guadalquivir (Spain), the Orwell (England) and the Gironde (France). In Europe, *Palaemon macrodactylus* was recorded belatedly after its introduction and hence very few data about its ecology and possible interactions with local shrimps are available.

Since 1979, a large part of the Gironde estuary had been monthly sampled for fauna survey (mainly fish). The date of the first apparition of the oriental shrimp *Palaemon macrodactylus* and its expansion were inferred from the examination of the preserved samples from 1992 to 2006.

The distribution of the invasive species indicated a spatial overlap with the distribution of the native species *Palaemon longirostris* Milne Edwards, 1837 and *Crangon crangon* Linnaeus, 1758, according to the seasons. We particularly focused on the possible interactions with *Palaemon longirostris*, which supports an important traditional fisheries in the Gironde estuary (73 tonnes in 2005). The first ecological data about *P. macrodacylus* in this area are presented, particularly its spatial distribution and its reproductive characters. These results revealed that the exotic species had an ecological advantage compared to the native one.

P. macrodactylus is becoming an abundant element of the Palaemonid community of Gironde. The strength of the exotic population may be responsible for the decrease in abundance of the native shrimp populations.

Based on the monthly sample survey of the Gironde estuarine fauna, a detailed analysis of the competitive shrimp population is carried out, aimed at modelling their dynamic interactions, within the framework of a PhD thesis.

NOTES

Limnomysis benedeni Czerniavsky (Crustacea, Mysidae) – A New Species in the Fauna of Croatia

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Limnomysis benedeni (Czerniavsky, 1882) (Mysidacea) was recorded for the first time in Croatia in the summer of 2004. The species was found in the Kopački rit Nature Park, which is a floodplain of the Danube River located in the northeastern part of Croatia, and is on the RAMSAR list of wetlands of international importance. Sampling was conducted weekly during July, August and September in Lake Sakadaš, which is the deepest water depression in the Kopački rit (depth 10 to 11.5 m during high water levels). Specimens of *L. benedeni*, with other invertebrate groups, were found in stands of *Myriophyllum spicatum* (L.) and *Ceratophyllum demersum* (L.), both submerged macrophytes with dissected leaves. Water depth, transparency or Secchi depth, water temperature, and dissolved oxygen (by WTW Multi 340i/set) were measured *in situ*. Results given by analysis of the total chlorophyll-*a*, phosphorus and transparency, indicated eutrophy to hypereutrophy that corresponds with earlier data on water quality of Lake Sakadaš. In the laboratory, samples from the field were put into plastic trays with tap water and the remaining material and fauna were sieved through a 60 µm mesh screen, transferred to plastic bottles, and preserved in a solution containing 96% ethanol, distilled water, 4% formaldehyde, and glycerine with an addition of Rose Bengal. Invertebrates were counted and isolated under a stereozoom-microscope Olympus SZX9. A total of 24 invertebrate groups were recorded with a dominance of Chironomidae larvae, Rotifera, Oligochaeta, and Crustacea (Cladocera and Copepoda). The total of five specimens of *L. benedeni* were found, four individuals within the stands of *C. demersum* and only one within the stand of *M. spicatum*. Whether it is just a random finding of few individuals, or is a part of a larger population, we cannot state for sure. However, some authors state *C. demersum* and *M. spicatum* are repellent species for Mysidae, so we can assume that there is a larger population of *L. benedeni* within the stands of other macrophytes in the lake, which are less dense and have a higher concentration of dissolved oxygen that is the preferred habitat for this species. Since *L. benedeni* is recorded in the Danube River, the Main-Danube Canal and in the Rhine basin, we presume that this "southern corridor" is the pathway by which *L. benedeni* came to Kopački rit.

From environmental monitoring data of the Kopački rit, no important effect from the presence of this species has been recorded yet. However, given its biological attributes, especially a short life span and generation time, protection of its juveniles, non-specific food preference, and suspension feeding, *L. benedeni* is characterized as a successful Ponto-Caspian invader. Monitoring of this species not only in the Kopački rit, but in all in Croatian inland waters is important.

NOTES

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

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The Columbia River is one of North America's most ecologically and economically important rivers, yet little is known about the phytoplankton and zooplankton dynamics in its lower reaches, and the extent to which non-indigenous species are present. In January 2005 we initiated a multi-year field study to investigate several aspects of the plankton dynamics in the lower Columbia River estuary, with particular emphasis on non-indigenous species and freshwater flow effects. Our sampling design consisted of three basic types of surveys: i) monthly sampling at 5 locations ranging from 180 km upstream to the mouth of the estuary, ii) four broad-scale surveys near the mouth of the lower estuary (two each in June and August, corresponding to high and low river flow periods, respectively), and iii) sampling every three hours over a full tidal cycle in August, 2005. We sampled hydrography, chlorophyll, nanoplankton, microplankton, and mesozooplankton at each station. The dominant microplankton groups observed were diatoms (*Asterionella formosa*, *Fragllaria crotonensis*, *Synedra* spp., and *Aulacoseira grannulata*), dinoflagellates (*Gonyaulex* sp.) and aloricate ciliates (*Mesodinium* sp.).

Dominant mesozooplankton taxa included the copepods *Eurytemora affinis*, *Coullana canadensis*, and *Acartia tonsa*. Two species of non-native copepods were also observed: *Pseudodiaptomus forbesi* and *Sinocalanus dorrii*. Preliminary results indicate a strong seasonal cycle, with spring blooms of diatoms and copepods, followed by compositional shifts in summer toward flagellates, ciliates and other copepods. With respect to freshwater flow, both biomass and abundance of microplankton were higher in June (high flow) than in August (low flow). The tidal cycle sampling showed large variation in abundance and composition of plankton with tidal stage, especially in diatoms, ciliates and copepods. These results will be discussed in the context of the role of non-indigenous species in the plankton dynamics of the lower Columbia River estuary.

NOTES

Evaluating the Biological Efficacy of NaCl Brine as a Ballast Water Treatment Technology for Transoceanic Vessels Entering the Great Lakes

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Voluntary exchange of ballast water at sea for transoceanic vessels operating on the North American Great Lakes was first recommended under Canadian regulations in 1989 (later made mandatory by US Coast Guard in 1993). In 2005, Canada amended its Ballast Water Control and Management Regulations to include management of residual ballast carried by vessels declaring 'no ballast on board' status. While these strategies certainly reduce the total abundance and diversity of taxa carried in ballast water, these practices should be regarded as temporary solutions until a more comprehensive methodology can be implemented.

The addition of NaCl brine has been proposed as a treatment solution for management of both residual, and incompletely-exchanged, ballast water. As marine seawater (30 ppt salinity) used in flushing and exchange practices can effectively reduce viability of fresh- and brackish-water taxa, brine (230 ppt full-strength) is expected to provide complete protection against low-salinity taxa, as well as against marine taxa. A feasibility study indicated that liquid brine is a cost-effective and readily-available strategy for management of ballast water on the Great Lakes that would pose little interference to current shipping operations. Target brine treatment concentrations will be dependent on exposure time (i.e. time brine will remain in tanks).

A two-phase study has been initiated to evaluate the biological efficacy of brine treatment. First, experiments are being conducted to determine the brine concentration required to achieve complete mortality of marine invertebrates collected from exchanged ballast tanks. A wide variety of marine taxa will be subjected to three different brine concentrations, with survival measured at discrete intervals over a 48h period. This phase of the study will discern the brine concentration/exposure time combinations required for complete extermination of marine invertebrate taxa. In year two of the study, species- specific trials will be conducted using high-risk European invertebrates (i.e., species with wide salinity tolerance with an invasion history in ballast water in European habitats). A successful evaluation of this technology will result in immediate enhancement of protection of the Great Lakes from aquatic invasive species.

NOTES

Gametogenesis and Population Dynamics of Alien Bivalves in a Brazilian Wetland

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Due to the lack of legislation and poor port surveillance, bivalve mussels brought from Asia have invaded the south, central and western parts of Brazil, occupying different habitats in the main hydrographic Basins of South America. There are already three species of invading bivalves that have reached the central region of Brazil: two belonging to the Corbiculidae family: *Corbicula largillierti* and *C. fluminea*, and one species of Mytillidae, *Limnoperna fortunei*. Aiming at management and control during the processes of spreading and installation of non-native populations, we are using the analysis of reproductive and growth dynamics as an efficient tool. We work with the population of *L. fortunei* using samples from two distinct regions: Porto Alegre, RS – southern Brazil and Corumbá, MS – Middle Paraguay River in central Brazil. The samples of *C. fluminea* are from the Cuiabá River, MT geodesic mark of South America.

Based on quantitative and histological analyses of biometrical and reproductive parameters such as length and height of the valves and diameter of the follicles of male, female and ovocites, we observed that the reproduction is continuous. However, both species show two peaks of characteristic spawning which coincide with the variation of temperature of the south and depth in the center of Brazil. The distribution of frequencies per classes of diameters of the reproductive and biometrical factors, coincide with the recruitment period described by the subsequent growth of the larvae densities. We infer that the seasonal fluctuations derived the seasonal flood pulse in the wetland and its physical, chemical and biological consequences can act as a controlling agent on the population densities.

NOTES

The Alteration of Lake Ecosystems by Invasive Alien Species. A Case Study on a Potential Keystone Species: *Orconectes limosus*

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In the context of the European Union Water Framework Directive (WFD) invasive alien species (IAS) represent a significant pressure that can alter the structure and functioning of aquatic ecosystems. IAS may lead to ecological degradation resulting in a lower classification of a water body, confound the interpretation of ecological assessment metrics and reduce the efficacy of restorative programmes of measures aimed towards other pressures such as eutrophication or acidification.

Among introduced species crayfish are among those with the greatest potential to alter ecosystems. For example, *Pacifastacus leniusculus* has been listed as the second most undesirable species by the UK Environment Agency. *Orconectes limosus* was introduced into Germany from Pennsylvania (USA) over 100 years ago and has rapidly spread to many European countries including Italy where it was reported in Lake Varese in 2002. This crayfish can become a keystone species: Haertel-Borer *et al.* (2005) found that it accounted for 49% of a lake's macroinvertebrate biomass and occurred at a similar biomass (81%) as that of predatory fish.

A study was carried out to examine the current population structure and differences in spatial distribution of *O. limosus* at six sites in lake Varese. The study used mark-recapture exercises marking the ventral somites of crayfish using visible implant elastomer tags. Using a combination of six colours and three injection sites it was possible to identify individual crayfish. Three methods were employed for capture: baited crayfish traps, refuge traps, and hand picking along stony shorelines. The results were interpreted in relation to site physicochemistry, macrophyte composition and hydromorphology determined using the newly developed *lake habitat survey* methodology.

Orconectes limosus has the potential to effect a substantial alteration of the structure and ecological function of a lake making IAS a priority research area relevant to WFD implementation and conservation strategies.

NOTES

INCOFISH: From Local Knowledge to Global Understanding of Sustainable Coastal Management Strategies

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The objective of the INCOFISH project is to conduct specifically targeted strategic research suitable to contribute to the goals set by the World Summit for Sustainable Development in Johannesburg, such as restoring healthy fish stocks and ecosystems by 2015.

The tools and concepts resulting from INCOFISH research are tested in real-world scenarios in selected coastal systems worldwide. Together, they form a package with the potential to impact on solving societal problems in the coastal zone in Europe and in developing countries. All data and tools are available online on the INCOFISH portal at: www.incofish.org. Results include: International Seafood guide, invasive species wizard, Shifting baselines backflash, Aquamaps, Revised or new Ecopath models of 12 systems, MPA management guidelines, CTAM- Coastal Transects Analysis Model and more.

NOTES

An Analysis of the Diffusion of Selected Federal Policies Relating to the Coordination of Aquatic Invasive Species Management Efforts Among States Within the Chesapeake Bay Watershed, USA

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The purpose of this analysis is to evaluate the diffusion of various management tools (i.e., management plans, invasive species councils, and invasive species advisory committees) utilized in the coordination of aquatic invasive species management efforts by the various states within the Chesapeake Bay watershed. The Chesapeake Bay is the largest estuary in the United States located along the Mid-Atlantic Coast, with a watershed of 64,000 square miles, including portions of the states of Delaware, Maryland, New York, Pennsylvania, Virginia, and West Virginia. And effective coordination is essential in maximizing prevention, early detection and rapid response, control and management, restoration, information management, and education and outreach efforts as related to aquatic invasive species.

It is apparent in the Chesapeake Bay watershed, as elsewhere in the United States that aquatic invasive species management efforts occur within a "patchwork" of often incongruent policies. In the absence of a comprehensive federal law and regulations requiring the coordination of such efforts in a prescribed fashion, the utilization of established guidelines for coordination by the states has been highly variable, with federal authority limited to an advisory role.

This analysis explores the variability in the nature of the diffusion of various management tools (i.e., management plans, invasive species councils, and invasive species advisory committees) utilized in the coordination of aquatic invasive species management efforts throughout the various states within the Chesapeake Bay watershed. It also examines the congruence of such management tools with specific federal guidelines in the context of existing national models for the coordination of aquatic invasive species management efforts.

NOTES

Navigational Buoy Survey of Invasive and Native Benthic Invertebrates of the St. Lawrence River, Lake Ontario, and the Welland Canal

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In January 2007 we conducted our annual survey of navigational buoys for invasive and native benthic invertebrates that had colonized these substrates in the St. Lawrence River and Lake Ontario throughout the 2006 shipping season. This was the 17th year of our ongoing long-term study of biotic changes associated with invasive species in the lower Laurentian Great Lakes navigable waterways.

The buoys are removed from the water each year at the end of December when winter navigation is closed due to icy conditions, then replaced in the same location every March. Our survey of 2006 settlement concentrated on dreissenid mussels, *Dreissena polymorpha* and *Dreissena bugensis*, with some attention to the invasive gastropod, *Bithynia tentaculata*, and amphipod crustaceans, including the invasive species, *Echinogammarus ischnus*. We continued to monitor population changes in native caddisflies of the families Brachycentridae and Hydropsychidae. We examined more than 250 buoys from Canadian and US ports and navigable waterways, as well as anchor chains and concrete anchors. Included in our study were harbor areas near major urban centers in Canada, as well as smaller watercraft channels, in addition to more open river stretches. A new area of study this year was the Welland Canal, which joins Lake Ontario to Lake Erie, where we examined several buoys.

Dreissenid mussel populations continued to remain relatively stable, with wide variation among sites, but with high- and low-density remaining similar to those of previous years. Dominance of *D. polymorpha* in major Lake Ontario ports such as Hamilton, Kingston and Toronto continued, with the highest densities occurring near Kingston. Abundance and distribution of hydropsychid caddisflies remained extremely high in the area near Cornwall, Ontario and Massena, New York, where they were the dominant benthic macroinvertebrate, often covering 100% of available buoy surfaces. However, the populations were much lower downstream toward Montreal. The important population of *Brachycentrus incanus* caddisflies near Prescott, Ontario and Ogdensburg, New York continued to decline in 2006, having dropped to very low levels in the 2004-2005 seasons. These insects were a dominant benthic keystone species prior to the dreissenid invasion. Amphipods remained more common on buoys from the upper parts of the river and in Lake Ontario, where some hydropsychid caddiflies also occurred. Welland Canal buoys yielded very few dreissenids, but small to moderate populations of *D. bugensis* were present on some. Caddisflies and amphipods did not occur on the Welland Canal buoys. We did not encounter *Bithynia tentaculata* this year, but this species does not readily colonize buoys, even in years when populations on other substrates are strong.

We plan to continue this annual survey into the foreseeable future to continue developing a long-term perspective of these important changes. This will continue to provide baseline biotic data for the St. Lawrence River and lower Great Lakes, and establishes a model for similar studies on other major river systems.

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NOTES

Is the Diversity of Aquatic Invertebrates Affected by the Red Swamp Crayfish?

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To determine the effect *of Procambarus clarkii* on invertebrate diversity we evaluated: 1) invertebrate diversity in the presence and absence of three sizes of crayfish under mesocosm conditions; and 2) the diet of *P. clarkii* under mesocosm conditions. In mescosm experiments at a density of 0.83 crayfish m^{-2}, invertebrate diversity was affected by crayfish presence and size. The highest diversity index was obtained in the absence of *P. clarkii*. Juveniles (average carapace length of 27.7 mm) significantly reduced invertebrate diversity whereas sub-adults and adults did not. Nevertheless, a graphical analysis clearly showed a progressive increase in environmental macroinvertebrate biodiversity as crayfish increase in size. Therefore the impact of *Procambarus clarkii* on aquatic invertebrates may be strong and it is size dependent. Our findings also indicate that crayfish may be an important consumer of potential disease carrier mosquitoes (culicidae) therefore contributing for a decrease in their abundance, especially in confined areas.

NOTES

Golden Mussel Abundance After Eight Years of Invasion in the Paraguay River, Brazil

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The bivalve *Limnoperna fortunei* (Dunker, 1857), also called golden mussel, was introduced into South America in 1991 in the La Plata River (Argentina). It has successfully colonized approximately 2100 km of the Paraguay River (a major tributary), including the Pantanal floodplain, where it was observed for the first time in 1998.

The purpose of this study was to describe the density of juvenile and adult of *L. fortunei* in the Paraguay River and connected lakes, eight years after invasion. Density on natural substrata was estimated during the low water phase, sampling from 2004 to 2006. Density on artificial substrata was estimated using 100 cm^2 nylon mesh inside a PVC tube or PET bottle, from October 2002 to December 2006. Both were closed to fish predation. Natural substrata (rocks) supported up to 27,000 indiv/m^{-2}, including adults and juveniles, in lakes close to the Paraguay River, up to 29,000 indiv/m^{-2} in the Paraguay River, and around 30.0 indiv/m^{-2} in the Miranda River. On artificial substrata in the Paraguay River, at the Porto Esperança location, the density of juveniles was between 10.0 to 685,675 indiv/m^{-2}. The fluctuation in density over the year was mainly related to water temperature. High densities were observed during the austral summer and quite low densities during the winter.

NOTES

The Invasion of *Gammarus tigrinus* Sexton, 1939 in the Gulf of Gdańsk (Southern Baltic) and its Adaptive Pattern of Osmoregulation

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Gammarus tigrinus, which originally inhabited the coastal waters along the eastern shores of North America, was found in England in 1931 and described by Sexton as new. Probably this species was first introduced to Ireland by American ships during World War I.

Later, in 1957, this species was introduced to the German rivers Weser and Werra. Since its introduction, *G. tigrinus* has successfully spread in these rivers as well as in some other German waters. In Polish waters it was observed since 1988. In 2001 it was first recorded in the Gulf of Gdańsk (the Puck Bay).

Adaptive pattern of *G. tigrinus* from the Gulf of Gdańsk was investigated under laboratory conditions. Animals used for the determination of osmotic concentrations of their body fluids were collected from the Gulf of Gdańsk (the Puck Bay). Experiments in the laboratory were investigated in 10 different salinity conditions within the range from 1 to 39 PSU, under the constant temperature of 10˚C. The osmotic concentration of body fluids was determined in a WESCOR vapor pressure osmometer 5520.

G. tigrinus from the Gulf of Gdańsk is strong hyper/hyporegulator with the isoosmotic point of about 20 PSU. The pattern of osmoregulation of *G. tigrinus* from the Gulf of Gdańsk is comparable to the typically estuarine genus.

NOTES

Balanus improvisus (Darwin 1854) in the Gulf of Gdańsk (Poland) – An Important Component of the Macrobenthic Community

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The barnacle *Balanus improvisus* (Darwin, 1854), native to North America, was first recorded in the Baltic Proper in 1844. Its wide tolerance to temperature, salinity and water pollution allowed it to reach all regions of the Baltic Sea. The aim of the study was to assess the time that barnacles need to establish on free patches during the period of its intense recruitment and its influence on the community structure during six months of vegetation. The experiment lasted 150 days (14.05.2005-12.10.2005). Investigations were focused on the settlement of adult barnacles and further development of macrobenthic communities on artificial substrates, i.e., PVC panels. Communities were disturbed randomly every fifth day to observe, which organisms establish firstly on free patches. A total of 15 taxa was distinguished within the entire course of the experiment. Green algae *Cladophora rupestris* appeared firstly on the panels. *B. improvisus* settled secondly. It became the most abundant species and dominated communities by the end of the study. Brown algae of the family Ectocarpaceae and the bryozoan *Bowerbankia gracilis* were also abundant. *B. improvisus* was colonizing free patches very quickly during summer. Only 10 days after disturbance, young individuals covered previously disturbed area completely. At the beginning of August, a decrease in the colonization by barnacles was observed. Following, during the last month of the study, only adult barnacles and no newly settled recruits of *B. improvisus* were present in the communities. At the same time, blue mussel larvae settled heavily. Three stages of the experiment, with focus on relationship between barnacles and blue mussels, can be distinguished: competition for space, coexistence and competition for food.

The study confirmed that *B. improvisus* is an important component of fouling communities. Its total abundance and time of recruitment highly influence the structure of communities. The only species, which can compete with *B. improvisus* in the six month old community in the Gulf of Gdańsk, is *M. trossulus*.

NOTES

The Impact of the Invasive Ponto-Caspian Hydroid, *Cordylophora caspia*, on Benthic Macroinvertebrate Communities in Southern Lake Michigan: Effects on Fish Prey Availability

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The ecological impact of invasive Ponto-Caspian species on benthic invertebrate communities in the Great Lakes has received much attention because these alien species can alter community composition and structure. An often overlooked Ponto-Caspian invasive species originating from the Caspian and Black Seas is the colonial, euryhaline hydroid *Cordylophora caspia*. *Cordylophora* is becoming a prevalent biofouler in brackish and freshwater systems globally due to water quality changes and its ability to colonize various hard substrata including zebra mussels. *Cordylophora* commonly coexists with and grows on the shells of zebra mussels attached to docks and offshore shipwrecks in southern Lake Michigan producing prolific colonies. *Cordylophora* preys primarily on zooplankton (zebra mussel larvae, cladocerans, copepods) and benthic macroinvertebrates (nematodes, annelids, harpactacoids and chironomids). Preliminary results suggest prey consumption differs as a function of habitat location (docks versus benthic offshore habitats). The prevalence of *Cordylophora* in southern Lake Michigan and the prey items it consumes is of interest since many of these prey items are important for larval and juvenile fish. We are especially interested in the diet overlap between benthic *Cordylophora* colonies and fish consumption of chironomids, a large prey item relative to the polyp size of *Cordylophora*.

The purpose of our work is to document the distribution of *C. caspia* in southern Lake Michigan and to assess the predatory effects of this invasive hydroid, by investigating prey consumption and differences in prey consumed relative to colony location.

To compare differences in prey consumption between dock and offshore hydroid colonies, snorkelling and SCUBA were used to determine the presence or absence of *C. caspia* at eight Chicago harbors and four offshore locations. *Cordylophora* colonies were found at seven of the eight Chicago harbors and two of the four offshore sites. When present, samples of *C. caspia* were collected and preserved; approximately 200 to 400 hydranths/sample were dissected to determine prey size (μm) and type. Gut analyses data obtained thus far from offshore wrecks suggest that chironomids (Diptera: Chironomidae: *Cricotopus* and *Orthocladius*) may be more frequently consumed at offshore versus nearshore dock sites; more samples are currently being analyzed necessary to reach definitive conclusions.

Little is known about the extent to which freshwater *C. caspia* colonies consume important prey items eaten by fish, such as chironomids. Examining prey consumption by this hydroid provides insight into the effects of *C. caspia* predation in non-native habitats such as Lake Michigan. These and future results will enhance our understanding of the ecological impact of this invasive species in freshwater communities. If this hydroid is abundant in certain locations and does consume substantial numbers of macroinvertebrates, then it could be considered a competitor with benthivorous fish for important prey items such as chironomids.

NOTES

Inventory and Mapping of Aquatic Invasive Plants in Kenya

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Invasive plant species, also referred to as exotic or non-indigenous are native to a particular area or region, but have been introduced elsewhere either by accident or on purpose, significantly colonizing their new home. Invasive plants constitute one of the leading threats to natural aquatic ecosystems and the associated biodiversity. The inventory and mapping of invasive aquatic plants in Kenya is an activity with a national scope and covers all inland water bodies including lakes, rivers, dams, ponds, irrigation canals, deltas, and sewage treatment plants.

Previous aquatic bio-invasions in Kenya have been reported in the major inland lakes Victoria and Naivasha having heavy infestations of *Eichhornia crassipes* (water hyacinth) and *Salvinia molesta*, respectively. However, dams, ponds and irrigation canals are affected by *Pistia stratoites,* Nymphae, Potamageton, Typha and Azola species. Invasive plants affect the provision of essential goods and services to the riparian communities. These include loss of biodiversity, blockage of fish landing sites, transportation routes and loss of aesthetic values among others.

The objectives of the study are therefore to document the distribution, species composition and habitat types of invasive aquatic plants and to develop a database for monitoring and control of bio-invasions in the inland water resources in Kenya.

The Methodology involves the use of geo-information tools including remote sensing and GIS to capture the actual location and mapping of the target areas, field surveys for ground verification and use of questionnaires to determine the perception by the local communities.

It is proposed that continuous data collection, inventory and mapping covering all the water bodies in the country be completed to facilitate the development of appropriate database for aquatic invasive plant monitoring and control. The study recommends that the involvement of the riparian communities be enhanced to ensure sustainable surveillance and early warning.

NOTES

The Introduced Clam *Ensis americanus:* Ecological Aspects and Genetic Diversity as Revealed by Nuclear and Mitochondrial Genes

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The American Razor Clam (*Ensis americanus* Binney 1870; syn. directus Conrad 1843) was introduced to coastal waters in Europe in the late 1970s, probably as larvae through ballast water from North America. Adults were observed on a tidal flat near the Elbe River in 1979. In the succeeding years the species dispersed widely along the European coastline from France to Scandinavia where it now appears to be a persistent member of the macrozoobenthos. In Danish waters it occurs in dense stocks both in the North Sea (intertidal and subtidal areas) and inner Danish waters (Limfjord and Kattegat). Experimental studies indicate that the clam is very well adapted to the temporal variations in salinity and temperature in its new surroundings. *In situ* experiments have also demonstrated the ability of adults to survive high in the intertidal zone far above its normal distributional limit. Even if the clam is established in sandy sediments to a depth of about 40 cm it is preyed upon by waterbirds such as Eiders, Common Scoter and Oystercatcher. Stomach analyses of Eiders from the Danish Wadden Sea indicate that it is one of the most preferred food items to Eiders. One unresolved questions is the frequently observed stranding of thousands of dead or dying clams. A high reproduction potential among surviving specimens compensate for the periodically high mortality. In this respect it is of interest to clarify the genetic diversity of the established populations.

Partial sequences of the mitochondrial 16S rRNA and COI (citochrome oxidase subunit I) genes and complete sequences of nuclear ribosomal region ITS1-5.8S-ITS2 were obtained from different individuals from the Danish localities of Sillerslev, Sundsøre and Juvre Deep, and from Harlingen (The Netherlands) in order to carry out a preliminary analysis of population structure in this alien species. Evolutionary distances between populations were calculated employing different models. Genetic variability within populations was estimated as haplotype diversity (*h*), nucleotide diversity (π) and nucleotide polymorphism per site (θ). Results obtained show that *E. americanus* displays high levels of genetic diversity, suggesting a model in which subsequent introductions of individuals coming from different sources, as seen in other invasive species. However, this model requires to be improved and confirmed by analysing a larger set of European localities colonised by *E. americanus*. Combining nuclear and mitochondrial markers seem to be very useful and adequate for understanding the invasion process.

NOTES

Habitat Preference of Alien vs. Native Gammarid Species in a Lowland Lake, Poland

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In most Polish rivers alien and native gammarid species are spatially separated, with aliens colonizing large disturbed rivers and natives thriving in their affluents. However, the situation is different in coastal lagoons, where alien gammarids co-occur with natives and eventually outnumber or even replace the latter. Recently we also observed two alien species *Pontogammarus robustoides* and *Dikerogammarus haemobaphes* colonizing a number of natural lakes in Poland, where native *Gammarus lacustris* have occurred. The process is still in its initial phase and the interactions between the native and the newcomers have not been studied yet.

The goal of our study was to reveal habitat preference and spatial distribution of recent colonizer *P. robustoides* compared to that of *G. lacustris* in Lucienskie Lake (Central Poland). Abundances and densities of both species were estimated in four habitat types (patches of decaying alder leaves, sand, wooden debris, reeds) dominating in the coastal zone of the lake; quantitative samples were taken monthly throughout the year. Among the studied habitats, pure sand was avoided by both species. Wooden debris was inhabited almost exclusively by *G. lacustris*, however its density was rather low. In reeds, both species co-ocurred with the native clearly dominating. Alien *P. robustoides* reached higher densities in patches of decaying alder leaves, but even in this habitat native species was more abundant. Also we found some evidence for seasonal migration of both species among habitat types.

Our results suggest that in the studied lake, the native is more versatile in habitat choice, however both species often co-occur. Still, the native species dominate over the alien in terms of abundance and density. Studying this colonization process since its initial phase will reveal the nature of long-term interactions between these species.

NOTES

High Phytoplankton Densities Reduces Feeding Rate of Ctenophores

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The lobate ctenophore *Mnemiopsis leidyi* originally distributed along the American Atlantic coast was introduced into the Black Sea in the early 1980s and expanded to the Caspian sea in the 1990s, resulting in massive predation on the fish stocks of these areas. Recently, the occurrence of the species was reported in the Baltic Sea, reaching high abundances. We examined the role of the spring phytoplankton bloom dominated by diatoms on the predation efficiency of this lobate ctenophore. Predation of *M. leidyi* on copepodite stages of the calanoid copepod *Acartia tonsa* was determined at three concentrations (0, low, high) using the natural phytoplankton community. Our data shows a negative effect of phytoplankton concentrations on the feeding rate of *M. leidyi* probably caused by mechanical damage of the colloblast cells by diatom chains. We discuss our results with the recent invasion of *M. leidyi* to European waters of the North Sea and Baltic Seas.

NOTES

Global Advances in the Ecology and Management of Golden Apple Snails

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The good-intentioned introduction and spread of the Golden Apple Snail (GAS) during the 1980s has metamorphosed from an obviously cheap and accessible source of food protein into a low-intensity global conflict between farmer and pest. The end to this conflict does not appear near, but efforts to at least control its damages are not being given up.

In the beginning, the taste and texture of these mollusks found their way to the kitchens, even restaurants, of their intended consumers. But the snails escaped to the rice systems and major irrigation waterways, where they became formidable pests of aquatic crops. Soon enough human appetite for snail meat also diminished.

GAS encroachments have expanded over the years from its homeland in Argentina into many Asian countries, as well as the USA, Dominican Republic, Papua New Guinea, and recently, Iran. The snails prefer young rice seedlings and can leave large patches of rice lands without or too little rice to harvest.

Eventually the losers are both rice farmers and consumers, as the Food and Agriculture Organization estimates that golden apple snails have inflicted about US$1 billion in crop losses in the Philippines in the 1980s alone, with global losses ranging from US$55 to 248 million per year. Today GAS is in the top 100 list of the world's most invasive alien species. It hosts organisms that can develop into endoparasites and *eosinophilic meningoencephalitis* in humans.

The so-called collateral damage that GAS can bring about ranges from water pollution as a result of pesticide use and abuse, to toxic hazards to farmers and non-target organisms; competition with native species and possible replacement of native flora and fauna; and even habitat modification.

Because of this endemic occurrence, a single and major publication is needed to synthesize advances in the ecology and management of the food-turned-pest creature. With this book, the otherwise fragmented and scattered information is compiled in one source, providing all information so far known about GAS and the rice systems and countries they have marauded. Around 500 pages of information fill the knowledge vacuum on the ecology and management of GAS. This book will be useful to all researchers, extension workers, students, industry workers, museums, and even libraries where exhaustive information on this subject is needed. Some 24 chapters cover various aspects of snail taxonomy (traditional as well as molecular tools), impacts of GAS on aquatic ecosystems and farmers' health, and pesticide abuse/misuse. Even GAS-invaded countries have submitted their separate country reports. Significant information has already been generated – GAS can be used as liquid bio-fertilizer, animal feed, human food, baits for rats and bugs; and even as natural weed control in rice paddies and as raw material for gift and souvenir items. For more information on this book, please visit: www.philrice.gov.ph

NOTES

Distribution and Hatching Success of Resting Eggs of *Cercopagis pengoi* in the Gulf of Finland

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The cladoceran *Cercopagis pengoi* was first recorded in the Baltic Sea in 1992 after which it has spread rapidly and formed permanent populations. In late summer it can attain high abundances by parthenogenetic reproduction, but during most of the year the environmental conditions are unfavourable for the species and it survives as sexually produced resting eggs in the bottom sediments. The yearly recruitment is thus dependent on the survival and hatching of these eggs.

Cercopagis pengoi occurs abundantly in the central Gulf of Finland, and the aim of this study was to assess the abundance and hatching potential of *C. pengoi* resting eggs in different parts of the Gulf. Six sites along a transect from east to west were sampled in May 2007 during a cruise on R/V Aranda. The samples were taken with a gravity corer and sliced in 1 cm intervals to 2 to 20 cm depths, depending on the sediment properties at each site. Eggs were extracted from the samples, counted and incubated to reveal their hatching success. At most sites, several thousand eggs per square meter were found. The abundance and hatching success of eggs are discussed in relation to sediment depth as well as location, sediment properties and oxygen conditions of the sites.

NOTES

Selective Behaviour of *Procambarus clarkii* in a Light Gradient

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To determine the light intensity preferences of *Procambarus clarkii*, a large-scale model built with a fibreglas trough was used. A discrete light gradient with different intensities (dark, 20, 100, 400, 1000 Lux) was used. The total length of the gradient was 20 m, and each level of light intensity occupied a length of 4 m. Four trials were performed to test whether the selection shown by the crayfish was influenced by the position of each light intensity. The light zones were set in each experiment at different parts of the channel. The experimental population considered 10 males and 10 females of adult *Procambarus clarkii*. The individual position of the crayfish with precision to a quarter of meter was recorded every hour during the daylight period. In our first trial – dark, 20, 100, 400, 1000 Lux – *Procambarus clarkii* showed high preference to the light, 47.8±3.2% selected the 1000 Lux area compared to 14.9±1.7% which selected the darkest area. In the second trial – 1000, 200, dark, 200, 1000 Lux again 55.0±9.4 % of crayfish preferred the light areas compared to 27.5±4.2% in the dark. In the third arrangement of the gradient – dark, 200, 1000, 200, dark – crayfish showed a different behaviour selecting both ends of the channel (51.2±5.2%), that means dark conditions, and only 17.0±3.0% preferred the light condition in the middle of the channel. Thus, the species showed a strong "end effect". The same pattern was found in the control trial (300 Lux in the whole length) where the crayfish selected the ends of the channel with a frequency of 71.0±4.6%.

NOTES

Impacts of Introduced Fish on the Feeding Habits of the Ichthyofauna in a Caribbean Estuary

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The African Nile tilapia *Oreochromis niloticus* (Pisces: Cichlidae) and the Asian Snakeskin gourami *Trichogaster pectoralis* (Pisces: Osphronemidae) have been accidentally introduced into the Cienaga Grande de Santa Marta estuary (CGSM), Northern Colombia, within the last two decades. Their abundance increased considerably when the input of riverine water into the estuary augmented between 1999 and 2001, also giving rise to an increase of native fresh water fish. This study aims to identify the influence of these two introduced fish and of environmental variation on the feeding habits of the most abundant and commercially used native fish species. Diet composition of seven native fish from periods before and after the introduction of non-native fish were studied based on stomach contents data from previous studies (1988/89, 1993, 2001) and additionally collected data (2003), along with the diet composition of the two introduced fish. Fish feeding strategies were categorized based on the Index of Relative Importance, Diet breadth (H') and Diet evenness (J'). Diet overlap (Ov) was calculated between introduced and native fish to look for possible inter-specific competition. Through Multiple regression analysis (MRA) the influence of salinity, river discharge, rainfall, dissolved oxygen and pH on the abundance of the most frequently consumed prey was assessed. Prey abundance was estimated from Catch per Unit of Effort (CPUE) data. In general, most fish fed on the most abundant prey types in any year and changes in diet composition paralleled those of prey abundance (CPUE), the latter mainly responding to the variation in salinity (MRA: $p<0.05$; $0.2<r^2<0.8$) within the estuary. Three feeding strategies could be distinguished: generalists, specialists and mixed feeders. None of the fish was found to be a complete generalist (J'=1; high H') in any of the years but *Eugerres plumieri* (Gerreidae) was a complete specialist (J'=0.0; low H') in 2001. *Diapterus rhombeus* (Gerreidae) changed from a specialist in 1989 to a mixed feeder in 2003, while *Cathorops* sp. 9, *Hexanematichthys bonillai* (Ariidae) and *E. plumieri* from generalists in 1989/1993 to specialists in 2001/2003. Neither the strategies nor the main prey of *Elops saurus* (Elopidae), a specialist, *Mugil incilis* and *M. liza* (Mugilidae), mixed feeders, changed considerably. The introduced fish *O. niloticus* was specialized on diatoms and cyanophytes in 2001 but on vegetal material and detritus in 2003, while *T. pectoralis* (data only from 1989) had a mixed strategy mainly feeding on detritus. The diet overlap between native and introduced fish ranged between none (Ov=0) and moderate (Ov= 51), with most values <30. The highest overlap was found between *O. niloticus* and *M. incilis* in 2003, presumably due to the high abundance of their common prey (detritus and diatoms) rather than inter-specific competition. Our study does not suggest strong competition for food between introduced and native fish, and the changes in feeding habits of the native ichthyofauna towards a more specialist feeding mode in recent years was probably rather caused by system–wide changes in food availability due to the great fresh water input into the system, than by the population proliferation of the introduced fish. We should not exclude the possibility, however, that a substantial and sustained biomass increase of the introduced fish under long-lasting fresh water conditions of the estuary, may (at least partly) force native fish to modify their feeding habits.

NOTES

Canada's Centre of Expertise for Aquatic Risk Assessment

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Many of the science issues facing the Federal Department of Fisheries and Oceans Canada (DFO) are associated with significant knowledge gaps and uncertainties. However, this does not relieve the Department of the need to make decisions on these issues. Under these conditions, decisions must balance the risks and uncertainties while ensuring the sustainability of Canada's aquatic ecosystems. Canada formally committed to control, eradicate or prevent the introduction of invasive species that threaten ecosystems, habitat or species under the 1992 Convention on Biological Diversity, with DFO responsible for aquatic invasive species (AIS). Faced with the ongoing threat of aquatic invasive species, DFO identified biological risk assessment as one of the implementation strategies to deal with this significant ecological threat. Biological risk assessment of AIS is the combination of ranking the likelihood of introduction (includes ranking elements of arrival, survival, establishment and spread) and the ecological and genetic consequences of the introduction of the AIS and its fellow travellers. Identification of uncertainty associated with the ranking of likelihood and consequences of introduction is an important aspect of conveying risk.

In 2006, DFO developed the Centre of Expertise for Aquatic Risk Assessment (CEARA); thereby, taking the first steps toward developing the necessary expertise in biological risk assessment across the country and building upon existing working relations with other countries. In the first year of its development, CEARA has met its mandates by developing a national standard for conducting biological risk assessments, a rapid screening-level risk assessment process to identify national priorities for conducting detailed-level risk assessments, and has overseen the biological risk assessment for Asian carps, northern snakehead and five tunicate species. Risk assessments have also been initiated for freshwater fishes found in live trade (bait, food, aquarium and water garden), *Codium*, Chinese mitten crab, green crab, and spiny-rayed fishes in western Canada. By identifying high risk AIS and vectors, key points in the invasion pathway, and areas vulnerable to invasion, science advice is provided for the development of policy and management actions to maximize the efficient use of limited resources to achieve the greatest potential for the prevention, early detection, eradication or control of AIS in Canada.

NOTES

Eliminating Bacteria in Ballast Water Using a Compact System of Utraviolet Radiation

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A secondary disinfective treatment is proposed to prevent translocation of invasive marine species into new environments by ships' ballast water. This treatment consists of a reactor based on ultraviolet light.

Ultraviolet light is a part of the electromagnetic spectrum between the visible spectrum and X-ray. Ultraviolet refers to all electromagnetic radiation with wavelengths in the range of 10 to 400 nanometers. UV treatment triggers photochemical reaction of cellular nucleic acids. When a microorganism is exposed to UV radiation, the energy is absorbed by the organism's DNA. If the organism receives a sufficient number of UV photons in a short period, dimmers are formed between adjacent bases in the DNA avoiding its replication.

There are several factors that have important influence on ultraviolet disinfection such as lamp placement within the reactor, light intensity to allow a complete disinfection, time of exposure (different flows have been tested to determine the dose required) water quality (suspended solids, turbidity), and type of microorganisms. Once designed a compact pilot plant, the influence of these parameters in ultraviolet light so in disinfection have been tested.

A well designed set-up and a thoroughly parameter control allows a safe and a most efficient depuration. Lamp placement determines an area of operation where DNA rupture is more feasible, so different configurations have been tested and the results have been compared with those obtained using a mathematical model. The source of light chosen to carry out the experiments emits in a simple wavelength (monochromatic) so its intensity is maintained constant. Due to this, the dose is increased by decreasing the flow, which leads to an increase of the residence time in the reactor. Different water qualities are tested by adding different concentrations of suspended solids and monitoring its influence on radiation measurement as well as survival of the target microorganisms.

NOTES

Too Hot to Handle: Evaluation of Steam Sterilization as an Aquatic Biosecurity Response Tool

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A tool for managing aquatic invasive species has been developed wherein heated freshwater or steam is applied to infested natural substrates. Such a tool has been developed by the New Zealand Department of Conservation for managing the invasive marine alga *Undaria pinnatifida.* As developed, the steam sterilization tool utilizes hot water or steam generated at the surface and delivered underwater where it heats seawater encapsulated inside a silicone cone held against the seabed. Although this tool was used to successfully manage founding populations, its efficacy was never scientifically tested. Assessment of the efficacy of heat treatment as a tool for managing non-indigenous organisms involved a combination of manipulative experiments and field trials on both artificial and natural substrates. The efficacy on specific target species (e.g., *U. pinnatifida*) and epibenthic/biofouling organisms generally was assessed.

Target species survivorship was determined under controlled conditions by hot water immersion of artificial substrates inoculated with *U. pinnatifida* gametophytes and settlement plates colonized by fouling organisms. Field trials to evaluate the efficacy of the sterilization equipment involved the treatment of inoculated artificial substrates and settlement plates, as well as field trials on naturally occurring rocky reef. While previous management of non-indigenous marine species has shown that heat treatment is an effective tool toward the control and eradication of introduced species (e.g., Wotton *et al*. 2004, Leighton 1998), our evaluation of the sterilisation tool as developed indicates that it is only partially effective as it does not result in the eradication of any organism with a single treatment.

In its present form, the tool is suitable for use only in specific circumstances where and when natural re-colonisation by the target organism is unlikely. The tool is most effective on uniformly flat substrata, as obtaining a seal about the circumference of the cone on complex topography is difficult. It is unsuitable for effective treatment of substrate within narrow rock fissures, confined overhangs, or closely grouped boulders. Furthermore, operation of the sterilisation tool is limited to relatively shallow depths by the amount of time SCUBA divers can remain under water due to the risk of decompression illness.

With these limitations in mind, it is considered that the sterilisation tool may be applicable in situations where the release of propagules from a founding population has been eliminated or is under control, even in the presence of small discrete satellite populations beyond the control area. In these circumstances, the apparatus could provide a technique to 'mop up' satellite populations, while leaving the surrounding communities largely intact. Similarly, the apparatus could be used as a follow up on large-scale management where a relatively small amount of re-colonisation by the target organism has occurred amongst areas otherwise colonised by indigenous species. Thus it could form a valuable component of an integrated pest management strategy (IPMS) involving other management techniques, such as manual removal.

The efficacy of the existing sterilisation tool could be improved through modifications, principally to improve delivery of heat treatments to complex topography, and reduce the amount of diver time required to deliver treatments. Potential modifications and applications to other substrates are discussed.

NOTES

Shipwreck Ahoy! Incursion Response to the Semi-Submerged Wreck of a Fishing Vessel from Southeast Asia in New Zealand Waters

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In January 2007 a partially submerged vessel, first thought to be a shipping container, was reported near the Bay of Islands, New Zealand. The vessel remnants were brought to shore and it was discovered that this was likely part of the wreck of a fishing vessel that was lost approximately 5 years previously off the coast of Thailand. The wreck was playing host to a large number of tropical and sub-tropical marine species, many of which were apparently unknown in New Zealand waters. A rapid response team commissioned by Biosecurity New Zealand and Northland Regional Council intercepted the wreck and collected organisms from the wreck in order to determine the biosecurity risk to New Zealand. At least 77 distinct taxa were collected from the wreck, 32 of which were unknown in New Zealand waters. The implications of such unexpected vectors of invasive marine species are discussed.

NOTES

Reproductive Periodicity of the Invasive Tunicate *Styela clava* in Auckland, New Zealand

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Although possibly present in New Zealand since 2000, *Styela clava*, the clubbed sea squirt, was first positively identified in Auckland in 2005. As part of its effort to respond adequately to this pest, Biosecurity New Zealand commissioned a study of the reproductive periodicity of this species. A population of *S. clava* has been sampled fortnightly since May 2006, coordinated with the lunar cycle at the time of the first low tide following the new and full moon. Environmental data, including sea surface temperature, salinity, rainfall and surface irradiation was also recorded. Animals were sacrificed in the laboratory and processed for examining changes in relative gonad weight and histology. Plankton samples were collected at regular intervals between spring and autumn and examined for the presence of tunicate larvae in the water column. Settlement plates were also placed at locations adjacent to the sampled population, in an effort to couple gonadosomatic data with recruitment events.

Initial observations of fouled aquaculture facilities suggested that spawning and recruitment occurred in the mid (austral) summer. The first year of data collected suggests that the species reproduces over an extended period in the Auckland region, beginning in the early spring and lasting through to late summer. This is broadly consistent with the findings of studies of *S. clava* on aquaculture facilities in eastern Canada. *S. clava* larvae were not detected in the plankton samples, nor were any recruits found on the settlement plates.

The consequences of this extended reproductive period for management of this marine pest species are discussed.

NOTES

Distribution and Expansion of Two Ornamental Aquatic Plants in an Irish Lake

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The nuisance aquatic plant Nuttall's pondweed *Elodea nuttallii* was first noted in 2005 in a large Irish alkaline lake, Lough Derg. A rapid increase in its range was noted during 2006. The all-female clone grows over the sediment during the winter and produces vertical shoots which can result in 'meadows' in the late spring. On reaching the surface in sheltered areas the many lateral branches spread and produce flowers. A further plant *Hottonia palustris* was found in a sheltered inlet of the lake in 2004 and spread to the opposite side of the lake in the following year. This plant unexpectedly became dominant locally and may still spread to other localities. Plants spread through drift following fragmentation by feeding waterfowl (e.g. coots and swans) in winter and cutting by boat propellers in summer. Drifting fragments of *E. nuttallii*, seen at the surface in mid-lake, can form heavy accumulations on exposed shores. Its rapid spread may also be due to plants winding onto propeller shafts and being carried to previously uninfested sites, especially shallow sheltered inlets frequented by boats. *E. nuttallii* can impede boat traffic and interfere with angling and swimming activities. It would seem inevitable that this plant will spread elsewhere in Ireland through human intervention (e.g. boat transport between lakes) as did *E. canadensis* ~150 years earlier. Controls over the sale of ornamental plants with invasive potential is recommended.

NOTES

Microparasites of Alien and Native Gammarids (Crustacea, Amphipoda) in Poland with First Record of Hyperparasitic Infection in Invasive Amphipod *Pontogammarus robustoides*

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The goal of our research was to identify microparasites (gregarines, microsporidia) of alien gammarids colonising Polish waters, versus those infecting native species in the same areas. Material was collected in October 2005. Altogether, over 4000 individuals of 12 gammarid species (four aliens and seven natives) were collected from the deltaic system of the Vistula River, littoral of the Baltic Sea, and from small rivers draining directly to the sea. All gammarids were identified and sectioned to collect tissue samples. Microparasites were identified with use of light and electron microscopy. Gregarines were recorded in digestive tracks of invasive *Pontogammarus robustoides* (*Uradiophora ramosa* and *Cephaloidophora mucronata*), and of native *Gammarus pulex* (*Cephaloidophora gammari*). Also Microsporidia were found only in these two gammarid species: *Pleistophora muelleri* in *G. pulex*, and *Nosema pontogammari* in *P. robustoides*. All the above microparasites are new to Poland. Only *P. muelleri* is a species widespread in Europe. The other microparasites were found before only in the Ponto-Caspian region and evidently were trasported to Central Europe with the invasive Ponto-Caspian gammarids. No microparasites were found in an invasive North American *G. tigrinus*, and in the Ponto-Caspian *Obesogammarus crassus.* Also no transfer of microparaistes between natives and aliens was observed.

Numerous prokaryotic endosymbionts were registered inside cytoplasm of sporonts of microsoridium *Nosema pontogammari*. Groups of bacilliform bacteria-like cells were enveloped by structureless electron-dense cover 20-30 nm wide. The prokaryotic cell wall was constructed in internal double plasma membrane and double layered coat of different electron density. Chromatinous electron-dense globules were diffused inside the cell cytoplasm. Delicate nests of filamentous structures filled parasitophorous vacuole. The cytoplasm of infected microsporidian sporonts was degenerated with weakly developed endoplasmic reticulum and not developed spore organelles. The data obtained demonstrate pathological character of host parasite relationships between endosymbiotic bacteria-like organisms and microsporidians.

The study was supported financially by a grant from the Polish Ministry of Education and Science, no 2P04F 030 28.

NOTES

Impact of the Planktonic Larvae of the Invasive Asian Bivalve *Limnoperna fortunei* on the Growth of Larvae of the "Sábalo", *Prochilodus lineatus* (Pisces) in South America

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Recent studies have shown that the larvae of at least 11 fish species of the Paraná-Río de la Plata watershed feed on larvae of the recently (1990) introduced Asian mussel *Limnoperna fortunei*. Larvae of "sábalo" (*Prochilodus lineatus*), whose adults represent over 60% of overall fish biomass in these rivers, have been observed to feed sometimes exclusively on *L. fortunei* veligers. In order to assess the effects of this dietary shift on the growth of this species, we conducted 28 days laboratory experiments feeding newly hatched *P. lineatus* larvae with 1) plankton artificially enriched with *L. fortunei* larvae, where these represented 90% of all zooplankton >100 µm; 2) natural zooplankton, where veligers accounted for 43% of the zooplankton; and 3) plankton artificially enriched with cladocerans and copepods, where *L. fortunei* accounted for 1% of the zooplankton. Fish larvae were collected in the Lower Paraná River near the city of Zárate, whereas plankton was collected every other day in the Rio de la Plata estuary, off Buenos Aires. Experiments were conducted in 3.5 L plastic jars with 35 fish larvae each at 22ºC. The average length, weight and gut contents of the fish larvae were assessed weekly. Proportions of *L. fortunei* biomass in fish gut contents paralleled veliger concentrations in the respective diets, but they were always higher than those of veligers in the food offered: 100%, 76% and 21% for diets 1, 2 and 3, respectively. This indicates that *L. fortunei* was always selected positively over the other prey items. *L. fortunei* larvae are slow and clumsy swimmers, and are therefore an easy prey for the fish larvae. Final average fish length and weight decreased when fed diets with lower proportions of veligers (average lengths: 10.6, 9.9 and 9.0 mm; average weights: 6, 4 and 2 mg, for diets 1, 2 and 3, respectively). Statistically significant differences were obtained between lengths of treatments 1 and 3 (ANOVA, $\alpha<0.05$, Duncan test $p=0.048$), and between weights of treatments 1 and 3 and treatments 2 and 3 (ANOVA, $\alpha<0.05$, Duncan test $p=0.004$). Our results indicate that *L. fortunei* veligers are consumed and assimilated by *P. lineatus* larvae, and that this new and abundant resource significantly enhances the growth of this species. Higher growth rates may stem from the higher energy supply represented by the veligers, and/or from the lower energy costs of capturing a slower prey.

NOTES

The New European On-line Journal *"Aquatic Invasions"* as an Effective Early Warning Tool

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Aquatic Invasions is a rapid on-line journal focusing on biological invasions in European inland and coastal waters and potential donor areas of aquatic invasive species for Europe (ISSN: 1818-5487, http://www.aquaticinvasions.ru).

The journal provides the opportunity of timely publication of first records of biological invaders for consideration in risk assessments and early warning systems. Also, the journal provides the opportunity to publish relevant technical reports and other accounts not publishable in regular scientific journals. *Aquatic Invasions* is an important part of the developing Pan-European and regional early warning systems on aquatic invasive species, with an important service of protection of author rights on primary geo-referenced records on introduced species and biological monitoring and surveys.

In 2006, more than 50 research articles and short communications in four regular issues of the first volume of *Aquatic Invasions* included geo-referenced information on recent range expansions and first records in European inland and coastal waters of such highly invasive species as Asian tunicate *Styela clava*, zebra mussel *Dreissena polymorpha*, Conrad's false mussel *Mytilopsis leucophaeata*, Wedge clam *Rangia cuneata,* veined whelk *Rapana venosa*, Ponto-Caspian mysid *Hemimysis anomala,* grapsid crab *Percnon gibbesi*, Chinese mitten crab *Eriocheir sinensis*, ctenophore *Mnemiopsis leidyi* and round goby *Neogobius melanostomus*.

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Manuscripts submitted to *Aquatic Invasions* are reviewed by independent experts. Accounts on inland invaders may be submitted to Vadim Panov (rbic@zin.ru) and for coastal invaders please approach Stephan Gollasch (sgollasch@aol.com).

NOTES

Free Choice Learning Initiatives to Mobilize Community Action Against Aquatic Invasions

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There is a need to expand self directed and voluntary learning opportunities to increase public appreciation about the causes of aquatic species invasions and their consequences. Through enhanced public understanding, we can expect greater acceptance, motivation, engagement, and mobilization at the community level to establish an efficient line of defence for prevention and control. The issues are catholic (the environment, economics, and human health) and will therefore appeal to diverse individual needs and interests. An effective program should have consistent and concise key messages that translate, communicate, and coordinate outreach efforts by utilizing partnerships and resources at the national, regional, and local levels. Here we present a smorgasbord of free-choice learning venues, outreach materials, and successful initiatives. One such initiative is "Aquatic Invaders", a comprehensive package that was developed by national, regional, state, and private agencies involved in aquatic invasive species research, outreach, and education. This program engages audiences for 20 minutes of fun interaction at more than 200 Association of Zoo and Aquarium-accredited institutes nationwide.

NOTES

Developing a Policy on Invasive Aquatic Plants at the Canadian Food Inspection Agency

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The mandate of the Canadian Food Inspection Agency (CFIA) is to safeguard the food, animals and plants, which enhance the health and well-being of Canada's people, environment and economy. As part of this mandate, CFIA develops and delivers programs and services designed to protect Canada's plant resource base. As a signatory party to the International Plant Protection Convention (IPPC) and to the Convention on Biological Diversity (CBD), Canada is responsible for administrating a plant health program that includes addressing the threats of invasive species. As Canada's National Plant Protection Organization, CFIA bears responsibility for delivering this program.

The Canadian federal and provincial governments developed in September 2004 *An Invasive Alien Species Strategy for Canada* and a more detailed *Proposed Action Plan for Invasive Alien Terrestrial Plants and Plant Pests*. This national strategy and action plan call for the development of a national approach to dealing with invasive plants that is consistent with that of the IPPC.

The scope of the new invasive plants program includes aquatic plants, currently a gap within federal programs targeting invasive species. A large volume and variety of aquatic plants are imported to Canada through the growing aquarium and water garden trades. A number of these (e.g., *Egeria densa*, *Hydrilla verticillata*, *Myriophyllum aquaticum*, *Trapa natans*) have a history of weediness elsewhere in the world and pose a serious threat to Canada's economy and environment. At present, however, no aquatic plant is currently prohibited entry to the country by any federal department and no national policy exists for addressing aquatic plants.

Development of the aquatic plants policy has required the increase of CFIA's scientific capacity in the area of risk assessment, with a particular emphasis on botany. Developing their techniques and procedures through literature reviews and consultation with other risk assessors in Canada and abroad, assessors at the Agency compare the native climatic range of an aquatic plant to the Canadian climate, given that aquatic plants or their propagules may be able to overwinter under ice, protected from temperature extremes. *Cabomba caroliniana*, for example, has shown itself to be very adaptable to colder climates, expanding into southern areas of central Canada in recent years, well north of its historical range. Aquatic plant species proposed for import are now reviewed by CFIA's risk assessors as part of the development of a list of species of concern, based on climatic tolerance, spread rate and potential impact on the economy and environment.

With respect to governance, development of this policy involves coordinating with other departments, both federal and provincial, with overlapping or complementary mandates and capacities. This is particularly important given the geographic size of Canada. Because of this, several plant species that are native to one region of the country in fact have the potential to be invasive elsewhere. Alien species may also be established in some regions but as yet be absent from others. CFIA therefore needs to work with other government agencies to determine how to control within-country movement of invasive aquatic plants. CFIA is currently hosting a series of national workshops across the country to discuss this and other issues under a proposed Canadian Invasive Plants Framework. A second series of workshops is planned to consult industry and collaboratively set a course of action.

NOTES

Learning Time Versus Prey Capture: How Does Learning Time Affect Successful Prey (Red Swamp Crayfish: *Procambarus clarkii*) Capture by Largemouth Black Bass (*Micropterus salmoides*)?

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The objective of the present study was to determine the effect of learning time in the success of prey Largemouth Black Bass (*Micropterus salmoides*) in capture juvenile Red Swamp Crayfish (*Procambarus clarkii*). Twenty Largemouth Black Bass (LBB) (12.67±1.50 cm mean total length) were submitted to four different periods of contact with juvenile crayfishes. Each LBB was placed in an individual aquarium with some juvenile crayfishes during a certain period of learning. The chosen periods of learning were 4, 2, 1 and 0 days and each period was replicated five times. After the period of learning new crayfishes were added and the number and fresh weight of crayfish consumed by individual LBB during a period of ten hours was recorded.

A one-way Anova followed by a Tukey-test showed significant differences in the number of consumed prey due to different periods of learning ($p<0.01$). Individuals submitted to four days of contact preyed more crayfish than the control group (5.75±2.50 vs 0.40±0.54 crayfishes respectively). The non-linear regression that was adjusted to the data showed that the maximum of captured prey was reached in the individuals submitted to four days of learning period.

These results showed that predacious fishes such as Largemouth Black Bass could easily adapt to new prey in a recently invaded habitat and are relevant both for management and modelling of crayfish and LBB populations.

NOTES

Integrating Economics into Invasive Aquatic Plants (IAP) Management in Sri Lanka: Alien Aquatic Plants, is this an Economic Problem?

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Water is acknowledged to be critical resource for Sri Lankan agriculture and key constraint to economic growth. Inland waters are the only source for irrigated agriculture, domestic requirements and associated economic activities for over 19 million of the population. Recent observations revealed that, freshwater systems in the country have become infested with some of the worst invasive alien aquatic plants. There are about 22 noxious invasive plants in Sri Lanka of which more than 40% are associated with aquatic systems. Despite the scope and the magnitude of the problem, IAPs have received very little attention in political agenda. The hypotheses being tested is the concept of biological invasions are primarily an economic problem and as such, require economic solutions.

The study will guide the future action for restoring ecosystem losses due to IAP, with an effective mix of regulatory, economic and persuasive policy tools. Poorly enforced, legislation is not effective. Instead the study proposes a viable mix of policy, ecological restoration and sustainable management, ensuring that economic prospects to peripheral communities from the restored habitats will provide strategic financing for restoration and sustainable management. Cost effective habitat restoration and alternative utilization practices are some of the economically viable suggestions to this phase of the study.

In both districts of Anuradhapura and Kurunegala, Salvinia, Echonia and lotus are identified as the most abundant invasive plants. Considering lotus as an invasive weed is debateable as it generates fair economic return. Even ineffective and outdated legislative enactments are not enforced. Excessive use of agrochemicals and silt sediments transported due to soil erosion increase the entropy of the tank water creating fertile medium for invasive aquatic weeds to proliferate. The breakdown of traditional management systems is one critical socio-cultural reason leading to further erosion of social capital for tank management. Hence regular tank cleaning is not functioning.

NOTES

Control of Golden Mussel by Ozonation of Cooling Water in Power Plants

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Invasive bivalves are on the move provoking worldwide problems with plugged piping and heat exchangers, wherever water out of rivers and lakes is used for cooling purposes. The control of this "large scale biofouling" is a big challenge due to the high resistance of bivalves against common disinfection methods.

Chlorination was the common method for many decades to prevent biofouling in different applications such as cooling towers, water for industrial use and municipal water works. Since the early 1990s two major incidents forced the industry to look for alternative methods: invasion of zebra mussel into lakes and rivers in North America causing problems with fast growing mussel layers in piping and heat exchangers and the increasing sensibility concerning ecological problems caused by chlorination by-products.

Ozone is known as the strongest oxidant available for water treatment and features various ecological advantages. No chemical precursors are required to be stored or handled, and it reacts to harmless oxygen. Due to its high reactivity ozone will be consumed rapidly by all kind of organics present in natural water coming out of rivers and lakes. Furthermore, ozone undergoes fast self-decomposition depending on temperature and pH. For that reason it is not possible to yield high residual concentration of ozone and it is not possible to protect widespread water distribution systems using this kind of water.

Nevertheless our tests showed that even a small dosage of 0,3 ppm ozone avoided growth of golden mussel *Limnoperna fortunei* efficiently. Between March and July 2005 the cooling water of one heat exchanger bloc in hydroelectric power plant Itaipu (Paraguay/Brazil) was treated with ozone on a trial basis. Growth of mussels was monitored in special bio-boxes, where settlement of veligars was measured over periods of 60 days. The total number of settled veligers was decreased by 50 % and the number of living veligers was reduced by 90 %. The results also correspond with the expertise of the heat exchangers. Already 2-3 months after the last cleaning there appeared thick coverings and even blockage of whole channels with mussels. 2-3 months after the ozone treatment the heat exchangers were considerably cleaner and all channels were free.

It is remarkable that 0,3 ppm ozone did not increase any risk of corrosion. Due to the high level of organic load in the treated water the ozone was reduced within seconds. We are coming to the conclusion that high concentrations of biozides are not required to combat growth of mussels efficiently. It seems to be sufficient to shock the mussels' larvae, for that reason they are not interested any more to settle down in piping, heat exchangers, and other fittings. Using low concentration of ozone enables the design of systems with best ecological compatibility.

NOTES

Eradication of Common Carp (*Cyprinus carpio*) with Rotenone in Laguna De Zonar, Spain

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The presence of common carp (*Cyprinius carpio*) in a new environment can cause changes in water quality like re-suspension of sediments, increment of eutrophication and reduction of light penetration. Abundance and composition of macrophytes, numbers and diversity of invertebrates and other associated biota due to feeding activity of carp, are other serious effects.

The natural reserve, *Laguna De Zonar* (size: 31 hectares, average depth of 6 meters [0-13 m]), south of Cordoba in Spain, is one of the last territories of the endangered (EN) White-Headed Duck, *Oxyura leucocephala*, and other diving ducks; Red-Crested Pochard, *Netta rufina* and Tufted Duck, *Aythya fuligula.*

The diving duck community disappeared after illegal introduction of common carp in the 1980s. After several unsuccessful attempts to control the carp population, the Environmental Agency of Andalusia developed an eradication program using the piscicide rotenone, CFT Legumine®. Two treatments were conducted in July 2006, with an interval of seven days. No dead carp were found after the second treatment. Consequently, no carp survived the first treatment. Around 13 000 kg of dead carp were removed and buried. The native fish species in the lake; *Atherina boyeri*, were restocked after the treatments.

The results from the monitoring program (June 2007) shows that:

a) The oxygenated part has increased from 43% (1994) to 55% (2007)
b) The water transparency increased from less than 1m (1994) to 3m (2007)
c) Return of macrophytes
d) The aquatic insect population has increased from 1 genus to16 different genuses (2007). Seventeen genuses were present before carp introduction (1980-84).
e) The White-Headed Duck, *Oxyura leucocephala*, and other diving ducks have returned to the lake.

NOTES

The Global Invasive Species Information Network (www.gisinetwork.org)

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Formed in 2004 to provide a platform for sharing invasive species information at a global level, the Global Invasive Species Information Network (GISIN) is a network of invasive species experts, researchers, information managers, and computer scientists sharing their knowledge and experience to improve access to information used to control the spread of invasive species.

With start-up funds from the Global Biodiversity Information Facility and in-kind contributions from the US National Biological Information Infrastructure, NISbase, the US Geological Survey, the Smithsonian Institution, and the IUCN Invasive Species Specialist Group, the GISIN is developing a pilot Web solution to cross-search existing invasive species information systems, from both aquatic and terrestrial realms. This poster explains the history of the GISIN, describes its mission, and portrays the developing network of data providers, consumers, and users.

NOTES

Modeling Habitat Capability for Invasive Species Using the ShoreZone Mapping System

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ShoreZone is a coastal habitat mapping and classification system in which low-altitude, georeferenced aerial imagery is collected specifically for the interpretation and integration of geological and biological features of the intertidal zone and nearshore environment. Mapped regions now include more than 16,000 km of coastline in the Gulf of Alaska (see www.CoastAlaska.net) and 45,000 km of coastline in British Columbia and Washington State (from the Columbia River mouth to the Alaska/BC border). An additional 10,000 km of imagery was collected in Alaska in 2006.

The mapping system (housed in ArcGIS and MS Access databases) provides a spatial framework for coastal and nearshore habitat assessment on local and regional scales, characterizing physical and biological components of discrete intertidal habitat units both along-shore and across-shore (including degree of wave exposure, type of substrate, sediment texture, intertidal flora and fauna, subtidal algae, and some subtidal fauna).

The coastal database is useful for habitat capability modeling in which mapped shorelines are examined to predict the distribution of habitats that would support a particular group or species of interest. A capability model developed for the European green crab (*Carcinus maenas*) appraises the sensitivity of mapped shorelines to colonization by this invasive species. The model employs the Delphi approach to compile green crab habitat attributes from scientific literature and expert interviews. The ShoreZone database is then queried for these attributes to identify shorelines that meet the criteria for supporting green crab colonization. Identifying potential green crab habitat "hot spots" could provide a spatial basis for the planning and implementation of monitoring stations for species detection and early intervention efforts.

NOTES

Orconectes virilis: A North American Crayfish Conquering The Netherlands

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In the period 2004-2005 the number of crayfish species known from The Netherlands doubled from four to eight. Of these eight species only the extremely endangered *Astacus astacus* is indigenous to The Netherlands. Although it is known that crayfish can feed at various trophic levels and can have significant biomasses the potential impact of these introductions on the Dutch aquatic ecosystems has largely been neglected.

The first Dutch record of *Orconectes virilis* has been reported by H. van der Willik in October 2004. At this site in the village Vinkeveen the species was already very common at that time. In 2005 unchecked reports from fishermen gave the idea that the species was already much more wide spread. This together with reports in North American literature about this species possible negative impact gave rise to an orientating research in 2006. Especially the distribution and the possibility of eradication had to be looked at.

The species *O. virilis* has been found at 42 sites. Together with checked information from fisherman it became clear that at least several hundreds of kilometres of waterway had been colonized by 2006. On most sites reproduction could be confirmed based on the presence of juveniles. The habitat varied from small rivers and channels to small ditches.

From 2004 to 2005 a small channel, the Kamerikse Wetering near Kamerik, has changed from clear water with extensive aquatic vegetation to turbid water without submersed vegetation. This change coincided with *O. virilis* becoming extremely abundant. In 2006 about 550 adult specimens of *O. virilis* were caught in one night with 12 small eel fyke nets.

From two sites with large numbers of *O. virilis* information was available on the past occurrence of crayfish. In these cases it was for sure that previously the only present crayfish was *O. limosus*, another North American crayfish occurring in the Netherlands. A replacement of one exotic crayfish with another, larger one, has taken place in these waters.

Clearly the crayfish *O. virilis* will soon become one of the most common crayfish species in The Netherlands. This is of great concern as the first signals of negative impact are coming in. Based on information collected, the possibility for eradication of this species could be turned down. Water authorities in The Netherlands, such as the Water Board Hoogheemraadschap De Stichtse Rijnlanden, need to anticipate on the presence of *O. virilis* in another way. Optimizing fish assemblages, so that fish predation on *O. virilis* is sufficient to keep numbers so low that the impact of *O. virilis* on the ecosystem is minimized, seems to be the only realistic approach.

This research has been carried out by order of the Water Board Hoogheemraadschap De Stichtse Rijnlanden.

NOTES

Distribution of the American Crayfish *Orconectes limosus* (Raf., 1817) in European Waters

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On the basis of long-term research considering the dispersal and distribution of the spiny-cheek crayfish *Orconectes limosus* (Raf., 1817) in European waters a map showing the geographical distribution range of this species was prepared. This species has been present in European waters for more than 100 years. After the first successful introductions of this North American crayfish in Polish, German and French waters, a series of introductions in the European waters followed. *O. limosus* penetrated to the larger European rivers – Vistula, Oder, Elbe, Rhine, Loire, Rhone, Danube, Pad, and Neman from where it could disperse over the whole continent; it is also present in smaller waters such as reservoirs, lakes, channels, ponds, and streams. In Europe, the species was recorded from the United Kingdom, Poland, Germany, France, Hungary, Belgium, Holland, Luxembourg, Austria, Switzerland, The Czech Republic, Italy, Kaliningrad District, Lithuania, Croatia, Serbia and Montenegro. Although introduced in the Iberian Peninsula and Slovakia, the occurrence of this crayfish species in Spanish as well as in Slovakian waters was not confirmed. The crayfish plague amongst the European native crayfish species caused that most of the countries decided to bring the spiny-cheek crayfish to their water reservoirs to compensate for the loss of native species. Unfortunately, these introductions were prepared in a wrong way. Ecological, economical and social aspects of introducing alien crayfish species were not considered. Countries that decided to introduce *O. limosus* in the past currently restrict or forbid such practices. Also culturing this species is forbidden, as spiny-cheek crayfish is nowadays considered as an undesirable species. This American crayfish continues its dispersal in Europe. For example *O. limosus* shows further dispersal in brackish coastal waters of the Baltic Sea. Furthermore, there exist already populations of this species in Africa – in Morocco where it competes with other, native crayfish species.

NOTES

Bactericidal Effects of Lime Stabilization and Recarbonation to Bacterial Fish Pathogens and Aquatic-Environmental Bacteria

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Unintentional introductions of non-native (i.e. invasive aquatic organisms) may result in serious detrimental consequences to the survival of native species and to the overall health of aquatic ecosystems. Some recent examples of invasive species that have significantly altered large ecosystems include zebra mussels (*Dreissena polymorpha*), quagga mussels (*D. bugensis*), Asian clams (*Corbicula fluminea*) and New Zealand mud snails (*Potamopyrgus antipodarum*). The most prudent strategy to control invasive organisms is to remove or greatly minimize the risks of their introductions to new environments. One of the generally recognized routes of spread of invasives is through the movement and release of cargo ship ballast water. Exotic organisms could survive the days to weeks of travel in the water or sediment in a ship's hull and be released at the ship's destination. An effective, safe and economically feasible procedure to decontaminant ballast while on the ship and prior to release, is a very effective means to control spread. Aquatic organisms (e.g., microbes) are generally intolerant to significant and relatively quick increases and/or decreases to the pH of their aquatic environments. Our studies are exploring methods to utilize and develop this intolerance into an applicable tool. We hypothesize that lime stabilization (sodium hydroxide) in conjunction with recarbonation (carbon dioxide) is bactericidal. Laboratory trials are being done to determine minimum cidal parameters within ranges of pH 10-12, within 48 hr, followed with carbon dioxide sparging to a neutral pH, or to saturation (about pH 5.0). We are evaluating effects to a variety of common aquatic bacteria. In replicate trials using the fish pathogen *Aeromonas salmonicida* at an average initial loading of 2.50×10^4 viable bacteria (cfu/mL), we have demonstrated 100 % cidal effect at pH 11.0, $\leq$ 24 hr, with recarbonation to neutral pH. Further testing using five different bacterial species isolated from pond water with mean initial cell densities of 4.80×10^5 to 1.80×10^7 cfu/mL has been done. The effects of pH 12, for 24 hr and recarbonation to saturation resulted in reductions of viable cells by 98.5 to 100 %.

NOTES

Toxicity of CO_2 to New Zealand Mudsnails (*Potamopyrgus antipodarum*): Implications for Control

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Introduced populations of New Zealand Mudsnails (*Potamopyrgus antipodarum;* NZMS) have caused concern for managers in the western United States because in high numbers, these snails can alter the trophic dynamics of aquatic systems. Infestations of NZMS at fish hatcheries limit or restrict the options for stocking hatchery-reared fish because of the risks of spreading snails to uninfested locations. Development of reliable and environmentally friendly methods that remove NZMS from source waters would be helpful to hatchery managers by creating an environment for snail–free fish production and/or transportation. We are evaluating a two-step control method for the piped spring water supply of the Hagerman National Fish Hatchery in Idaho (USA). We are testing the efficacy of hydrocyclonic separation of NZMS, followed by carbonation of the hydrocyclone waste (snail) stream. Our analysis of NZMS particle size distributions, combined with proprietary simulation tools (Krebs Engineering, Tucson Arizona), suggest that hydrocyclonic separation of NZMS will be complete. Testing of hydrocyclonic separation will be completed during the summer of 2007. Recent tests have demonstrated that aquatic species are generally intolerant to forced increases in dissolved carbon dioxide concentrations (DC) given its effect on water, blood, and hemolymph pH. These species are also sensitive to elevated total dissolved gas pressures. The gas bubble trauma that develops following exposure can, as with elevated DC exposure, cause mortality. We are exploiting this sensitivity in NZMS under both atmospheric and hyperbaric pressure conditions. Testing of NZMS at 100 kPa CO_2 and 15°C has been completed for the reproductive stage of snails (>2.5mm). A probit model of survival predicts the 100% lethal time of exposure at 9.6 h for 15°C. Testing is continuing at 8°C and 20°C for representatives of at least three sizes of snails to determine NZMS sensitivity under elevated DC conditions. Preliminary results indicate an inverse relationship between temperature during elevated DC exposure and survival. To determine whether altered pH of test water affects survival, we are evaluating the effects of a range of pH from 2 to 12. When water is saturated with CO_2 the pH can drop to approximately 5. Our results indicate that these pH shifts have little effect on the survival of NZMS.

NOTES

The Baltic Sea Alien Species Database: Ten Years Online

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An Internet database on aquatic alien species in the Baltic Sea area was developed as an initiative of the Baltic Marine Biologists´ Working Group on Non-indigenous Estuarine and Marine Organisms in 1997; The goals of the database were formulated as follows: i) to provide a qualified reference system on alien species for the Baltic Sea area, available online for environmental managers, researchers, students and all concerned; and ii) to update the information on the Baltic Sea alien species, their biology, vectors of introduction, spread, impacts on environment and economy, involving the data input from research institutions and responsible environmental authorities; and iii) to encourage the exchange of data among different geographical regions and thereby to serve a node in the Global Information System for Invasive Species.

In its current state, the Database includes 117 alien species found in the Baltic Sea and adjacent waters; 77 of them are defined as "established" in the Baltic Sea ecosystem. A selection of 16 species are considered in greater detail in the form of case histories providing information on species taxonomy, identification features, area of origin, vector of introduction, distribution history in the Baltic, abiotic preferences, life cycle and ecological and economic impacts. The Database is an interactive user-friendly tool, which includes several information retrieving options: "Database Search", "Baltic Regions", "Species Directory" and "Literature Search". The later option allows the users to search literature (more than 700 issues) on the Baltic Sea alien species according to different types of information: species name, its ecological/economical impacts, ecological traits, etc. The Baltic Sea Alien Species Database is cited widely both in scientific research papers and various informational online sources dealing with aquatic alien species. The database represents an important regional node for a future global information system on invasive species. The development of the database was supported by the Baltic Marine Environment Protection Commission (HELCOM) and a GEF-sponsored project, "Baltic Sea Regional Project".

NOTES

Byssogenesis of Invasive Marine Mussels *Perna viridis* and *Perna perna:* Implications for their Invasion Race

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The green mussel *Perna viridis* (Linnaeus) and the brown mussel *Perna perna* (Linnaeus) often co-exist with each other and recently invaded new geographical regions probably through international shipping, either as adults attached to ship hulls or as larvae in ballast water tanks. *P. viridis* and *P. perna* were also introduced to the different parts of the world for culture purpose. *P. perna* is a subtropical-tropical mussel that colonized Caribbean Sea several decades ago. In recent times, *P. viridis* is replacing *P. perna* from its natural beds. Mussels attach with any substratum by means of byssus threads. Temperature and salinity are among the most important environmental factors affecting the byssus thread production and byssus attachment strength of mussels. These factors affect their metabolic rates which may be reflected in their activity level. For that reason, a study has been carried out to determine whether *P. viridis* has a higher tolerance and adaptability than *P. perna,* in terms of byssus thread production under different salinity, temperature, mechanical agitation and light conditions. Our results on byssus thread production under different environmental conditions clearly indicate that *P. viridis* has wider tolerance limits than *P. perna*. This may explain why *P. perna* has been displaced by *P. viridis* in various locations in the world.

NOTES

The Ecological Role of the Invading Species *Cercopagis pengoi* (Crustacea, Cladocera) in the Gulf of Finland and in the Baltic Proper

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The brackish water Ponto-Caspian predaceous cladocerans *Cercopagis pengoi* have recently invaded the Baltic Sea and now presents an important component of aquatic food webs. They almost exclusively feed on small-bodied zooplankters.

In the summer period of 2005 and 2006, *C. pengoi* specimens were widely spread in the Gulf of Finland and in the open parts of the Baltic Sea. On most stations of the Gulf of Finland the *C. pengoi* biomass consisted of more than 80% of total zooplankton biomass. At one time the small-bodied zooplankters abundance noticeably decreased.

The strongest impact of *C. pengoi* on the zooplankton community in the Gulf of Finland was determined at the locations where the role (percentage) of *C. pengoi* in the total zooplankton biomass was the highest. The *C. pengoi* impact values are much higher than those registered in the Gulf of Finland during the first years after *Cercopagis* appearance in the eastern Gulf of Finland

C. pengoi coexisted with native Baltic species *Bythotrephes brevimanus* and *B. cederstroemii*. A strong negative correlation between *Cercopagis pengoi* and *Bythotrephes* probably reflects competition between the species. Thus, with the advent of the new species in the Baltic Sea essential structural changes in the pelagic community were detected.

NOTES

Natural Currents: A Pathway for the Spread of Marine NIS in Tasman and Golden Bays, New Zealand

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Many pathways have been identified for the spread of non-indigenous marine species (NIS). Such pathways can be classified as either *human-mediated* or *natural*. Human-mediated pathways include, among others, commercial shipping, aquaculture and fishing industries, the aquarium trade and recreational boating. Most human-mediated pathways are subject to some form of management; e.g., ship ballast water management plans, which help in the prevention and control of marine invasions. Natural pathways include, most significantly at least in terms of numbers, the dispersion of propagules and other life-cycle stages via currents, and to a lesser extent other natural mechanisms including the transfer of propagules via debris and other organisms, which may also be partly determined by currents. Natural pathways are a feature of all marine and estuarine systems, and direct management of them is generally unrealistic.

With regard to NIS pathways in New Zealand, the focus of management agencies and researchers has been on ballast water and hull fouling. Although several studies have been conducted on the dispersal via currents of the larvae of various commercially significant and native species such as abalone (*Haliotis iris*), the role of natural pathways in the spread of NIS is not well known.

Located at the top of the South Island, New Zealand, Golden and Tasman Bays encompass marine and estuarine environments that are highly valued for their economic, environmental, social and cultural resources. As with most other regions in New Zealand, Tasman and Golden Bays have experienced a number of marine incursions (e.g. *Undaria pinnatifida* and *Styela clava*), which threaten these resources. It is therefore essential to design and implement biosecurity programmes that prevent future new invasions to the region, and to control the further spread of already established marine pests. For such management programmes to be successful, risk assessments must incorporate the potential dispersion patterns of natural pathways, especially currents, in addition to a knowledge of the human-mediated pathways.

Knowledge on the hydrodynamics in Golden-Tasman Bays is relatively limited. The most recent study, by Cawthron, has generated a numerical model that simulates the hydrodynamic flows within this region. Based on this model, and using real atmospheric data (e.g., wind, temperature, precipitation) over a twelve-year period, an hourly 2D current velocity profile was generated for Golden and Tasman Bays. This profile was used to simulate the dispersion of passive particles within the bays under different scenarios. The location of the release point of the particles was varied along the coastline and different patterns of dispersion were identified. Similarly, the effect of the life span of the particles in the final dispersion pattern was investigated.

By assuming that NIS larvae would experience similar dispersion forces to the passive particles, the model is used to identify *donor sources* and *recipient areas* in Golden and Tasman Bays. This will enable managers to identify and prioritize NIS surveillance, eradication and control activities in the region. The approach can also be used to determine whether management of specific human-mediated pathways in the region is likely to be cost-effective, and to prioritise research needs.

NOTES

Changes in Macrozoobenthos of the Eastern Gulf of Finland After Introduction of Alien Annelids

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During the past ten years bottom communities in open areas of the eastern Gulf of Finland were adversely affected by invasions of North American polychaete *Marenzelleria neg*lecta and North Sea tubificid oligochaete *Tubificoides pseudogaster*. At present *M. neglecta* become a common and abundant macrobenthic species in the eastern Gulf of Finland. The maximal biomass was found on sand and clay bottoms in shallow areas (depth less than 30 m). At some sites *M. neglecta* became the dominant species forming 70-90% of the total biomass of macrozoobenthos. However, as yet, no adverse affects on the native fauna were observed. *T. pseudogaster* was successfully established in local area previously occupied by a poor community of glacial relict crustaceans, where it has become a dominant species. The drastic decline of population of native amphipod *Monoporeia affinis* was observed after invasion. The most probable explanation of this decline is deterioration of sediment quality as a result of tubificids activity. Annelid worms are often considered opportunists because of their ability to reproduce quickly and attain high abundance in disturbed areas. Generally, present environmental conditions in the eastern Gulf of Finland are more favorable for introduced annelids, rather than native species of relict crustaceans. In last years the extensive areas of lifeless bottom were formed because of periodic anoxic and hypoxic conditions. It is the excellent opportunity for alien species to colonize the new areas. Replacement by alien species of native fauna causes the irreversible changes in bottom communities that, in the future, can have adverse consequences for whole ecosystem of the Gulf.

NOTES

Aquatic Invasive Invertebrates in the United States: Rusty Crayfish as a Case Study

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Documentation and regulation of 'injurious wildlife' in the United States largely has focused on terrestrial plants (i.e., noxious weeds and agricultural pests) and vertebrate species (i.e., mammals and fish). In addition, the traditional perception of invasive species is that the organism is from an exotic or distant locale. Often overlooked, however, are freshwater invertebrate species that can become invasive within a country, or even an adjacent watershed. We evaluated the distribution of aquatic invasive invertebrates in the US using data from the US Geological Survey (USGS). Overall, we found low documentation of invertebrates outside the Great Lakes region. In addition, many invasive invertebrates in the US are native transplants that have been introduced outside of their native watersheds.

The rusty crayfish (*Orconectes rusticus*) is an example of a native transplant that was naturally restricted to lotic systems in the Ohio River basin and has become invasive in neighboring water-bodies. In only the past 30 years, boaters and anglers have introduced rusty crayfish into many other aquatic environments, primarily lentic systems in the Great Lakes region. Once introduced, rusty crayfish can attain densities up to 20 m^{-2} in only a few years. Their relative large body size and aggressive behavior successfully out-competes native congeners and other benthic species for food and habitat. In addition, crayfish are omnivorous, with the potential to impact multiple trophic levels of aquatic food webs.

We studied the effect of rusty crayfish on stream food webs in the upper Midwestern streams (MI/WI) using two approaches 1) using electric exclusion in an invaded stream and an uninvaded stream, and 2) comparing fish populations in native and invaded streams. We predicted that the invasion by this large benthic omnivore would result in declines in the abundance of detritus, invertebrates, and fish. In the first experiment, ten electrified hoops (5 electric and 5 controls) were used to exclude crayfish. We measured decomposition rates of sugar maple leaves (*Acer saccharum*), invertebrate abundance, and primary production on days 0, 2, 14, 28, and 42. Leaves exposed to rusty crayfish decayed significantly faster ($k=0.1061$) than leaves in electrified hoops ($k=0.0792$) ($p<0.001$). Fewer benthic invertebrates were found in non-electric hoops compared to electric hoops in the rusty crayfish stream ($p=0.005$) but crayfish exclusion did not alter primary production. In the native crayfish steam, however, we found no difference between treatments across all measurements. Finally, we compared fish abundance, biomass, and diversity across 4 invaded, and 4 uninvaded streams. We found that streams invaded by rusty crayfish had significantly lower fish abundance ($p=0.02$) and biomass ($p<0.001$), but had no effect on taxa richness. In addition, brook trout streams had significantly fewer trout if invaded by rusty crayfish compared to uninvaded streams. In both studies, we found that rusty crayfish decreased resource availability and altered historical food webs. Our results suggest that invasion by rusty crayfish can be particularly severe due to their effects on multiple trophic levels. In addition, a better understanding of species distributions and impacts of aquatic invasive invertebrates is essential in prioritizing management efforts.

NOTES

Dispersal of Red Swamp Crayfish (*Procambarus clarkii*, Girard), Does Population Density Matter?

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The spreading of the invasive crayfish *Procambarus clarkii* throughout the world is attributed to human introductions, however, the rapid and widespread diffusion of the species following its establishment is the result of its dispersal capabilities. Introduced in Portugal in the late 1970s, the red swamp crayfish has invaded many water bodies, giving rise to breeding populations that now altered freshwater ecosystems. An understanding of the spatial behaviour of this crayfish could be the baseline for future research aimed at control and management. This study aimed to provide further information for the comprehension of the invasive potential of this crayfish by underlining some factors that could affect crayfish dispersal ability such as population density and other external co-variables.

Crayfish (54.45±3.80 mm mean cephalotorax length, sex ratio approximately 1:1) were submitted to an outdoor experiment in an experimental irrigation ditch. Five densities, 1, 5, 10, 15 and 20 individuals, previously confined for five days in 0.25 m^2 tanks, were released in the centre of the ditch at five different periods of the day and the position of each crayfish was recorded every five minutes. Each density was replicated five times.

Density affected both mean total distance and mean individual velocity attained by crayfish at the end of the experiment (ANCOVA; $p<0.001$). Crayfish kept at the higher density achieved higher velocities (2.89±1.11 $m.^{s-1}$) and went further (114.12±42.67 m) than those kept at the lowest density (2.38±1.09 $m.^{s-1}$ vs 77.55±31.79 m).

These results are relevant both for aquaculture and for modeling crayfish population dynamics.

NOTES

Reproduction and Growth of *Orconectes limosus* Raf. in Baltic Brackish Waters – Is it Possible?

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American crayfish (*Orconectes limosus* Raf.) is a freshwater crayfish of North America origin, first introduced to Europe in 1890. Presently, it is a species that is still expanding to new areas including brackish waters. In Poland it is a dominant crayfish species in inland waters. The American crayfish is also noticed in the Pomeranian Bay (7 psu), Szczecin Lagoon (4 psu) and in the Vistula Lagoon (3-5 psu). The aim of this study was to investigate reproductive and growth possibilities of *O. limosus* in brackish waters. Females with pleopodal eggs, wild-caught from the Vistula Lagoon were used in the experiment. Animals were held in aquariums, at water salinity of 3 and 7 psu. There was a 100% reproductive success in both cases. Neither of the two salinities influenced the development of eggs and larvae stages. Buried females survived exposure to salinities of 3 and 7 psu whilst incubating their eggs and their mortality was stated only after moulting. Eggs hatched into stage 1 larvae and subsequently moulted into stage 2 larvae with full success. The total number of freshly hatched crayfish from 10 females was 1100 in salinity 3 psu and 827 in salinity 7 psu. The total mortality in stage 2 larvae was 1.6% in salinity 3 psu and 2.5% in salinity 7 psu. Reduction in number of juvenile specimens was approximately 50% after 5 weeks from hatching in both salinities. For the assessment of the crayfish growth rate, 50 juvenile specimens from 3 psu and the same number from 7 psu were used. The growth rate was assessed as a mean increase in carapace length at moult. It was 0.5 mm higher for crayfish from 7 psu. The maximum increase of carapace and total length was (a) 3.5 mm and 6.5 mm in salinity 3 psu and (b) 4.0 mm and 7.0 mm in salinity 7 psu. During the experiment 77 moults in 3 psu and 44 moults in 7 psu were stated. Every increase in carapace length was classified to four length classes. The percentage contribution of increase in carapace length in class 0-1 mm was higher in 3 psu (58.4%) than in 7 psu (34.1%). On the other hand, in class 1.5-2.0 mm it was equal in both salinities (about 32%) while much higher in 7 psu in classes 2.5-3.0 mm and 3.5-4.0 mm (25% and 6.8% respectively) than in 3 psu (9.1% and 1.3% respectively). These results revealed that *O. limosus* can reproduce in brackish waters with a salinity up to 7 psu and reach larger sizes with salinity increase.

NOTES

The Effect of Water Temperature on Number of Moults and Growth for Invasive Crayfish *Pacifastacus leniusculus* D. During the First Three Months of their Life

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The growth rate, the frequency of moulting, and the moulting interval of juvenile signal crayfish *Pacifastacus leniusculus* was studied under experimental conditions. Juveniles were reared individually in small boxes (45x30x40 mm) under a light regime of 12 (dark): 12 (light) in two different temperatures, 15°C (cold) and 21°C (warm). Juveniles were fed frozen chironomid larvae.

Altogether five moults were observed in the cold water treatment and seven moults in the warm water treatment. The moulting periods for cold water were much longer than for warm water. On average, the 6th developmental stage was reached in 57 days (1195 day degrees) in warm water and in 94 days (1353 day degrees) in cold water. By the time juveniles in cold water attained the 6th stage of development, juveniles in warm water already reached the 8th stage. All of the intermoult periods for cold water were significantly longer compared to warm water conditions. The temperature therefore influenced significantly the duration of intermoult periods.

In both temperatures, the average percent weight increments per moult decreased when increasing the ordinal number of the moult. In warm water, the decrease occured faster, but the final values were very similar for both temperatures. The absolute weight and length increments and increments variance increased with increasing number of moults, length, weight and number of days after hatching. The mean absolute weight and length moult increments for cold and warm water were similar and differences were not statistically significant.

The average weight and length of consecutive stages were very similar in both temperatures, but juveniles in warm water moulted more often. At the same time, the growth rate of juveniles was significantly higher in warm water. The juveniles in warm water had higher length and weight than in cold water at the identical age. At the end of experiment, the weight and length was 147 mg and 18.5 mm in cold water (6th stage) and 259 mg and 22.2 mm in warm water (8th stage), respectively. Variance was largest for the oldest stages.

Values of SGR decreased with the ordinal number of the moult from 5.6% and 10.4% in the first moult to 1.4 and 1.5 % day^{-1} at the end of the experiment for cold and warm water, respectively. The SGR showed a significantly higher growth for *P. leniusculus* juveniles in warm water. SGR values showed a negative correlation with the number of days after hatching, weight, and the number of moults.

NOTES

Evaluating Recruitment Dynamics of the Chinese Mitten Crab, *Eriocheir sinensis*: Methods for Early Detection, Monitoring and Determining Year Class Strength

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The Chinese mitten crab, *Eriocheir sinensis*, has spread worldwide and caused severe economic and ecological impacts where it has become established. These impacts have varied in severity due to dramatic fluctuations in the abundance of crabs, a phenomenon observed in several countries including the United States, Germany, and England. It has been hypothesized that variation in early recruitment success may be driving these population fluctuations. Specifically, strong year classes are believed to coincide with environmental conditions that promote recruitment. To evaluate this hypothesis, we have conducted two studies to: 1) develop methods and identify sites for measuring early recruitment, 2) examine spatial and temporal variation in early recruitment, and 3) evaluate associations between mitten crab recruitment and selected environmental variables (water temperature, water flow). We adapted sampling techniques traditionally used in marine systems to measure early recruitment of mitten crabs. These techniques exploit the molting behavior of crabs by providing complex habitats for them to hide in while shedding their old and hardening their new shell. At these small sizes, crabs are typically molting every one to two weeks. The passive plastic mesh collectors (scrubbing pad; Tuffy®) used targeted the collection of early life stages of mitten crabs including: post-larval megalopae, early stage post-megalopal juvenile crabs or recruits (< 5 mm carapace width (CW)) and small juvenile mitten crabs (5-10 mm CW). Collectors were retrieved every 10-14 days for a minimum of 2 months and a maximum of 8 months depending on the site and year.

Although our data are limited, we found that early recruitment of mitten crabs: 1) was heterogeneous among sites, 2) occurred primarily in the upper reaches of tidally influenced areas, in low salinity waters (< 5ppt), 3) included at least one peak recruitment period in the spring (April/May), 4) was possibly related to an increase in water temperature and 5) was apparently inversely related to water flow. These initial findings support the hypothesis that early recruitment is driving population fluctuations of mitten crabs in California, although additional studies are clearly needed to refine our understanding of recruitment dynamics in California, and elsewhere. In addition, our work illustrates an approach that may be useful for early detection, monitoring and predicting year class strength of mitten crabs. Application of these methods could assist in detecting the spread of mitten crabs into new areas, as well as help identify locations and years for applying site specific control measures in areas where mitten crabs already occur. We encourage others to adapt and apply our techniques to assist in the further development of their use for mitten crab research and management.

NOTES

Appraisal of Molecular Detection Methodologies for Identifying and Enumerating Aquatic Pests

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Methods for the detection of marine pests in aquatic environments require formats in which it is desirable to quantify as well as efficiently and accurately identify these pests. A method showing promise in this area is the sandwich hybridisation assay (SHA). One constraint in developing this method (particularly for species that are not easily accessed) is that the target RNA in preserved specimens degrades over time. We describe how target rRNA can be preserved by treatment with "RNAlater" for a variety of potential pests for New Zealand, including invertebrate larvae of the northern Pacific seastar, *Asterias amurensis* and toxic dinoflagellates. We also report on the development of SHA probes for *A. amurensis* and other high priority pest species such as the Asian clam, *Potomocorbula amurensis*, with the view to developing an array system for detection. Finally we present comparative quantitative data for both SHA and qPCR for toxic dinoflagellates (e.g., *Alexandrium* spp.) enumerating at the cell rather than nucleic acid level.

NOTES

Phylogeny and Population Genetics of Invasive Asiatic Clams (*Corbicula* spp.) in the Meuse

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Among invasive exotic species, Asiatic clams (*Corbicula* spp.) are famous for having invaded American and European rivers. The aim of this study is to identify the species/taxa of *Corbicula* present in the Meuse on basis of existing molecular data from other rivers and to understand the genetic structure of populations. This approach will allow the study of the invasive process in those organisms, among others, by estimating the number of inoculation points in our regions. The study of genetic diversity within those populations will permit the estimation of their potentiality to survive on the long term in Europe. To obtain this information, the use of hypervariable markers such as microsatellites will be necessary. The first step of this research was a sampling campaign along the Meuse. Morphological data and tissue samples were collected and COI gene was sequenced in diverse populations.

NOTES

Identifying the Origin of the Cryptogenic Ascidian *Molgula manhattensis* (De Kay, 1843)

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Molgula manhattensis is a common member of fouling communities in temperate waters on both coasts of the North Atlantic Ocean. It was recently introduced on the Pacific coast of the US, in Japan and Australia. Possible vectors of introduction are hull fouling, ballast water and oyster shipments. Based on its disjunct amphi-Atlantic distribution, the observed recent introductions to other areas, association with various transport vectors, and inconclusive reports of the inferred introduced status of this species, *M. manhattensis* is qualified as a cryptogenic species in the North Atlantic Ocean.

The number of cryptogenic species in the ocean is greatly underestimated. Biological invasions are generally seen as a modern-day phenomenon. However, biologists only started investigating coastal communities in the 18th century, whereas the advent of shipping was many centuries before. Wooden hulls, long journeys, slow speeds and long port residence times created an ideal opportunity for uptake, en route survival and introduction of non-indigenous species.

Taxa that were introduced then may be important components of coastal communities now, but may falsely be viewed as native.

In this study we investigated the historical biogeography of *M. Manhattensis* with the use of molecular tools. We sequenced a 530bp fragment of the mtDNA COI subunit of *M.manhattensis* specimens of from nine populations in the North Atlantic, one population from San Francisco Bay and a Japanese population. Additionally, we sequenced a few individuals from museum collections, dating back to the 19th century. Based on the geographic distribution of haplotypes and haplotype diversities, the native range and the timing of spread of *M. manhattensis* were analyzed.

NOTES

Genetic Structure of an Invasive Species *Dreissena polymorpha* in Ebro River, Spain: Results of PCR Based AFLP-Fingerprinting

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The zebra mussel, *Dreissena polymorpha* (Pallas, 1771), is a successful invasive bivalve that originates from the Ponto-Caspian region. The dispersal of *D. polymorpha* began at the end of the 18th century, and spread to most of the lakes, rivers and waterways in Europe by a combination of natural and anthropogenic dispersal mechanisms. *D. polymorpha* invaded Spain around 2001, being found for the first time in the Riba-roja reservoir (lower part of the Ebro River, North-East Spain). The relatively late invasion of Spain was most likely caused by the presence of the Pyrenees, which isolated the Iberian Peninsula from the rest of the European continent, and acted as a dispersal barrier of *D. polymorpha*. Previous studies have tried to infer the origin of invasion by using the presence of *D. polymorpha*'s parasites in the Ebro River as origin tracers. They recorded the presence of *Phyllodistomum folium* in the branchiodes of *D. polymorpha*. This helminth is widely known in Europe but, to date, not known in North America, suggesting a European rather than an American origin of the *D. polymorpha* population in the Ebro. However, the exact source region in Europe remained uncertain. Recent studies have revealed the usefulness of genetic markers (e.g., RAPD, AFLP and microsatellites) as a tool to study the genetic structure of populations and infer source regions of invasion of *Dreissena* species. Phylogeographic analysis, expressing the hierarchical descendence of populations, allows the identification of source regions by comparing the genetic similarity between the newly established population and potential surrounding source populations. In this study, we applied the AFLP-fingerprinting method to determine the most likely origin of the *D. polymorpha* population in the Ebro River, Spain.

NOTES

Aquatic Invaders in the European Alien Species Database

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Aquatic alien species constitute an essential part of the European Alien Species Database (EASD) which is being developed under the EU sponsored Strategic Research Project DAISIE (Delivering Alien Invasive Species Inventories for Europe). In this Database only those species which were intentionally or unintentionally transferred outside their natural historical range by humans are included. Natural shifts in distribution range (e.g., due to climatic change or dispersal by ocean currents) do not qualify a species as alien. The data on aquatic alien species in EASD is being collected in the form of national check-lists representing all EU and non-EU European countries, as well as Asian and African coastal countries of the Mediterranean Sea. Authors' rights on the information in EASD are protected via publication of national checklists in the e-journal *Aquatic Invasions.* The Database compiles information on taxonomy, date and vector of introduction, invaded habitat, population status and data availability on ecological/ economic impacts of approximately one thousand alien aquatic species in inland and marine waters of Europe and neighbouring regions. This paper presents the main goals, structure and vocabulary used in the EASD.

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NOTES

The Most Invasive and Impacting Introduced Aquatic Species in Europe

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Within the framework of the EU-funded Programme "Delivering Alien Invasive Species Inventories for Europe" (DAISIE, see also www.daisie.se) 100 of the most invasive and impacting introduced aquatic and terrestrial species of Europe were selected for closer consideration. This overview focuses on the aquatic environment and we provide a complete list of the species selected, the habitat(s) they occupy including the current distribution and indicate their impact. In addition, the most recent aquatic invaders into northwestern European coastal waters, such as *Rapana venosa*, *Neogobius melanostomus* and *Mnemiopsis leidyi*, their potential to spread and possible impact scenarios are described.

NOTES

Alien Species in European Seas: Regions at Risk

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As part of an EC-sponsored comprehensive inventory of alien species in Europe, a voluminous body of literature, including research papers, surveys, and conference abstracts, was assembled and critically examined in order to construct an authoritative dataset tracing the origin, date and manner of introduction, current distribution, rate of spread, and actual and potential impacts of over a thousand marine alien species recorded in European waters – from the North Sea to the Mediterranean. A taxonomic classification of the list shows that the alien taxa most frequently recorded are molluscs, crustaceans, fish, and red algae. Phyla not represented in the list include the little studied Nemertea, Priapula, Enteroprocta, Pogonophora, Sipuncula, Echiura, Brachiopoda and Phoronida. The data is presumably most accurate for large and conspicuous species, which are easily distinguished from the native biota, occurring along a frequently sampled or fished coast and for which taxonomic expertise is readily available.

An analysis of the native range of the alien taxa shows that most of the alien species in the Mediterranean are thermophilic, originating in the tropical Indo-Pacific or parts thereof, at odds with the widely held assumption that successful bioinvasions originate in similar latitudes. Aliens recorded from the Atlantic, North Sea and Baltic coasts of Europe have far more diverse origins, and most stem from similar latitudes. Most alien species are littoral and sublittoral benthic or demersal. Since the coastal benthos has been extensively studied, the chances that new arrivals will be encountered and identified are higher. Also, the species most likely to arrive by the predominant means of introduction are shallow water species. The largest number of alien species was recorded along the Levantine coastline (382 species/800 km). The majority of Levantine aliens entered through the Suez Canal (73%, 13% vessel-transported, 2% mariculture), whereas mariculture and vessels are predominant elsewhere.

Conspicuous impacts of invasive alien species were recorded from some areas with relatively few invaders, but the most impacted areas have large concentrations of alien species. Though no extinction of a native species is known, sudden decline in abundance, and even local extirpations, concurrent with proliferation of aliens, had been recorded. Examination of the profound ecological impacts of some of the most conspicuous invasive alien species underscores their role, among multiple anthropogenic stressors, in altering the infralittoral communities. Local population losses and niche contraction of native species may not induce immediate extirpation, but they augur reduction of genetic diversity, loss of functions, processes, and habitat structure, increase the risk of decline and extinction, and lead to biotic homogenization.

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NOTES

Online Database "Aquatic Invaders of Belarus": Goals and Structure

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Republic of Belarus is one of very few European countries that still lack an electronic database on aquatic invasive species. Moreover, until recently even a comprehensive list of exotics that are already known in Belarus was not available. However, the geographical position of Belarus is very important as it includes the continental divide separating the Black Sea and Baltic Sea basins, and a considerable part of "Central invasion corridor" (i.e., a system of canals connecting Dnieper River with various rivers of the Baltic Sea basin). This corridor played an important role in the introduction of numerous Ponto-Caspian species from the Black Sea basin into Western Europe. Nevertheless, Belarus is still a "white spot" on European maps of distribution of aquatic invaders. There are several reasons for that, including the absence of national strategy on biological invasions, lack of financial support, and lack of taxonomical experts. As a result, only the most aggressive invasive species (e.g., zebra mussel) are well studied. Information on other species is scattered and in most cases is not readily available to English speaking scientists. At the same time, easy access to such information would be essential for understanding vectors and routes of spread of aquatic invaders in Europe. To address this problem, in 2005 we initiated the development of an Internet database "Aquatic Invaders of Belarus" (www.aib.com), which is to be launched at the beginning of 2007 and will contain information on aquatic exotic invertebrates and fish in Belarus. The site will be available in both English and Russian.

The key module of the database is a search form allowing visitors to retrieve information by Phylum, Class, Order, Family and Species, as well as to view the entire list of species in the database. For each species the following information will be included:

Accepted scientific name, synonyms and a picture (if available)

- Common name.
- Taxonomy (Phylum, Class, Order, Family).
- Native area.
- Initial time of introduction/first record.
- Vector of introduction.
- List of records with references and a link to the map with species records. The map will be managed via the GoogleMap technology.
- Potential ecological impacts.
- List of references.

In addition to the search form, the site will contain information on hydrology and physical-climatic conditions in Belarus, a list of related Internet links and other data including news, the project's history, and contact information.

NOTES

Harmonia, an Information System Dedicated to Non-native Invasive Species in Belgium

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Harmonia is a new information system on non-native invasive species in Belgium, which is developed at the initiative of scientists gathered within the Belgian Forum on Invasive Species (http://ias.biodiversity.be). This system aims at collecting standardised information on the impacts of non-native species that are assumed to be detrimental to native biodiversity in Western Europe. It includes a high diversity of taxonomic groups from terrestrial, freshwater and marine environments.

Species included in the system are allocated to different list categories (black and watch lists) based a two dimension ordination, i.e., environmental impact and geographic distribution in Belgium. Such categorisation offers a scientific background to prioritise actions to prevent introduction and mitigate the impact of invasive species (restriction to importation, trade regulation, local control actions, etc.).

The environmental impact of non-native species is assessed in a standard, objective and transparent way through a simplified protocol developed by the Forum, the Invasive Species Environmental Impact Assessment (ISEIA) protocol. It consists of four sections matching the last steps of the invasion process, i.e. the potential for spreading and colonising natural habitats as well as the adverse impacts on non-native species and ecosystems. Scores for each section are assessed based on organism's history of impact in neighbour areas together with their ecological profiles.

The first assessments performed with the ISEIA system demonstrate that data can be easily collected from the literature for most organisms and that repeatability is quite good, providing that criteria were thoroughly discussed among the expert group. Results from these assessments will be briefly presented and discussed.

NOTES

A Computational and Experimental Approach to Prediction of the Effectiveness of Flow-through Ballast Water Exchange

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Flow-through ballast water exchange (FTE) is a primary means of reducing the discharge of waterborne non-indigenous species into coastal and inland waterways. From a theoretical standpoint, if it is assumed that the incoming and original ballast fluids are instantaneously and completely mixed, three tank-volumes of overflow would need to be completed to replace 95% of the initial water. From a practical standpoint, however, due to internal tank structures and a wide range of flow velocities in the tank, it has been both very difficult to determine what the actual proportion is of fluid exchanged during an FTE, and furthermore whether the final mixture is uniform throughout the tank or exists in separate stratified patches of varying end-member proportions. Because of these difficulties it has been difficult to assess whether ships that comply with the three-volume exchange rule actually do reach 95% exchange efficiency and whether there are pockets of fluid, typically in the tank tops, that still carry significant portions of the original ballast water and species.

For the last three years we have been developing an experimentally-validated computational method for evaluating FTE. The advantage of using computational fluid dynamics (CFD) is that it provides the transient and three-dimensional data with which the exchange efficiency can be computed and where and when mixing and trappage occur, thus providing much better understanding of the physics of FTE, allowing its more rational application. The disadvantage of CFD is that two-fluid calculations are difficult due to a number of computational aspects: temporal- and spatial discretizations, two-fluid and turbulence modeling and grid quality to name a few. For that reason we have structured a research project to perform physical model experiments and computations together such that the experiments provide both physical insights and quantitative data with which to perform validations. At the 14th ICAIS we presented results in which we validated the CFD code against 1/3-scale experiments on a portion of a bulk carrier ballast tank that had been limited to single tank-volume exchange with a 35 ppt density difference at scaled 1000 gallon/minute (gpm) inflow rate. In this presentation we will show experimental results and CFD validations for complete three tank-volume exchanges at scaled flow rates of 1000 and 1700 gpm and 35 ppt and 20 ppt density differences between original and incoming fluids. The comparison between experimental data and computations is quite good although differences point out that additional mixing is necessary in the model for high flow rate, low density difference flows and that fine computational grids are needed in the model at the tank tops to resolve the stratified shear layers.

NOTES

Biological Effectiveness of Open-ocean Ballast Exchange for Preventing Invertebrate Invasions Between Freshwater Ports

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Mandatory ballast water exchange (BWE) was implemented for vessels carrying ballast water into the Great Lakes in 1993. Despite this, little data are available on its effectiveness, and additional invaders continue to be reported in the Great Lakes. In this study, we conducted experiments to assess the efficacy of BWE on six operational transoceanic vessels traveling from the Great Lakes to European ports. Each vessel had paired ballast tanks, one of which was designated as a control that remained filled with Great Lakes water while the other was exchanged with mid-ocean water. Community composition was assessed after tanks were filled and again prior to water discharge in European ports. BWE was verified by ship records and, in two cases, in-tank sensors. BWE was highly effective (>99% loss) for reducing concentrations of freshwater zooplankton, exceeding proposed IMO ballast water performance standards. Live sentinel amphipods and oligochaetes deployed in incubator chambers sustained nearly universal mortality in tanks that experienced BWE. Also, it is likely that BWE reduced *in situ* recruitment of zooplankton from diapausing eggs present in ballast sediments, via mortality of previously hatched freshwater individuals upon exchange and/or suppression of hatching cues due to exposure to saltwater. Collectively, these studies support the contention that BWE by transoceanic vessels provides very strong protection against invasions both pelagic and benthic species between source and donor freshwater ports.

NOTES

Estimating Probability of Establishment for Parthenogenetic Taxa with Small Founding Populations: An Assessment of the Proposed IMO Ballast Water Treatment Standards

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Activities associated with transoceanic shipping have been the putative introduction mechanism for ~75% of aquatic non-indigenous species recorded in the Great Lakes since 1960. Management practices involving ballast water exchange (for vessels loaded with ballast), and more recently, saltwater flushing of tanks (for vessels carrying residual ballast) have been implemented to reduce the frequency of invasion events by this vector until more effective management strategies are developed. A variety of alternative treatment methods, such as deoxygenation and filtration, are currently being developed for management of ballast water. The International Maritime Organization (IMO) has proposed minimum discharge standards for ballast water treatment technologies, comprised of maximum densities of viable organisms and indicator microbes. For example, a discharge density of 10 individuals·m^{-3} has been proposed for organisms greater than 50 µm in minimum dimension, such as zooplankton.

Theoretically, as the number of organisms (propagules) in ballast water decreases, the probability of long-term population establishment also decreases due to density-dependent demographics (such as Allee effects) and environmental stochasticity. The discharge standards proposed by the IMO probably represent the lowest limits achievable by treatment technologies under operational conditions. To our knowledge, however, there has been no empirical testing of the efficacy of the proposed standards. We are particularly interested in the impact the proposed standards would have on asexually reproducing taxa that are not subjected to density-dependent demographics (e.g., cladocerans and rotifers).

Mesocosm experiments (5000 L) were conducted in Hamilton Harbour, Lake Ontario, Canada to measure growth rates of six cladoceran taxa given low inoculum density. We modified a diffusion approximation to estimate establishment probabilities based on four parameters: inoculum density, critical reproductive threshold density, and the mean and variance of the stochastic growth rate. Only one of the study species (*Daphnia retrocurva*) exhibited a low-moderate probability of establishment (~25%) at inoculum densities of 10 individuals·m^{-3}. Two additional species (*Bosmina coregoni* and *Bosmina* spp.) exhibited very low probabilities of establishment (<1%) at this inoculum density, while the remaining species appear incapable of establishment given such low inocula. Our results indicate that the proposed regulation for zooplankton load in ballast water is highly precautionary but that the probability of establishment may not be insignificant for some cladoceran species.

NOTES

Assessing the Importance of Biological Uncertainty in the Management of Species Introductions Via Ballast Water

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Commercial ships' ballast water operations are considered to be the most important transfer mechanism for dense and diverse assemblages of organisms within and among ocean basins and estuaries. Reducing propagule pressure, specifically the quantity, quality and frequency of organisms discharged, at a specific location by performing mid-ocean ballast water exchange or using treatment can decrease invasion risk. However, most decisions regarding the management of ballast water are complicated by uncertainties related to the biology of invasions, the performance of treatment options, and industry behavior. Empirical evidence has shown that the concentration, composition and survival of organisms in ballast tanks vary significantly in time and space among vessel types and voyage routes. This variability, which directly affects the selection of suitable treatment options to reduce propagule pressure is, however, not well understood.

Here we demonstrate the application of a comprehensive decision-analysis framework (the Ballast Water Discharge and Decision Support Model) to international ship arrivals during 2004 in two distinct port environments: the Delaware Bay Port System and the Port of Miami, in order to examine the importance of biological uncertainty in the management of ballast water. The model is run in the General Algebraic Modeling System (GAMS), a high-level modeling system for mathematical programming and optimization. Ballast water discharges are incorporated into the model on an individual tank basis, using ballast water volumes, source locations, and uptake dates from the National Ballast Information Clearinghouse (NBIC) database. A set of treatment options that represents the current ballast water efficiency-cost technology frontier is identified. Ranges of initial concentration, and growth rates of ballast water entrained populations, are extrapolated from the literature, and the use of satellite images to aid the estimation of initial concentrations is explored. Current policies, including those based on discharge concentration limitations, as well as alternative policies such as quantity limits, are evaluated.

Our results further the understanding of the current limitations and costs that uncertainties impart to the management of ballast water and shed light on scientific and policy efforts to reduce ballast water-mediated introductions.

NOTES

Results and Lessons Learned from the ETV Beta Test

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The US Naval Research Laboratory in Key West has partnered with the United States Coast Guard (USCG) to design, build and operate the Ballast Water Treatment Test Facility (BWTTF). This facility has been developed to perform standardized validation testing of ballast water treatment equipment (BWTE) according to draft test protocols developed under the Environmental Protection Agency's Environmental Technology Verification Program (ETV). Verification testing under the ETV program is a three-step process consisting of planning, verification, and data assessment/reporting phases. Thorough documentation is required to describe the test operations and quality assurance protocols, which provide an independent and objective assessment of BWTE performance. Technologies proposed for ballast water treatment include, but are not limited to, filtration, ultraviolet (UV) light, biocides, chemical oxidation, and various means of subjecting organisms in ballast water to physical stress.

The draft ETV protocol calls for operational and maintenance testing under ambient conditions and performance testing under challenge conditions consisting of ambient water augmented with biological surrogates, particulates and organics. The facility has developed and validated techniques for addition and measurement of challenge constituents to ambient seawater as part of establishing and instrumenting a full-scale ground based ballast water storage and transfer system. During the execution of the challenge test protocol, both a control tank and a test tank are filled, remain ballasted for approximately 24 hours, and then are deballasted to a discharge tank, where all remaining challenge components are removed.

To generate the challenge water, challenge constituents are injected into the ballast uptake stream used to fill the tanks. During each tank fill operation, time integrated sample volumes are collected of the challenge water, and during each tank deballast operation, additional time integrated samples are obtained of the deballasted water. These samples are analyzed for water chemistry parameters and biology activity. These analyses provide the means for verifying test parameters at the input, and observing results of treatment and control at the output.

A Pilot Test of the facility was conducted over a four-month period starting in October of 2006, using a commercial electrolytic chlorine generation system to treat ballast water. This system is designed to inject hypochlorite generated from incoming seawater back into the ballast uptake flow, resulting in a target concentration of 18 ppm free chlorine in the ballast tank. The chlorine level will dissipate to a few ppm over 24 hours, and the residual chlorine in the ballast is dechlorinated upon deballast of the tank through the injection of sodium metabisulfite. This system was tested according to an ETV Pilot Test plan based on the draft ETV protocols, and is the first test at the facility to measure performance of a commercial treatment system against a standardized set of operating and challenge conditions.

NOTES

Automated Methods for Planktonic Enumeration and Viability Analysis

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Standardized testing of ballast water treatment equipment (BWTE) necessitates the complete characterization of challenge water used to evaluate the efficacy of the equipment. Characterization of basic water quality parameters such as pH, total dissolved solids, salinity and other parameters will validate compliance with water chemistry test protocols. To document biological treatment performance, concentrations and viability of both indigenous (ambient) and surrogate (challenge) phytoplankton and zooplankton must be determined. The assessment of BWTE efficacy requires comparison of measurements of phytoplankton and zooplankton concentrations and viability before and after treatment.

During support of standardized testing at the Naval Research Laboratory Ballast Water Treatment Test Facility (BWTTF), significant man-hours are expended determining the concentrations of phytoplankton and zooplankton in challenge and post-treatment samples and determining their viability. In the case of zooplankton, it takes a microbiologist conservatively 3½ hours of intensive microscope observations to determine the concentrations the zooplankton and to assess the number of viable organisms. In the case of phytoplankton, most probable number (MPN) methods that are used to determine viability do not provide "real-time" results. Significant microscope time is additionally required to classify phytoplankton species and determine their concentrations.

To reduce the man-hours required to perform these analyses, the Naval Research Laboratory (NRL) is developing automated methods for determining the concentrations of zooplankton and phytoplankton and determining their viability.

With zooplankton, a stereo microscope is used in conjunction with a high resolution "firewire" camera to collect time resolved image sets of sample wells. Image processing and classification algorithms are applied to these image sets to enumerate the zooplankton in the sample well and to assess their viability (based on mobility over a 75 second observation window). This automated method should reduce the time required to completely characterize samples from at least 3 ½ hours to approximately 20 minutes. Another advantage of this method is that it creates video archives of sample observations that can be reviewed by a microbiologist, in the event that a particular result is questioned.

With phytoplankton, a specially modified imaging flow cytometer (Fluid Imaging Technologies 4-channel FlowCAM) is used in conjunction with a DNA staining dye to determine both the concentration of phytoplankton in samples and their viability. This instrument captures high-resolution images of detected particles. The instrument additionally captures chlorophyll intensity florescence values and florescence intensity values at a wavelength optimized to the response of the DNA staining dye. These florescence intensity values are used in conjunction with "features" extracted from the images to determine the types of phytoplankton present, their concentrations and their live/dead ratios. The advantages of this method are that it provides a "real time" measure of phytoplankton viability and that it generates a high-resolution image archive of all detected particles. This method significantly reduces the time required to analyze phytoplankton samples compared to direct microscope observations.

NOTES

Counting Viable Phytoplankton and Bacteria in Ballast Water

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Ships transport 5-10 billion tons of ballast water annually all over the globe, loaded with an enormous variety of organisms. These organisms belong to the natural ecosystem in the port of origin but are usually not endemic in the ports of destination at the end of a ship's journey. In hundreds of cases around the world, this has resulted in severe damage to the receiving ecosystem because these non native organisms developed into a pest. This often has a devastating impact on the ecosystem, resulting in a decrease of stocks of commercially valuable fish, shellfish species and occasionally outbreaks of diseases like cholera. To minimize these risks for the future, the International Maritime Organization (IMO) has adopted a Ballast Water Convention in 2004. This Convention states that finally ALL ships (>50,000 in number) should install proper Ballast Water Treatment (BWT) equipment on board between 2009 and 2016. NIOZ has the ambition to become the European research and test centre for the certification of BWT equipment. To achieve this, we have developed and adapted existing automated analyzing methods for phytoplankton, zooplankton and bacteria for this special purpose. This was done in an experimental study together with the German firm Hamann AG. A full scale SEDNA® BWT installation, with a capacity of 250 m^3/h, was used as a test unit. This unit was tested in the NIOZ harbour using Wadden Sea water, which is rich in mineral particles and planktonic organisms. In this presentation we will focus on the results obtained for the smaller organisms, mainly phytoplankton and bacteria. Results on larger organisms are presented in an additional poster (Veldhuis, Nelson, Peterson, Poulton).

An accurate and reproducible counting method was applied to enumerate the phytoplankton applying flow cytometry even at extreme low densities. Phytoplankton could easily be distinguished from other particles because of the presence of chlorophyll showing a bright red fluorescent signal. Cell counts as low as 10 cells per ml could easily be counted with CV's for cell counts of < 30 % (based on at least 5 replicates). The viability of the cells was examined using a nucleic acid specific stain (SYTOX Green) staining only cells with a compromised cell membrane, i.e. non-viable. This method could even be applied in water with a high mineral (clay particles) although this resulted in enhanced background staining. The SEDNA® BWT system turned out to be very effective in killing all phytoplankton cells. For the larger phytoplankton cells this resulted in a complete disruption of the cell whereas most of the smaller size picophytoplankton (ca. 2 µm in cell size) remained intact but showed a bright staining with SYTOX Green, indicating that the cells were non-viable. No regrowth of phytoplankton was observed of treated water when incubated under favourable conditions.

The applied bioactive substance of the BWT system (PERACLEAN Ocean) did not kill all bacteria (ca. 70 % remained viable) according to the viability tests. However, regrowth of bacteria was prevented for as long as the bacteriostatic compound H_2O_2 was present (ca. 5 days). After this period bacteria numbers increased, using the organic detrital material and nutrients as a substrate. This growth was accompanied by a reduction in the ambient oxygen concentration.

NEN/ISO standard tests for the human pathogens *E. coli* and *Enterococci* showed bioactive substances was effective in killing these specific groups of bacteria to values below the detection limit.

NOTES

Using a Continuous Imaging Particle Analyzer (FlowCAM®) as an Integrated System for Ballast Water Analysis and Regulatory Compliance

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A major source of the introduction and spread of invasive species in both freshwater and marine environments is the ballast water discharge from large vessels as they travel from port to port. A Ballast Water Convention has been adopted by the International Maritime Organization (IMO) that will require vessels to treat discharged ballast water. The Ballast Water Performance Regulation-D2 set by the IMO will require limitations on the amount of viable organisms within certain size ranges in discharged ballast water.

As stated by the IMO Regulation-D2, a key component to Ballast Water compliance is the ability to detect, enumerate and determine the viability of organisms that remain after ballast water treatment. Currently, treatment efficacy for certain organism size range is as follows:

Category 1 viable organisms not more than 10 viable organisms per $m^3 \geq 50$ µm in minimum dimension, and

Category 2 viable organisms not more than 10 viable organisms per ml < 50 µm in minimum dimension and ≥ 10 µm in minimum dimension.

While the challenge exists to develop the treatment systems that meet Regulation-D2, there is also the challenge of effectively *measuring* the efficacy of treatment systems for compliance, i.e. to detect this low number of live organisms in a given volume of ballast water.

An instrument for plankton analysis developed by Fluid Imaging Technologies (Edgecomb, Maine USA) called the FlowCAM® has been used by aquatic researchers for the past six years as a tool to study planktonic organisms. Today the FlowCAM is being used by a number of ballast water land based testing facilities as well as treatment system manufacturers themselves to evaluate the efficacy of treatment systems.

The core of the instrument is a high-resolution microscope/digital imaging system which images organisms as they pass through a flow chamber. This instrument combines the capabilities of a flow cytometer with a digital imaging microscope (Sieracki et al, 1998). The FlowCAM can be configured in a variety of different ways depending upon the needs of the user for monitoring purposes. Illumination of the sample is accomplished by the electronics triggering a flash LED light source and the frame grabber at preset intervals. The computer then processes and stores the images to disk for further post-processing analysis using Fluid Imaging Technologies proprietary software (VisualSpreadsheet©).

The instrument has the ability to detect, image and enumerate planktonic organisms from 3 µm to 3 mm in size, encompassing a range of organisms in the environment from picophytoplankton to near mesozooplankton (Buskey and Hyatt, 2006, Liu et al. 2005, Lavrentyev et al. 2004).

The FlowCAM adds a unique capability to the ballast water monitoring process, that being the ability to detect auto- or induced fluorescence in organisms and use it as a "trigger" for the camera to capture images. The fluorescence of an organism can be naturally occurring, such as the presence of chlorophyll a in phytoplankton, or can be a selective stain, such as live stains used for viability detection.

The FlowCAM is currently being used by researchers as an automated monitoring tool to assess how effective different ballast water treatment methods are for removing and eliminating viable organisms from ballast water. Compared to traditional methods such as microscopic detection and enumeration, which are laborious and can be plagued by

operator error, the value of the FlowCAM lies in the immediate feedback the user receives with regard to viability. The FlowCAM automatically determines the size, quantity, concentration, and viability of the organisms (after staining) and can run without immediate supervision of an operator. An added benefit of using the FlowCAM is the ability of the instrument to acquire images and data for archival purposes, as the data and images can be recalled and reanalyzed for verification purposes. Viability assessments need to be evaluated very quickly once sampling occurs (usually within 6 hours). Due to the automated nature of the FlowCAM, monitoring for viable organisms may be done quickly and effectively.

An overview of the technology will be presented along with results from different protocols that are being developed to measure the efficacy of ballast water treatment systems using the FlowCAM for both Category 1 and Category 2 viable organisms.

NOTES

Microzooplankton Response to Variable UV Treatment in Ballast Water Mesocosms

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Ballast water transport is known to be a major vector for invasion of non-indigenous zooplankton and aquatic invertebrate taxa into estuaries, lakes and rivers. However, ballast water may also contain a wide range of protist species, including both autotrophic (i.e., algae) and heterotrophic and/or mixotrophic forms (i.e., protozoans, or "microzooplankton") – some of which may have important ecological impacts. Several different treatment technologies have recently been proposed for removal or eradication of planktonic organisms from ballast water, including ultraviolet (UV) radiation. We recently conducted a series of mesocosm experiments using natural seawater treated with variable levels of UV radiation to determine its effectiveness as a treatment for eradication of planktonic protozoans in ballast water. Four replicate 120-liter tanks were filled with unfiltered seawater collected from Puget Sound, Washington, USA (controls); an additional three sets of four replicate tanks were filled with unfiltered seawater that had been irradiated at three different levels of uv radiation: 60mJ, 100 mJ, and 200 mJ. All 16 tanks were covered to exclude light and were gently mixed once per day for 20 days. Each tank was subsampled on 5 dates (days 0, 2, 6, 13, 20) to enumerate and identify the protozoan taxa present. We found UV treatment to have no significant effect on total chlorophyll concentration at any treatment level over the course of the experimental period. Chlorophyll concentration declined over time in all control and treatment tanks. Conversely, we did observe significant treatment effects on both the abundance and composition of planktonic protozoans on Days 2 and 6, with substantial reduction in total abundance at all UV treatment levels relative to controls. However, in the second half of the experimental period, protozoan abundance increased such that by Day 20 there was no significant difference in abundance between any treatment level and control tanks. In terms of taxonomic composition, there were no treatment effects, but all tanks showed a significant shift from dominance by dinoflagellates (e.g., *Protoperidinium*) on Days 0, 2, and 6 to dominance by aloricate ciliates (e.g., *Euplotes*, *Uronema*) on Days 13 and 20. Notably, all tanks showed a substantial increase in dinoflagellate cysts over time. These results will be discussed in the context of proposed ballast water treatment technologies, including and especially UV radiation, and their potential ecological effects on aquatic ecosystems receiving ballast water discharge.

NOTES

From Lakes to Rivers – Downstream Larval Distribution of *Dreissena* in Irish River Basins

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Although it is recognised that zebra mussel infested lakes provide reservoirs for downstream recruitment in river catchments, there is a lack of information on relevant environmental factors. Irish *Dreissena* surveys carried out during August 2006 took into account various riparian characteristics: variability in size of out-flowing rivers; flow rates; substrates and aquatic plants. Zebra mussel larval densities were examined in five river systems downstream of highly infested lakes. These rivers were size selected (small, medium and large) in an Irish hydro-geographical context. Sampling for both larvae and adults were carried out close to lake outfalls and at different intervals downstream.

Results indicated either absence or reduced numbers of zebra mussels downstream of weed-choked, depositional river sections. A parallel survey in a Shannon lake, Lough Derg showed highly reduced larval densities within macrophyte beds. This suggests that plants may have a baffling effect in lakes and may also hinder downstream transport and recruitment in weeded rivers.

Successful downstream transport of larvae was positively correlated with river size and flow rate. The large river systems had larvae present throughout their length, whereas small, shallow rivers had significantly decreasing densities downstream (<10km) of lake outfalls. A survey carried out upstream and downstream of a hydroelectric dam showed no significant difference in larval densities despite variance in flow and tidal influence. Very few river survey sites had adult zebra mussels present, confirming that the lotic environment in Irish rivers is generally unsuitable for high density *Dreissena* colonisation.

NOTES

Dreissena polymorpha (Zebra Mussels) Versus *Dreissena rostriformis bugensis* (Quagga Mussels): A Review of Their Different Invasion Dynamics

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Compared to the zebra mussel, *Dreissena polymorpha*, the rate of spread of the quagga mussel, *Dreissena rostriformis bugensis,* has been much slower both in Europe and North America. Zebra mussels have typically had a much faster rate of dispersal, with quagga mussels typically lagging decades if not centuries behind.

Europe: Zebra mussels quickly spread from Eastern to Western Europe during the 19th century through river systems interconnected by canals. Over the last two centuries, they have continued their expansion into inland waters throughout much of Western Europe. In contrast, only in about the last 50 years has the quagga mussel significantly dispersed from its native range in the Ukrainian Dnieper and Bug rivers/limans. During this period, commercial shipping is suspected to have aided both in its eastward expansion into Russia and its more recent westward dispersal, with the latest report documenting a quagga population in The Netherlands.

North America: Recently quagga mussels have been documented in the southwestern United States, indicating that they apparently "jumped" a few thousands kilometers from well established populations in the Great Lakes region. In North America such a long range dispersal "jump" is very unusual for this species. After their introduction into the Laurentian Great Lakes in the 1980s, zebra mussels spread rapidly though inland waterways reaching as far south as Louisiana and as far west as Oklahoma. Except for the above-mentioned "jump" to the southwestern USA, quagga populations, however, for all practical purposes had not expanded beyond the Great Lakes region during the two decades after their North American introduction.

Although the dispersal of zebra mussels is relatively faster, when the quagga mussel does catch up, it often demonstrates a remarkable ability to displace the zebra mussel. This has been observed both in North American and European sympatric populations. Hypotheses to explain both the quicker rate of dispersal of zebra mussels and its inability to maintain its population densities following the arrival of quagga mussels are reviewed.

NOTES

The Invasive Zebra Mussel *Dreissena polymorpha* as a Habitat Engineer in a Boreal Coastal Lagoon

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This paper summarizes recent studies on habitat engineering effects of the zebra mussel *Dreissena polymorpha,* which invaded the Curonian Lagoon (south-eastern part of the Baltic Sea) in the beginning of the 19th century. Now the zebra mussel is the main habitat forming animal species, which to a great extent determines the taxonomic and functional guild structure of the local bottom communities. The living druses (clusters) of *D. polymorpha* and its shell deposits form a specific habitat which covers about 25% of the lagoon's bottom. This habitat hosts the highest macrozoobenthos diversity in the Lagoon. The species richness increases along the gradient "bare sediments – shell deposits – living druses"; also there is a clear change in species composition along this gradient. The zebra mussel habitat is characterized by the highest invasive species richness comparing to other habitats in the nearby area. This may indicate the facilitative effect of *D. polymorpha* on establishment new introduced species. Other aspects of the engineering impact of the zebra mussel in the lagoon ecosystem include changes in physical structure and chemical quality of sediments; enhanced linkage between pelagic and benthic parts of the ecosystem and modification o the near-bottom nitrogen and phosphorus fluxes.

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The Zebra Mussel Shells as a Substrate for Periphyton

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One of the numerous ecological impacts of *Dreissena polymorpha* in freshwater waterbodies is the formation of complex 3D-structures composed of its shells. This phenomenon is followed by several other important effects. For example, clumps of the molluscs attract many species of aquatic organisms, especially detritophagous ones, which find shelter and abundant food resources presented by *D. polymorpha* feces and pseudofeces. In addition, filtration activity of zebra mussels improves the oxygen regime for benthic invertebrates. All these environmental effects caused by aggregations of *D. polymorpha* are quite well studied. However, aquatic ecologists actually have overlooked that zebra mussel shells (ZMS) substantially increase the amount of hard substrate available for occupation by sessile organisms. Taking into account that *D. polymorpha* may form extremely dense populations, we hypothesize that periphyton growing on its shells make considerable contribution into transformation of matter and energy in invaded ecosystems. In 2006, we launched a research project, the main goal of which was to reveal the structural-taxonomical composition of ZMS periphyton and to quantify its contribution into gross primary production and destruction in Lake Naroch (north-west of the Republic of Belarus; surface area 79.6 km^2; max depth 24.8 m; invaded in mid-1980s). This paper presents the preliminary results of this work obtained in August 2006.

The *D. polymorpha* occurs in Lake Naroch down at a depth of 8 m. Using data on density and size structure of the molluscs' population, as well as empirical relationship between shell length and its surface area ($S=0.017*L^{1.942}$, n=87, $R^2=0.978$), we found that total area of hard substrate presented by ZMS is 8.4 km^2 (ca. 11% of the lake surface area). The amount of periphyton growing on this "additional" substrate was estimated to be 104 tons of organic matter. This latter figure is about 14% larger than the amount of periphyton which was growing in August 1981 on *Chara* spp. – the main hard substrate in the waterbody before zebra mussel invasion. Thus, we may conclude that the establishment of *D. polymorpha* population resulted in the formation of a considerable "additional" amount of periphyton, which likely is playing a significant role in transformation of matter and energy in Lake Naroch.

The dry weight of periphyton on shells and chlorophyll *a* content in it were found to positively correlate with size of the molluscs. As shell length is a function of the mussels' age, this pattern is likely related to time spent for development of periphyton community. However, both dry weight and chlorophyll *a* content dropped with depth, which may be explained by limitation by light and decrease of mean shell length of mussels.

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Physiological and Ecological Traits in Invasive Zebra Mussel and Local Unionids

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Zebra mussels can cause changes in food webs and the physical environment through filter-feeding and biodeposition. In the invaded ecosystems, zebra mussels often co-occur with unionids, native strong seston-feeders. The aim of this study was to compare digestion and biodeposition by analyzing quantity and quality of rejected and egested material in *Dreissena polymoprha, Unio tumidus* and *Anadonta anatina*, co-occurring bivalves in Lake Malaren (Sweden). To do that, we applied a combined approach assaying biochemical compounds (ash content and photosynthetic pigments) and molecular tracers (LIVE/DEAD assay to quantify proportion of dead algal cells) and using both field-collected animals and those incubated in feeding experiments. The comparative analysis was based on composition of 1) suspended matter (served as a food resource), 2) stomachs, 3) rectum (field collections) or faeces (experimental animals), and 4) mucous aggregates from mantle cavity (field collections) or pseudofaeces (experimental animals).

In both unionid species and zebra mussels, rates of pseudofaeces production and ash content in pseudofaeces were similar, while proportion of photosynthetic pigments was different: e.g., in zebra mussels this proportion was similar to that of seston, while unionids discovered acceptance of chlorophyll *a* and rejection of chlorophylls *a* and *c*. The latter is likely to result from a differential sorting of algae and detritus by native mussels. Moreover, gut passage time was significantly different between zebra mussels and unionids: 38 min and > 1 d in zebra mussel and unionids, respectively. This may in part explain the higher viability of algae (all analyzed taxa) in the faeces of *Dreissena* then in those of unionids. In egested material content of phaeophytin *a* in total chlorophyll *a* and contribution of chlorophyll *a* to total chlorophyll were higher for unionids, at a contrary, a proportion of chlorophylls *b* and *c* was higher for *Dreissena*. We consider this as evidence of a differential digestion of different food items in invader and local mussels. Results of analyses using field-collected mollusks supported the experimental data.

Our results suggest that not only differential sorting by the studied bivalves, but also significant differences in their digestion efficiency may affect structure and functioning of phytoplankton communities. In particular, biodeposition of high proportion of viable algae by dreissenids and their subsequent re-suspension may promote persistence of algal species in the water column, including cyanobacterial blooms. This together with effects of direct grazing and nutrient recycling is facilitated by zebra mussels' mode of life: unlike native unionids, dreissenids are able to form dense beds and thus accelerate all these processes per unit of bottom area due to their high densities.

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NOTES

Impact of the Zebra Mussel *Dreissena polymorpha* on the Ecological Integrity of Lough Sheelin

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The principal study site for the project is Lough Sheelin, a highly productive midlands lake on the upper Shannon catchment in Ireland. This was originally an excellent trout fishery of high water quality. However, since the early 1970s, the lake has been under considerable environmental stress from eutrophication. On top of this, the recent introduction of the zebra mussel *Dreissena polymorpha*, is now exerting an additional pressure as it becomes established in the lake. This project is attempting to assess the impact the invasive species is having on particular aspects of the ecology of Lough Sheelin. The distribution, extent of colonization, and population characteristics of the mussel are being determined over the three-year duration of the project. In addition, changes to the fish and macroinvertebrate communities as well as to physiochemical parameters and fish diet are being assessed. Over 20 years of background biological and physiochemical data are available to aid in the assessments.

Preliminary results show *D. polymorpha* was present at all stone substrate sites sampled and the majority of soft substrate sites surveyed in the lake. In addition the mussel has extensively colonised both submerged and emergent plant vegetation.

Physiochemical water quality results show a reduction in annual mean chlorophyll a levels and a corresponding increase in water transparency since the zebra mussel invasion, although total annual mean phosphorus levels in the lake remain high.

Fish population trends post *D. polymorpha* colonisation show a substantial decline in the roach population and early indications of recovery in the wild brown trout population in the lake. This is consistent with an apparent change in trophic status of the waterbody from a highly eutrophic to a more mesotrophic state.

Results of fish diet analysis indicate that *D. polymorpha* was a constituent part of the diet of roach and roach bream hybrids.

NOTES

First Report of a High Prevalence and Intensity of Parasitic Infection in North American Zebra Mussels: What's the Significance?

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Since their introduction in the 1980s, there has been no evidence of extensive infectious disease in any North American *Dreissena* population. This is in contrast to Europe where infectious disease is present in virtually all zebra mussel populations. Thus, field investigations in North America have indicated that these mussels are practically disease-free and apparently did not bring any of their European parasites with them. The few isolated accounts of parasites found within North American *Dreissena* have reported:

1. parasites that were likely native to North America and thus using *Dreissena* as a new host;
2. very low levels of infection;
3. no evidence of a negative impact on the mussel population and little to no impact on the host mussel itself.

Herein we report finding a population of *Dreissena polymorpha* with a high prevalence and intensity of infection with a parasitic ciliate in the genus *Ophryoglena* in the Mohawk River in New York State. Infection was first noticed in the summer of 2006 at which time field and laboratory investigations were initiated to identify the *Ophryoglena* sp. and characterize:

1. its infection within individual host mussels, including degree of pathogenicity and impact on host organs;
2. its prevalence and intensity of infection in the host population in the Mohawk River;
3. its potential impact on host population dynamics.

The progress and significance of this investigation will be discussed. In particular, the data presented may help answer two important questions:

1. In which life stage were *Dreissena* transported to North America from Europe: as attached mussels or as pelagic larvae? Parasites are sometimes useful as "tags". In this regard, this ciliate parasite could possibly shed light on the above question. *Ophryoglena* spp. are relatively common parasites of *D. polymorpha* populations in Europe, living within the digestive system of attached mussels (planktonic veligers are not suitable hosts). Thus, if the *Ophryoglena* sp. observed in the Mohawk River is a European species, previously unrecorded in North America, it would provide evidence that *Dreissena* infected with these ciliates arrived in North America as attached mussels. Thus, identification of the *Ophryoglena* sp. infecting the Mohawk River zebra mussels is a key objective.
2. Is it true that parasitism plays no role in limiting *Dreissena* populations in North America? If this Ophryoglena infection is shown to cause serious host pathology in the Mohawk River *D. polymorpha* population, it would be the first such evidence of parasites having an adverse serious impact on a North American Dreissena population.

Assessment of Waterborne Parasites in Irish River Basin Districts – Use of Zebra Mussels (*Dreissena polymorpha*) as Bioindicators

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The recent arrival in Ireland of the aquatic invasive species *Dreissena polymorpha* has provided an opportunity for the effective detection of various human waterborne parasites. Zebra mussels from a number of river basin districts were tested for *Cryptosporidium parvum*, *Giardia lamblia*, and human-virulent microsporidia (i.e., *Encephalitozoon intestinalis*, *E. hellem*, *E. cuniculi*, and *Enterocytozoon bieneusi*), by the multiplexed fluorescence *in situ* hybridization (FISH) method.

Two native bivalve shellfish (*Anodonta anatina*, duck mussel and *Mytilus edulis,* blue mussel) were also included in this study.

Molluscan shellfish collection sites (total, $n = 8$) were impacted either directly or indirectly by agricultural runoff from sheep or cattle farming, or by human wastewater treatment plant effluent originating from a constructed wetland. Transmissive stages of *C. parvum*, *G. lamblia,* and *E. bieneusi* were detected in shellfish from all collection sites, and were present in highest concentrations at the sites directly impacted by agricultural runoff and wastewater effluent (total, $n = 4$). On average 75% of transmissive stages of all pathogens were viable; thus, capable of initiating human infection. The waters sampled were polluted with anthropozoonotic waterborne pathogens most likely originating from agricultural runoff and wastewater treatment plant effluents.

Where present, zebra mussels can provide an effective monitor for human waterborne parasites in Irish waters. Using this aquatic invasive species, the FISH technique can be readily utilized as an effective water quality assessment method for the Water Framework Directive (2000).

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Recent Invasion of the Zebra Mussel: The Spanish Experience

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The zebra mussel, *Dreissena polymorpha* (Pallas) was first found in the Ribarroja reservoir, Spain in 2001. The Ebro Hydrographic Confederation undertook several measures to restrict the invasion or to eradicate the mussels. The main goals of these measures are: 1) to spread awareness of the magnitude of the problem of zebra mussel invasion, 2) to get everyone including public involved in possible control measures, 3) to join efforts of different civil services and the affected users and 4) to find solutions to the problem and to stop further spread of the zebra mussel invasion to new environments. These measures also include actions such as modification of the existing navigation practices, the installation of washing stations near water reservoirs and preventing illegal or uncontrolled accesses to jetties.

One of these actions has been the execution of manual and mechanical extraction trials, carried out by military engineers. These trials were executed at different substratum and underwater cameras and a suction machine were used in the mechanical extraction trials.

Larval population has been studied at different locations in order to monitor the spread of zebra mussel. Skilled personnel have been doing regular tests following a certain methodology. These tests use samples obtained at chosen sample points. The results of these tests provide monthly and annual average larval concentration data.

The Ebro Hydrographic Confederation has also monitored the occurrence of adult zebra mussels at 15 sampling stations at monthly (once every three months at two stations) intervals, following a methodology developed by the University of Barcelona and the Diputación General de Aragón (DGA).

Some management measures have been executed with the purpose of broadening the knowledge about biological characteristics of the zebra mussel. These measures include a decrease in the height of the Ribarroja reservoir, in order to obtain a reduction in the population, and to study survival of mussels against drought.

An economic assessment of the zebra mussel invasion has been done by the Ebro Hydrografic Confederation. The costs of the zebra mussel invasion at the Ebro basin are compared with the costs of invasion at the northeast of the United States of America. This economic assessment also projects estimates of the accumulated costs of the zebra mussel invasion at the Ebro basin for the next 20 years.

This paper will analyse the efficiency of different monitoring methods in relation to zebra mussel invasion in Spain. Attempts will be made to highlight the ecological impacts of zebra mussel invasion and to outline possible control measures.

NOTES

Does the Biofouling by *Dreissena polymorpha* in Waterways Impact *Rhodeus sericeus* Reproductive Success? A Potential Competitive Interaction between Two Common Aquatic Invaders in Europe

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The European bitterling (*Rhodeus sercieus*) is introduced in Britain and parts of Western Europe and has shown recent increases in abundance in British waterways. It is well known that the European bitterling requires native unionid mussels to act as a host for successful reproduction. The bitterling have also been shown to be able to distinguish the quality of the host through a number of sensory mechanisms.

The zebra mussel (*Dreissena polymorpha*) is similarly invasive in Britain and Western Europe, and has also seen recent increases in range and abundance. It is well documented that zebra mussels, once established in a waterway, will biofoul native freshwater mussels, including unionids. In some cases the siphon of an infested native unionid may even become occluded. The presence of zebra mussels on native unionids, has also been shown to directly impact the condition of the unionid. Infestation by zebra mussels was shown to significantly decrease bitterling load in *U. pictorum* (one way ANOVA, n=63, F=5.12, d.f.=62, p=0.026). These results were additonally supported by observational data collected from the nearby Great Ouse River (paried t-test, n=90, t=3.05, p=0.004).

Experiments were undertaken in the Great Ouse River, Cambridgeshire, UK, in order to establish whether infestation of *Unio pictorum* by zebra mussels affected bitterling host choice, either through creating a physical barrier around the siphon, through confusing the sensory message understood by the bitterling regarding the quality of the mussel, or through directly impacting the quality of the host mussel.

This study provides not only useful insights into whether or not two invasive species are interacting significantly in British waterways, but also how the interaction between two invasive species can impact on native biota.

NOTES

Evaluating the *Stop Aquatic Hitchhikers!* Campaign to Prevent the Spread of Aquatic Invasive Species by Recreational Boaters in Three States

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In the United States, recreational boaters and anglers pose one of the greatest risks for overland transport and spread of aquatic invasive species (AIS). Of the 12.8 million boaters nationally, there are over 4 million in the Great Lakes with another 2 million boaters in Canada. Sea Grant-sponsored survey research has shown that AIS public education efforts can protect water resources from the spread of AIS through effective boater/angler education. Minnesota Sea Grant is helping to build upon previous efforts to reach boaters/anglers to extend and evaluate the national *Stop Aquatic Hitchhikers!* campaign along ten key invasion (highway) corridors in Minnesota, Wisconsin and Iowa.

Stop Aquatic Hitchhikers! provides a communication vehicle for Sea Grant to build partnerships with agencies, businesses, non-government organizations (NGOs), associations, and communities to extend AIS prevention messages to boaters/anglers. Minnesota Sea Grant is collaborating with Minnesota, Iowa, and Wisconsin Departments of Natural Resources, Wisconsin Sea Grant, and others to promote natural resource conservation ethics related to AIS in local communities. In 2006, a strategic multimedia campaign was launched in the three states featuring the *Stop Aquatic Hitchhikers!* logo and prevention messages. Based on a federal grant, resources are being leveraged to develop and use: traveler information systems to broadcast prevention messages on AM radio, highway signs, billboards, display panels at rest areas, dioramas at airports, television, radio and newspaper advertisements, kiosks at retail outlets, gas pump toppers, lawn banners, windshield tags, and stickers. As an effort to evaluate the campaign, a face-to-face and self-administered survey was administered in 2006 at water accesses in the three states. Preliminary survey analysis suggests that *Stop Aquatic Hitchhikers!,* its messages, and partners are well positioned to reach and empower boaters/anglers to take precautionary actions. Results show that boater/angler awareness and behavior was changed due to their exposure to the *Stop Aquatic Hitchhikers!* campaign messages. These results provide further evidence that effective public education needs to be made a priority to protect lakes, rivers, and streams from the spread and harmful impacts of AIS.

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NOTES

Hydrilla: From Rapid Response Planning to Reality

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Hydrilla verticillata is an invasive aquatic plant that has caused significant ecological disturbance and great economic cost in the southern United States. In early 2004, Michigan's Aquatic Nuisance Species Council became aware that a variety of the plant is able to survive in northern latitudes and had already become established in locations as far north as Maine and close as Pennsylvania. The council appointed a task force to develop plans for increasing public awareness of the species in Michigan and to prepare a rapid response plan for addressing the problem if it is found in the state. Michigan Sea Grant and the Michigan Office of the Great Lakes led a public awareness campaign beginning in 2004, employing a fact sheet, *Hydrilla* Hunt postcard mailer and a strategic mix of other media. The task force drafted a rapid response plan, based on a model developed by the Great Lakes Panel on Aquatic Nuisance Species.

This presentation will review the significant elements of the rapid response plan and describe the approaches used by the Indiana Department of Natural Resources and Michigan agencies and programs when hydrilla was discovered in 2006 at Lake Manitou in northern Indiana, about 50 miles from the Michigan border near a major highway linking the two states. The presentation will compare the different resources and approaches available to the two states as they attempt to prevent and deal with a new invasive species.

NOTES

Alaska Green Crab Monitoring Project

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Ballast water is one of the most common modes of transportation for aquatic nuisance species. In Valdez, Alaska, tankers arriving to load crude oil at the Alyeska Marine Tanker terminal discharge millions of tons of ballast water every year in Port Valdez. Even though the practice of exchanging ballast water in other parts of the world, the tanker trade between the West Coast of the United States and Alaska remains exempt from such regulations. In 1998, our research concluded that over 264 billion organisms were delivered to Prince William Sound in ballast water – and these were only the largest organisms. The larvae of one of these potential aquatic invaders, Carcinus Maenas, or commonly known as the European Green Crab, is known to be transferred in ballast water. The European Green Crab was first discovered in San Francisco Bay in 1989, and since migrated as far north as Vancouver Island. They can be found in a wide range of temperatures (22°C to -1°C) and salinities between 10 and 33 ppt, feed on the benthic invertebrates, mainly on mollusks and crustaceans, and have proven to be efficient predators on the native crab populations. Research by the Smithsonian Environmental Research Center concluded that green crab larvae can grow and live in Prince William Sound. Because of the serious threat of green crab invasion in Alaska waters, the Prince William Sound Regional Citizens' Advisory Council established a Port Valdez monitoring program in 1999. In 2005, the citizens' based group brought in a local Youth Area Watch group to assist with the project. The Prince William Sound Regional Citizens' Advisory Council decided to expand green crab monitoring to other communities in and near Prince William Sound using a similar approach with high school and other youth-based education programs.

NOTES

Of Gods and Government: What Can *Cherax quadricarinatus* in Black River, Jamaica Teach Us About Invasive Species Communication and Management?

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Efforts to convince the public of the importance of invasive species continue to frustrate scientists and policy makers all across the world. Increasing interest in outreach and education methods testifies to the recognition that there is a need for more effective communication. However, most current outreach and education efforts go little further than literal translations, simplifying language, and product placement. Little attention is paid to other factors such as cultural traditions and religion, which play important roles in determining the responses of their audiences.

This paper presents the case of the Australian reclaw crayfish in Black River, Jamaica, as an example of the multifarious factors that need to be taken into consideration in the development of effective communications strategies, as well as equitable invasive species management methods and policies.

Jamaica has developed an invasive species management plan in fulfillment of their obligations as a signatory to the 1996 Convention on Biodiversity. Policy makers are committed to controlling and eradicating invasive species to protect the island's biodiversity.

Black River was designated as a Ramsar Site in 1998 and is an ecologically and economically significant river that runs through St. Elizabeth Parish. Middle Quarters is a small town along the Black River in the parish of St. Elizabeth – one of the poorest in Jamaica – that calls itself "Shrimp Country". In this small town there are dozens of "higglers" – independent business women – who eke out a living selling shrimps to passing vehicular traffic.

Cherax quadricarinatus, the Australian redclaw crayfish, was introduced to Jamaica in the 1990s and is now found in abundance in Black River. Current studies and anecdotal evidence suggest that it is out-competing and predating on native shrimps. It is showing up ever more frequently in the shrimp traps of the fishermen, and consequently the baskets of the higglers.

The crayfish is considered by the higglers and their customers as inferior in quality to the native shrimp. As a result, customers exhibit greater demand for native shrimp, and crayfish fetch a lower price. While the case against the crayfish may seem clear cut, it is instead complicated by other factors, e.g., native shrimps (as opposed to the crayfish) are affected by the dry season, which translates into seasonal employment for the higglers, and religious beliefs.

Interviews, ethnographic research, and discourse analysis methods examine the ways in which policy-makers, scientists, and small businesses in Middle Quarters frame their narratives of the issue. This study reveals some deeply-held beliefs and worldviews that ought to be taken into consideration in invasive species communication and management.

NOTES

NISbase and GISIN: Building a Pilot System to Cross Search Invasive Species Online Databases

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The Global Invasive Species Information Network was formed in 2004 to provide a platform for sharing invasive species information at a global level via the Internet and other digital means. GISIN is collaborating with NISbase and the US National Institute of Invasive Species Science to create a pilot system to share information across a broad spectrum of online non-indigenous and invasive species information systems from around the globe (http://www.gisinetwork.org). The NISbase portal's web interface currently allows users to search records on up to seven data providers at a time (http://www.nisbase.org). The GISIN is building, based on the NISbase model, a pilot system with advanced search capabilities, more data providers, and compatibility with TAPIR (the Taxonomic Databases Working Group's Access Protocol for Information Retrieval). Results from a GISIN needs assessment survey of 137 participants from 41 countries will be presented, as well as the alpha version of a data provider toolkit so that your organization can become part of the GISIN.

NOTES

Invaders of the United States National Parks: Using Film as an Education Tool to Conserve Resources

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This presentation will illustrate how film can be used effectively to educate the public on the issue of invasive species management in United States National Park Service (NPS). The award winning film engages viewers in the breadth and severity of the issue of non-native plant species in national parks. Film was the media format chosen because it allows for juxtaposing the beauty of park resources against the threat of non-native plant species. It imbues a sense of place, is effective at making a dry subject more interesting.

The unparalleled beauty of Arches National Park is the backdrop for this 22-minute, broadcast-quality film that illustrates the ecological and economic impacts of non-native plant species (salt-cedar or tamarisk) on natural resources. The film highlights the NPS model for addressing this issue as well as providing viewers with actions they can take to limit the spread of non-native plants. Meticulously researched, the film includes interviews with scientists and interpreters. Animated sequences render complex issues and concepts more accessible and personally relevant to viewers. After watching the film, the viewer will be able to explain how non-native plant species impact ecosystems, describe how the NPS is addressing the issue, and identify two actions they can take to help prevent the spread of non-native plant species. The film is intended for use at park visitor centers, by broadcast television, and is available to individuals and academic institutions. The film is closed captioned for the hearing impaired. The film recently received a prestigious award from the National Association for Interpretation. The presenters will address questions on the development and effectiveness of this film.

NOTES

Understanding the Realities of a Private Sector Technology Provider in the Ballast Water Treatment (BWT) Market

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This presentation will *briefly* cover the complex issues that impact entrepreneurs and existing businesses in building a company or business unit in a regulated industry such as ballast water treatment (BWT). This includes factors such as market opportunity, technology and product development, organization, finances, regulatory compliance, and market timing. Adding to the complexities in the BWT market are the facts that the various regulatory agencies involved all move at different speeds, can not seem to agree on the specifics of the regulations, do not yet know how to implement regulations or assure compliance once specifics are agreed upon, or how to address jurisdictional issues.

Private investors and company financial officers have a limited amount of patience with CEOs and business unit managers who keep singing the same song; "the market is coming, the market is coming..." If we want to solve the environmental problems caused by aquatic invasives, we need to work together closely, and we need to work faster than we currently are to qualify and certify the best available technologies and put them to work. These products cannot, nor can any other, be fully developed in a laboratory or in a land-based testing facility setting. Optimization can only be done in actual operation aboard operating commercial vessels. No technological product has ever been successfully developed without putting it in the hands of early customers to work out real-life implementation issues. In the case of BWT technologies, this means not just on one or two vessels, but a variety of vessels with differing needs and differing operational challenges.

Ballast water treatment systems, utilizing differing technologies, developed and manufactured by a handful of talented and dedicated suppliers, are ready for placement aboard vessels today. Indeed, several are already operating on commercial vessels, but more opportunities are needed. In this way, and possibly only in this way, we can move the process forward and begin implementing solutions to solve the real problem – the devastating environmental and economic impact of aquatic invasives.

NOTES

Treatment of Ballast Water With Chlorine Dioxide to Control Invasive Species Under Actual Shipping Conditions

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The introduction of invasive species via the discharge of ballast water by large ships constitutes a major threat to the integrity of coastal ecosystems. Although there are several options currently available to eliminate organisms in ballast water, these methods are generally limited to specific water conditions and/or classes of ships. Therefore, more robust methods providing effective and environmentally sound treatment of ballast water are needed by the maritime industry. One promising treatment uses chlorine dioxide (ClO_2) as a biocide. We are currently determining the effectiveness and reliability of ClO_2 at eliminating organisms present in ballast water of a RORO containership, the 292-m M/V *Atlantic Compass*, under actual operating conditions along the US east coast. The biocide is delivered directly to the incoming ballast water immediately after safe and simple shipboard generation by the Ecochlor system at a calibrated rate to obtain a final concentration of 5 mg L^{-1}. We had previously determined under laboratory conditions and in preliminary ship-based testing that this concentration was both practical to deliver and effective at eliminating a variety of potentially harmful marine organisms. The estuarine planktonic assemblage and environmental parameters from two treatment tanks and two control tanks are compared under two sampling protocols. The first protocol is a time course study designed to quantify the decay of ClO_2 concentration and the abundance and viability of organisms in three size classes (< 10 µm, 10 to 50 µm and > 50 µm) over time. The second sampling protocol represents an endpoint approach, where the planktonic assemblage and environmental parameters are measured just prior to deballasting, ~4.5 days following the initial treatment. Early results indicate that a 5 mg L^{-1} ClO_2 concentration generally eradicates zooplankton, phytoplankton, and bacteria (including *Vibrio* spp., *E. coli*, and enterrococci) within the first 24 hours. Time to undetectable ClO_2 residuals varies between 6 and 50 hours. Whereas preliminary tests in summer 2005 had shown that bacteria had resumed their growth four days after treatment, bacterial activity remained low in four tests between November and March (12 to 5°C). No zooplankton and phytoplankton were detected in the treatment samples, except in March where recently hatched *Eurytemora* sp. nauplii were observed in the treatment tanks; the eggs apparently survived the treatment and hatched. Monthly sampling will continue through 2008 in order to test the effectiveness of the ClO_2 treatment on various planktonic communities under a range of environmental conditions, paying particular attention to the influence of temperature.

NOTES

Shipboard Testing of Seakleen® as a Ballast Water Treatment to Eliminate Non-indigenous Species Aboard a Working Tanker in Pacific Waters

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Trials were conducted aboard the tanker *Seabulk Mariner* to test the efficacy of a natural product, SeaKleen®, as a biocide controlling non-indigenous organisms in ballast water. SeaKleen® was dosed into matched ballast tanks at two different concentrations, 0.8 mg L^{-1} active ingredient (a.i.) and 1.6 mg L^{-1} a.i. during a ballasting operation off the Oregon coast at the beginning of a three-day passage to Prince William Sound, Alaska. Counts of live organisms in treated water were compared with untreated samples drawn from the same area. The objectives were to test the product as a means of controlling natural populations of plankton and bacteria, and to use shipboard chemical analyses to verify dose and quantify chemical degradation and residuals following dilution. Results indicated that both SeaKleen® doses resulted in complete zooplankton and phytoplankton mortality and that the higher dose (1.6 mg active ingredient L^{-1}) caused a 1-log removal of culturable bacteria. Spectrophotometry confirmed initial dosing to within 5% of nominal values. Shipboard bioassays were conducted using larval fish (*Cyprinodon variegatus*), brine shrimp (*Artemia salina*) and the bioluminescent dinoflagellate, *Pyrocystis lunula*. Exposure to SeaKleen® treated water following a 48h residence time in the tanks resulted in 100% mortalities in *Cyprinodon* and *Pyrocystis* at both doses. Corresponding mortalities for *Artemia* larvae were 100% and 60% for high and low SeaKleen® doses respectively. Toxicity testing of treated water subjected to varying dilution indicated that residual toxicity to even the most sensitive organisms would be eliminated beyond 100' from the vessel on discharge.

NOTES

New Method for Treating Ship Ballast Solids to Prevent Future Introductions of Aquatic Invasive Species: Effect of Lime Stabilization/Recarbonation on Survivorship, Water Chemistry and Process Economics

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The release of ballast water from ships is a major transport mechanism for non-indigenous aquatic organisms as recognized by the US National Invasive Species Control Act of 1996. There is a pressing need for new economical and environmentally safe control strategies for both ballast water and residual solids often present in the "no-ballast-on-board" (NOBOB) condition. NOBOB ships represent about 90% of the ship traffic into the Great Lakes. These ships carry residual volumes of unpumpable ballast water and sediment that typically support live aquatic organisms and resting stages of these organisms that have accumulated over previous ballasting operations. During a recent survey of NOBOB conditions with total ship ballast capacities of between 1459 and 25533 tons total ballast residuals ranged from negligible to 200 tons and sediment accumulation ranged from negligible to 100 tons. Sixty percent of the ships surveyed carried less than 10 tons with about 50% of the residuals falling in the fresh or brackish water category. Residuals contained high numbers of virus-like particles, bacteria, algae and invertebrates which combined represent a significant threat to receiving waters if discharged without treatment during standard tank fill/drain operations. Stabilization of biologically active water and sludge has been achieved in wastewater applications through use of excess lime treatment. Here hydroxide alkalinity is elevated through reagent addition (NaOH or hydrated lime) so as to establish an antimicrobial effect that is easily controlled by regulation of the target pH (11-12). Exposure requirements are short and pH, in NOBOB applications, could be readily returned to neutral levels through use of dilution during a subsequent reballasting step or dilution combined with recarbonation. The hydroxide pretreatment step appears particularly attractive in NOBOB applications given 1), the long history of successful applications in agricultural and wastewater solids applications as a means of controlling pathogens and other hard-to-kill life forms 2), the limited volume of NOBOB residuals involved 3), the ease of applying the relatively inexpensive base as a suspension through existing ballasting/deballasting plumbing, and 4) the avoidance of ship corrosion concerns, associated with pH depression, that are linked to certain alternative acid/oxidant addition treatments. Preliminary reagent cost estimates established for the proposed stabilization processes are attractive but research is required to verify treatment effect and required dosages. In this presentation, we described results of studies underway, at the USGS Leetown Science Center, that are designed to establish reagent requirements versus residual salinity and solids concentrations, reaction products and exposure period effects on mortality of selected target species.

NOTES

Peraclean® Ocean for Ballast Water Treatment: Onboard Ship Evaluation in Very Cold Temperatures

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The objective of our study was to verify the effectiveness and the potential toxicity of Peraclean® Ocean chemical treatment at very cold temperature in real ballast conditions. Peraclean® Ocean is a commercially available treatment using peracetic acid (PAA) and hydrogen peroxide (H_2O_2) as active ingredients with a temperature-dependent degradation rate. The experiment was conducted in March 2006 aboard the Canadian Prospector, a 560 foot bulk freighter overwintering in the port of Montreal, Quebec. Two ballast tanks (750 m³) filled with water from the St. Lawrence River were treated with 100 and 150 ppm of Peraclean® Ocean and two other tanks were untreated. Water temperature in the tanks varied between 0.1 and 0.5°C. Levels of PAA and H_2O_2 gradually dropped by 45 to 50% over 5 days. The pH of water dropped by 1 to 1.4 units whereas dissolved organic carbon increased 4 to 7 fold after treatment. Levels of cellular ATP dropped by one order of magnitude for both the large (>10µm) and small (0.7-10µm) size fractions of microorganisms. Chlorophyll *a* levels and the chlorophyll/phaeopigment ratio were significantly lowered in the treated tanks.

Due to its long degradation rate in very cold freshwater, Peraclean® Ocean treatment was effective in killing some aquatic organisms present in ballast water but not against zebra mussels and some benthic nematodes buried in sediments. The treatment will chemically alter water quality and results of five ecotoxicological assays showed a positive toxic response of treated waters 5 days after treatment suggesting that the discharge of treated waters can have potential harmful impacts on the receiving environment.

NOTES

Offshore Oil Platforms and Aquatic Invasive Species: Implications of Recent Discoveries in California

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Offshore oil and gas platforms are among the largest artificial structures in the marine environment and nearly 7000 of these platforms are distributed worldwide. Platforms provide habitat for a diverse assemblage of native marine invertebrates in areas that typically lack hard substrate and vertical relief. We have recently discovered that offshore platforms in California are also colonized by exotic invertebrate species that are rare or absent on natural rocky reefs. We surveyed seven platforms arrayed geographically in the Santa Barbara Channel, located 2.9 to 16.9 km offshore, in water depths ranging from 29 to 225m. We photographically sampled conspicuous invertebrates at these platforms. In addition, we sampled two of the seven platforms for small, less conspicuous invertebrates using air lift vacuum methods. We found high percent cover and density of three exotic invertebrates; a bryozoan, *Watersipora subtorquata*, an anemone, *Diadumene* sp. and a caprellid amphipod, *Caprella mutica*. The bryozoan, *W. subtorquata*, occurred at a single platform, reaching a mean cover of 41% and 15 cm thick at a depth of 6m. A second conspicuous species, the anemone, *Diadumene* sp., also occurred at only one of the seven platforms, with mean cover up to 38% at a depth of 12 m. The Japanese giant caprellid amphipod, *Caprella mutica*, was found at two of two platforms sampled for inconspicuous species, reaching densities of more than 600 individuals per 400 cm^2.

These exotic species have either not been reported (bryozoan, anemone) or are present in extremely low abundance (caprellid) on local natural rocky reefs. However, two of these species, *W. subtorquata* and *C. mutica*, occur in some embayments and harbors. Both the bryozoan and anemone may have preempted native species for space, as suggested by the inverse relationship in the cover of exotics and native species at the platforms. Similarly, densities of the exotic caprellid amphipod were much higher than densities of native caprellids, making up 80-90% of the total caprellids. Species richness of native caprellids was also lower at the two platforms. Our results suggest that platforms could facilitate the introduction of exotic species into new habitats and geographic areas, with potential negative impacts to native species. In addition, the presence of exotic species at these sites raises questions about the "habitat value" of offshore platforms and the options for decommissioning these structures. Our findings suggest the value and potential fate of offshore platforms should be evaluated on a platform-by-platform basis. Leaving decommissioned platforms in place may pose risks to surrounding habitats if exotics are present. Further, the removal or transport of decommissioned platforms containing exotics will likely require new methods that minimize the spread of these invasive species. Overall, our results support the need for increased attention to the role of offshore oil and gas platforms as vectors and stepping stones for aquatic invasive species.

NOTES

Vessel Biofouling as a Vector for Invasive Marine Species: Biosecurity New Zealand's Research Programme

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Vessel biofouling has been recognised as a vector in many historical introductions of marine species into New Zealand, such as Pacific oysters (*Crassostrea gigas*), and continues to contribute to both the international and domestic spread of marine species. Biosecurity New Zealand is the lead agency charged with the protection of New Zealand's indigenous fauna and flora from invasive species. In the marine environment, shipping movements provide a vector for both international and domestic translocations of species that would otherwise be impossible. Ballast water has received the most attention with several high-profile introductions, such as the zebra mussel (*Dreisenna polymorpha*) in North America's Laurentian Great Lakes, proving the catalyst for international action. However, ships have other vectors for translocations such as biofouling of sea chests, cooling and ballast plumbing, and hull surfaces. Biosecurity New Zealand has been pursuing a research program into the potential risk posed by marine biofouling, surveying four categories of vessels arriving in New Zealand ports. International yachts, fishing and passenger vessels, commercial vessels, and slow moving barges and oil platforms are all being surveyed over a two-year period to correlate ship type, geographical movement, fouling level and fouling organisms. Results from this research will help inform risk analysis which will combine known life-history characteristics, probability of (re)introduction, probability of establishment and probability of spread to provide a hierarchical list of high risk invasive species. Such analysis will consequently allow for the development of prevention, mitigation and management measures.

NOTES

How to Gift-Wrap a Frigate: Hull Encapsulation as a Potential Incursion Response Tool for Large Vessels

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Response to marine pest incursions requires adequate prevention, early detection and effective protocols for the system to work efficiently. Although large vessels are important vectors of introduced species, cost-effective, rapid response tools for these vectors are in need of considerable refinement. A decommissioned frigate of the New Zealand navy was purchased by a charitable trust with the intention to create an artificial reef and diving wreck. The frigate had been docked in Auckland's harbour, a location supporting populations of several invasive species, notably the clubbed tunicate *Styela* clava and the alga *Undaria pinnatifida*. It was the intention of the trust to scuttle the vessel in the Bay of Islands in the north of New Zealand, an area free of both these marine pests.

A routine inspection revealed the presence of *S. clava* on the vessel's hull, and given its proximity to known populations of *U. pinnatifida*, it was considered likely that this species was also present. Prior to relocating the vessel, the trust was therefore required to have it dry-docked for cleaning. This provided a unique opportunity to undertake a feasibility trial of in-water encapsulation as a potentially cost-effective method for removing fouling organisms. Such encapsulation had been conducted on smaller vessels in the past, but never on a vessel as large (113 m) as the frigate. Biosecurity New Zealand commissioned Cawthron Institute and Golder Associates to undertake the trial in partnership with a commercial diving company. Encapsulation involved sheathing the hull below the deckline in thick plastic in order to create dark, anaerobic, watertight conditions. Water quality within the capsule was monitored over the duration of the trial in order to assess likely efficacy. Problems in implementation of the wrap resulted in a premature loss of integrity and ultimately failure of the encapsulation. Despite these problems a post-experiment inspection revealed the onset of mortality in biofouling species present. Should these difficulties be able to be overcome, large-vessel hull encapsulation can offer a more cost-effective and rapid solution to responding to marine pests than dry-docking.

NOTES

Chokeberry (*Aronia* spec.) an Invasive Species in the Marshlands of The Netherlands?

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Most non-native species in The Netherlands occur in anthropogenic or semi-natural habitats. Chokeberry (*Aronia* spec.) is one of the non-native species in The Netherlands, which occurs in natural habitats, in particular lowland peat marshlands. It is regarded by the nature conservation organizations, which manage most of these marshlands as an invasive species, especially in the second half of the 20th century. It contributes to the eutrophication, structural changes including threatening rare native species of this important ecosystem type. The taxonomic status of the wild *Aronia* populations is still unclear. Probably we are dealing with a hybrid swarm, *A. x prunifolia* (Purple Chokeberry), between *A. melanocarpa* (Black Chokeberry) and *A. arbutifolia* (Red Chokeberry). Besides the diploid populations, also tetraploid populations seem to occur in *A. melanocarpa* and *A. x prunifolia*. Chokeberry is also a popular garden plant, sold at many horticultural centers.

We analyzed the distribution and population development of Chokeberry in The Netherlands. We used on the one hand distribution data on a scale of square kilometers and on the other hand we used relevées on a scale of tens of square meters. We characterized the ecological profile of this species in The Netherlands and tried to find out which other species are positively or negatively correlated with Chokeberry, as an indication of possible negative effects. We performed a web-based survey for nature conservation organizations to investigate the extent of the problem with Chokeberry. In addition we performed a web based survey for commercial plant breeders to get more insight in which species and cultivars are sold and how much. In 2007 we will start molecular research, using the RAF-technique, to develop genetic markers to identify parent and hybrid populations.

NOTES

Understanding Eurasian Watermilfoil: Nutrients, Growth and Invasion

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The invasion of Eurasian Watermilfoil (*Myriophyllum spicatum*) into North American lakes has been rapid allowing little opportunity for detailed studies investigating the trophic and nutrient changes associated with such an invasion. Because of its oligotrophic nature, the spread of milfoil in Lake George has been sufficiently slow to study changes in the structure and function of the littoral zone associated with milfoil establishment. In 2003, four established milfoil beds were selected for study: two small and secluded, two large and open. Submerged aquatic vegetation (SAV) biomass, height and density of the milfoil beds, as well as, transition zones and native communities were analyzed for each site. Within the milfoil beds, milfoil dominance was near 100% while the native communities consisted of 5-6 species. Plant height and density were 3 and 4 times that of the native communities, respectively. While it was easy to identify the physical differences between the milfoil and native beds, elucidating trophic and nutrient distinctiveness proved more difficult. Only trophic uniqueness for primary producers was identified between the milfoil and native beds. Epiphytic biomass within the milfoil beds exceeded that of the natives in all four sites; however the differences were more distinct in the larger milfoil beds. Also, the larger and open beds were dominated by Chlorophyta while the smaller and secluded beds were predominantly Chrysophyta. Phytoplankton biomass in the milfoil beds exceeded that of the natives in the larger sites but did not show any trend in the smaller sites. Both the epiphytic and phytoplankton data indicate that the trophic changes associated with these invasions are at least partially dependant upon the size of the milfoil bed. Zooplankton enumerations indicated the seasonal shifts expected but showed no differences in abundance or species. Nutrient variability in lake water chemistry hindered the formation of any trends, but porewater being more consistent, showed a dramatic nutrient depletion early in the season and continued throughout the growing season. However, it appears the degree of nutrient depletion in the porewater is affected by the groundwater recharge of the area, which was initially identified by the consistently higher water content of the sediment. Preliminary analysis of plant tissue has shown that the phosphorus content of milfoil was the lowest out of 14 plant species tested within the milfoil and native beds. Further analysis will help determine the C:N:P of all the plant species present and the sediments in which they grow in an attempt to better understand milfoil's ability to out compete native plant communities.

NOTES

Lessons From Four Freshwater Invasive Plants in New Zealand

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New Zealand has four invasive submerged aquatic plants that have significant implications on the status, management and biosecurity of our freshwaters. Three macrophytes (*Lagarosiphon major, Hydrilla verticillata* and *Ceratophyllum demersum*), and a filamentous diatom (*Didymosphenia geminata*) have the potential to dominate a wide range of our waterways. All three macrophyte species were either deliberately or accidentally introduced to the country as part of the trade in ornamental plants, but in 1982 they were legally prohibited from sale and distribution.

Lagarosiphon was first recorded in 1950 and has since spread to many waterbodies around the country. Introduction and spread were initially associated with the ornamental plant trade, but subsequent spread within catchments has been primarily from recreational activities, particularly boating. Early infestations can be controlled with suction dredging, while large weed beds are effectively controlled using diquat.

Dioecious male Hydrilla plants have had a limited distribution since first reported in 1963, with containment facilitated by use of grass carp and prohibition of motorised craft. Chemical control options have been limited to endothall, which was only recently registered for use in New Zealand waters. Competitive growth trials under controlled conditions show this plant has the potential to dominate most other submerged aquatic plants in our lakes. Subterranean tubers are viable for up to 10 years making the prospect of eradication difficult.

Ceratophyllum was first recorded in 1963 and has since spread through the top half of the country (North Island) and has a major impact on many natural and hydroelectric lakes. Tonnes of weed biomass are produced in autumn and weed beds can grow 6m tall and in water 10 m deep. Harvesting, pulverising, mechanical removal and diquat provide some measure of control. Exclusion nets are under evaluation in some sensitive areas. This species poses a major threat to the South Island lakes and spread is primarily by human activities.

Didymosphenia was first reported in October 2004 where it formed dense fibrous mats covering an entire stream bed. The distribution of this alga has now significantly expanded, with 15 South Island river systems infested by July 2006. Introduction and spread appears to be closely associated with recreational activities, particularly trout fishing. This alga has the potential for large environmental and economic impacts, including tourism, fishing and power generation. Research is presently focusing on containment and control or eradication measures.

These four invasive plant species are thriving in a wide range of habitats, including waters with low nutrients and cool temperatures. Concern is expressed over their potential to show similar invasive properties in other cool temperate countries and the need for establishing appropriate Biosecurity measures, including border control, legislation, surveillance and incursion response strategies.

NOTES

The Quantitative Abundance of *Lagarosiphon major* in Lough Corrib, Ireland

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The invasive macrophyte, *Lagarosiphon major* was first identified in Ireland in Lough Corrib, Co. Galway in 2005. Lough Corrib is the second largest Irish lake (169 km^2) and is one of the premier European lakes for brown trout (*Salmo trutta*) angling. In terms of conservation legislation, Lough Corrib is both a Special Area of Conservation and a Special Protection Area.

Lagarosiphon naturally occurs in its native range in southern Africa but due to its ornamental and oxygenating capacity as an aquatic garden plant it has spread to many other countries worldwide via the aquarium trade.

The invasive properties of this plant were already evident in Lough Corrib before this research was undertaken in 2006. This research established the distribution and density of this alien weed within Lough Corrib using extensive field survey work and GIS mapping. Relevant physical, chemical and biological data were also monitored in the lake.

Results show *L. major* to be widespread throughout Lough Corrib. This has resulted in a significant decrease of indigenous macrophyte species and changes to substrate in the infested locations. Additionally the spread of the invasive weed has already affected the utilisation of Lough Corrib as a natural amenity.

The probability of completely eradicating the alien weed in Lough Corrib is remote unless a defined system of weed management is put in place, combined with correct funding initiated at each infested location. The invasive properties of the weed have compromised the "good status" of this lake for the Water Framework Directive.

The question is whether *L. major* can be controlled by management strategies before it spreads and becomes a widespread problem in Irish lakes.

NOTES

Lagarosiphon major in Irish Watercourses – Awareness and Control

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The highly aggressive submerged aquatic plant species *Lagarosiphon major* (Curly waterweed) was recorded from eight sites in Lough Corrib, the second largest lake in Ireland, in 2005. One year later the plant had spread to 24 separate locations throughout the upper and middle lake and was posing problems for amenity exploitation, principally brown trout fishing. Where it established it also seriously impacted on the survival and performance of indigenous plant and animal communities. To date, the distribution of *Lagarosiphon* in Ireland has been limited, although recent records reveal that the plant is expanding its range within the country. In order to control the spread of this invasive plant a programme of actions was undertaken. The first involved the development of a public awareness campaign that included the mass production and distribution of leaflets and calendars. The second focused on developing method to physically control or remove the plant from the lake. In one of the bays in Lough Corrib that is worst affected by *Lagarosiphon* a series of scientifically controlled trials was undertaken in late 2006 and early 2007. Methods trialled included the use of herbicides, mechanical cutting, hand removal using divers, suction dredging and light occlusion using submerged geotextile. The results from these trials and information on the impact of this plant on indigenous biological communities in the lake will be presented.

NOTES

The Invasion of the Water Hyacinth (*Eichhornia crassipes*) in Southwest Europe

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The water hyacinth (*Eichhornia crassipes*, Pontederiaceae) is an aquatic plant of Amazonian origin that at the moment invades continental aquatic habitats of extensive areas confined to the intertropical latitudinal belts of both hemispheres. In Europe it has recently been known in the Iberian Peninsula, and in 2005 it covered 70 km of the river basin of the Guadiana River in Badajoz (Spain), producing a remarkable social, economic and environmental impact.

In this communication we present the distribution and ecology of the water hyacinth, as well as the characteristics of its breeding systems at these latitudinal levels, its floral phenological behaviour, its local pollinators, life cycles, floral biology, seed germination success, rates of quantified growth and dispersion for the European Mediterranean climatic conditions, and the risks that its indiscriminate propagation raises in the hydrographic river basins of Spain and Portugal. There is also exposed the main measures that have being carried out in order to approach the integrated management and control of the plague, especially those by the Hydrographic Confederation of the Guadiana (Environment Ministry) in collaboration with the Autonomic Administration and the University of Extremadura, Spain, that are currently in the developmental execution phase.

NOTES

Pond Apple (*Annona glabra*) Economic Prospecting: Opportunities for Meeting Challenges of Alien Invasive Plant Infested Ecosystems in Sri Lanka

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Wetlands are critical ecosystems for maintaining ecological sustainability. Buffering flood shocks, habitat provision for biodiversity, and systematic replenishing of ground water are among the uncountable number of unique functions wetlands offer. Reclamation for human utilities, unplanned urbanisation and industrialisation are major contributors to wetland degradation. Most development practitioners treat wetlands as wasteland. The result is rapid disappearance of wetland habitats according to their functional meaning.

In the recent past a notorious perennial plant invaded and densely colonised uncultivated space in the modified ecosystems. Pond apple (*Annona glabra*) became invasive and encroaches into the habitats of the wetland, which leads to depletion of species richness and ecosystem degradation. Large numbers of lighter pond apple seeds disseminate using water as the medium and become established along the banks of the streams. Hardy shrubby morphological features and absence of natural enemies made pond apple a strong invader in the ecosystem. Compared to the other relatives of the *Annona* family, pond apple fruit does not have a food value, although it is edible. For restoring the degraded ecosystems, this notorious weed needs to be controlled by eradication, prevention or bio-prospecting (inventing novel, innovative economic uses).

Considering the above observations and facts, the Biodiversity Secretariat and the Promotion and Education Division of the Ministry of Environment, formulated an integrated management plan for the revitalisation of pond apple infested modified wetland ecosystems on a pilot scale.

The project will be completed by December 2007. A research component of top grafting pond apple using *Rollinia* shoots is underway. *Rollinia* mother plants have been identified. A place where Pond apple root stock has been identified. Grafting is underway. Researchers expect to have more than 60% success rate from the grafting experiment. Farmer awareness is underway. Researchers wish to share their experiences with the scientific community and obtain advice from the experts.

NOTES

Physiological Age-Grading Techniques to Assess Reproductive Status of Insect Biocontrol Agents of Aquatic Plants

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Physiological age-grading is used to assess reproductive health and status of many insect species using ovarian morphology to ascertain reproductive status, reproductive history, and eggs oviposited. Three physiological age-grading systems have been developed for biological control agents of aquatic plants including two weevil species; *Neochetina eichhorniae* (waterhyacinth) and *Euhrychiopsis lecontei* (Eurasian watermilfoil), and the leaf-mining fly; *Hydrellia pakistanae* (hydrilla). All three systems utilize ovarian morphology to determine changes in reproductive condition. The two weevil species have similar ovarian developments/morphologies and thereby utilize almost identical systems where changes in fat body, cuticular hardness, and follicular relics give rise to three nulliparous and three parous stages. Ovarian morphology/development differs in the fly but also uses characteristics of follicular relics to distinguish three nulliparous and four parous classes. Strategies of ovarian development differ between these species based on longevity and habitat. The weevils are long-lived and reside in relatively protected habitats and mature/deposit eggs individually throughout most of their life. The fly is short-lived, resides in open areas and only oviposits when an entire batch or compliment of eggs are mature. Interestingly, the fly emerges as an adult with mature eggs ready for oviposition; another strategy to maximize egg production and minimize predation over a short life span.

NOTES

An Ecological Approach to Aquatic Plant Management

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A simple, yet often used concept of integrated pest or plant management (IPM) is one where all available management options are considered as part of a toolbox or arsenal. These "tools/weapons" are then used singly or in combination in an effort to maximize control without impacting the use of one or more strategies. While this approach can be effective, it tends to provide only short-term control by neglecting the underlying reasons for the formation of the infestations. A more prudent and ecologically compatible approach would be the use of an ecosystem based IPM program that relies heavily on ecosystem management and restoration strategies and addresses causative factors that allow such formations. A key component of an ecosystem approach to managing aquatic plants is the use of host-specific biological control agents. Most of the economically important invasive/nuisance aquatic plants are introduced species that have escaped their host-specific herbivores and pathogens. In addition to their high intrinsic rates of increase this lack of sustained feeding and resultant damage allows the formation of extensive monospecific infestations. By re-establishing a complex of host-specific herbivores and pathogens, and implementing re-vegetation using native plants, these invasive species can be held at non-problem levels.

NOTES

Predicting Lake Vulnerability to Species Invasion Using a Hierarchical Approach

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Ecologists have utilized many approaches to assess risk of species establishment in new ecosystems. Our lab subscribes to an approach that first considers introduction effort to identify which lakes are exposed to an invader, following which environmental suitability (e.g., physical and chemical suitability) of the lake is considered. A third screen considers whether biological residents of the remaining lakes may increase or decrease establishment success. We highlight this approach for the first time using all three steps using the zebra mussel *Dreissena polymorpha*, a non-indigenous species spreading in Ontario. We measured introduction effort using a doubly-constrained 'gravity model', which linked invaded source lakes with non-invaded destination lakes via an array of human activities that may vector the species. Of 291 lakes, invasion status was accurately predicted for 80% of lakes using only lake gravity scores in a Multivariate Adaptive Regression Spline (MARS) analysis; 69% of 48 lakes predicted to be invaded were invaded. A second MARS model based upon 17 physical and chemical parameters indicated that establishment success was correlated with only two parameters: dissolved organic carbon (-) and pH (+). Of the 48 lakes predicted to be invaded based upon introduction effort, 75% were correctly classified with regard to invasion status when lake characteristics were considered. Of these lakes, 45 of 48 (73%) lakes predicted to be invaded were invaded. Finally, a third MARS model used fish community composition for the 45 lakes predicted to be invaded based upon combined information from introduction effort and lake chemistry. Overall classification accuracy of the fish model was 82%, with 30 of 35 (86%) of lakes predicted to be invaded being invaded. This model was negatively affected by lake whitefish, which are known to prey on dreissena, and positively affected by largemouth bass, possibly reflecting predation release from molluscivorous fishes by the bass. Overall prediction of invasion success was successively improved as considerations of introduction effort, lake chemistry and fish community were added to models. While this approach is data and computationally intensive, it may provide the most realistic assessment of where spreading non-indigenous species may colonize successfully. We are utilizing this approach to predict spread of other non-indigenous species including spiny waterfleas *Bythotrephes longimaus*, fishhook waterfleas *Cercopagis pengoi*, and Chinese mitten crabs *Eriocheir sinensis*.

NOTES

Phenology and Population Dynamics of the Invasive Ctenophore *Mnemiopsis leidyi* in Recipient Areas of the Eurasian Seas - Changes Linked with Environmental Variability and Climate Forcing

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The predatory ctenophore *Mnemiopsis leidyi* is a polymorphic species, which was introduced into the Black Sea in the early 1980s and had spread throughout the entire Black Sea by 1988. From the Black Sea it spread north to the Sea of Azov, south to the Sea of Marmara and into to the Aegean Sea, and in 2005 it was found in the northern Adriatic. In 1999 it reached the Caspian Sea with ballast water, where it is currently expanding at an even more rapid rate than in the Black Sea.

In 2006 this species outbreak was recorded along the northwestern European coast. The native habitat of *M. leidyi* is the Atlantic American coast. Therefore an analysis of factors that control its development is important for prediction of its possible future expansion into new areas.

M. leidyi shows wide environmental tolerance and could become established under different environmental conditions. Various conditions determine its morpho-physiological features within its possible range of phenological development.

We analysed the variability of *M. leidyi* morphological, ecological-physiological features in the Black, Azov, Caspian, Aegean and Baltic Seas as a response to different environmental conditions (salinity, temperature, prey concentration) of these seas and climate shift effects, including large-scale atmospheric forcing.

The physiological features of *M. leidyi* apparent in different environments determine life cycle factors, including fecundity, phenology, growth rate and individual size, pattern of distribution and finally predation rate on zoo- and ichthyoplankton. However many factors including: interannual individual and population size; spatial distribution in springtime; seasonal time of spreading from the Black Sea to the adjacent seas and spread from the Southern Caspian to the north are controlled by surface water temperature (SST), particularly by minimal winter SST, which are determined mostly by global scale atmospheric patterns such as the North Atlantic Oscillation (NAO). In the southern seas researched in this study, the effect of NAO often modified by East Atlantic-West Russian index, particularly in winter.

The effects of *M. leidyi* on the southern seas ecosystems were found to vary with. the strongest impacts recorded in the productive Black, Azov and Caspian Seas. But these effects were dependent on population size, which appeared to be controlled by climatic forcing.

NOTES

Invading Ecosystem Engineer Dramatically Alters Benthic Communities In and Out of Marine Reserves

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Invasive species, especially those that are ecosystem engineers can affect the species composition of a community through creating and modifying habitat. The introduced oyster, *Crassostrea gigas*, a large bodied, long-lived animal that attaches to hard substrata, has invaded the rocky intertidal zone of the Pacific Northwest of North America. When in high abundance, this species can cover > 70-90% of available space on the shore. We compared the species composition (richness and abundance) of the community overgrown by oysters (by directly observing the species composition on the underside of shells removed from the rock) to the community that presently uses the oyster shell as habitat for oysters found in and out of marine reserves. We found that the communities overgrown by oysters significantly differed than those found on oysters both in species composition and in the relative abundance of dominant species. We found significant declines in macroalgae and some species of barnacles (e.g., *Chthamalus*) and significant increases in limpets and other species of barnacles (*Balanus*). In addition, we found significant differences between the communities found on oysters inside and outside of matched reserve sites. Thus this invasion is having a differential impact on marine reserves, which also have higher densities of this invader.

NOTES

The Economic Impact of Aquatic Nuisance Species on the Corps of Engineers

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The US Army Corps of Engineers operates 562 reservoirs (5,500,000 surface acres), 237 navigation locks, 926 harbors, 75 hydropower projects, and 25,000 miles of inland and coastal waterways and all these facilities are impacted by aquatic invasive species. In 2003 the Corps of Engineers began to participate in an annual Cross-Cut Budget process developed by the National Invasive Species Council. The budget process was designed to document the actual dollars each federal agency was spending on invasive species. Seven key areas are examined (Prevention, Early Detection and Rapid Response, Control and Management, Research, Restoration, Education and Public Awareness, and Leadership and International Coordination). The total funding utilized in fiscal year (FY) 2003 by the Corps of Engineers to address the seven items in the Cross-Cut Budget was over $54 million. In FY 2006 this number has increased to over $74 million. Over 70% of the funds expended by the Corps of Engineers each year on aquatic invasive species went to the Control and Management area. Restoration was the next largest expenditure accounting for over 12% of the annual funds. This allowed only minimal efforts to be funded in the five remaining areas. The cost of dealing with invasive species continues to rise annually and this trend will continue unless significant resources are devoted to addressing all the areas contributing to the invasive species problem.

NOTES

Introduced Marine Crustacea Decapoda and Stomatopoda in Syria: An Overview and Recent Data

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Since the opening of the Suez Canal in 1869, water of the Mediterranean and the Red Sea, which had been separated by the isthmus from Suez, came into direct contact. This creates a connection between the fauna of the Mediterranean and that of the Red Sea, which also leads to the colonization of the Mediterranean by species of the Red Sea via the Suez Canal. Quite a large number of Crustaceans (mainly Decapoda) arrived in the Mediterranean more or less recently. They are mainly from the Red Sea (and the Indo-Pacific) and entered the Mediterranean through the Suez Canal after its opening. They subsequently colonized the eastern coasts of the Mediterranean including Syria since favourable conditions of temperature, habitats and salinity are available there.

Some species such as the shrimps *Marsupenaeus japonicus* (Bate, 1888), *Metapenaeus monoceros* (Fabricius, 1798), *Metapenaeus stebbigni* Nobili, 1904, *Penaeus semisulcatus* de Haan, 1844, *Trachysalambria palaestinensis* (Steinitz, 1932) or the crabs *Portunus pelagicus* (Linnaeus, 1758), *Charybdis hellerii* (A. Milne Edwards, 1867), *Charybdis longicollis* Leene, 1938, *Thalamita poissonii* (Audouin, 1826), *Atergatis roseus* (Rüppell, 1830) are common along the Syrian coasts. This latter species is particularly abundant on costal areas and often collected by divers. Some other crustaceans such as the mantis shrimp *Erugosquilla massavensis* (Kossmann, 1880), the shrimps *Metapenaeopsis mogiensis consobrina* (Nobili, 1904), *Alpheus inopinatus* Holthuis and Gottlieb, 1958, *Leptochela pugnax* de Man, 1916, *Leptochela aculeocaudata* (Paulson, 1875) or the crabs *Micippa thalia* (Herbst, 1803), *Ixa monodi* Holthuis & Gottlieb, 1956, *Leucosia signata* (Paulson, 1875), *Myra subgranulata* Kossmann, 1877, *Thalamita indistincta* Apel & Spiridonov, 1998 [first record for Mediterranean], *Heteropanope laevis* (Dana, 1852) were also reported from Syria. Seven of these decapods (*Metapenaeopsis mogiensis consobrina, Alpheus inopinatus, Micippa thalia, Ixa monodi, Charybdis longicollis, Thalamita poissonii, Thalamita indistincta*) represent new records for Syria.

Some indigenous species such as *Melicertus kerathurus* (Forskål, 1775), usually caught by fishermen in the past, are now almost eliminated because of the competition with alien species. These aliens, especially penaeid shrimps, are very common at present and can be found in seafood restaurants.

Alien species play a great role in the modification of the original specific composition of the eastern coasts of the Mediterranean. Nevertheless, the specific composition of decapods crustaceans in this area is still unstable as shown by the discovery of many new alien species. The present occurrence of Indo-Pacific species not recorded previously in the Mediterranean Sea or on the Syrian coast such as T. spinifera does not necessarily indicate a recent immigration. These might just be old inhabitants of the Mediterranean that did not come to the attention of taxonomists up to now. Especially that these species have been recorded for a long time elsewhere in the eastern basin of the Mediterranean and that some of them are widespread in marine waters of Syria.

Information is scarce about alien species along the Syrian coasts and more investigations are needed for a better knowledge of their distribution in time and space.

NOTES

Non-indigenous Species Invading Italian Inland Waters: Distribution, Case Studies and Threats

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Biological invasions have recently emerged as one of the "big five" issues of concern in conservation: the deliberate or accidental human-mediated introduction of some non-indigenous species is today regarded as the main driver of biodiversity change. Recent analyses suggest that biodiversity in freshwater systems declines at far greater rates than in the most affected terrestrial ecosystems, and that the spread of cosmopolitan, invasive species is leading to a constant increase in the "homogenization" of the native biota.

Our aim here is to describe the ongoing process of invasions in Italian inland waters by an ever-lengthening list of species among mammals, fish, mollusks, and crustaceans. Some case studies will be analyzed and the threats they pose to the native ecosystems discussed. Finally, we will attempt to raise hypotheses for their control and for the prevention of further invasions.

NOTES

Environmental Modulation of the Reproductive Activity of the Invasive Mussel *Limnoperna fortunei* in South America

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Between 1997 and 2006 we monitored the reproductive activity of the invasive fouling mussel *Limnoperna fortunei* in five Argentine water bodies of the Río de la Plata watershed and one reservoir located farther west. In all cases reproductive relaxation occurs in the winter. At four of the six sites surveyed larval densities are above 10% of the yearly mean for 8.8 to 10.2 months per year. In contrast, at a reservoir with comparatively low food supply reproductive activity drops to 5.9 months, and at another where strong blooms of microcystin-producing Cyanobacteria occur, in addition to the winter trough, there is a very well defined drop in larval numbers in the middle of the summer. These results suggest that, in addition to temperature, two major factors modulate the reproductive activity of *L. fortunei*: 1) the availability of food, and 2) blooms of toxic Cyanobacteria, shortening the otherwise very long reproductive period significantly. This information is important for the design of antifouling programs involving the use of moluscicides as it can allow cutting down the environmental impact due to flushed out biocide by 40%, and reduce the overall costs of chemical treatment by 50% or more. It also may allow designing alternative strategies in areas and/or with products that have limitations in the number of applications per year allowed.

NOTES

Effects of Nile Perch on the Ecology of the Spot-Necked Otter and Competition with Fishermen in Lake Victoria, Kenya

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The effects of the Nile perch *(lates niloticus)* on the cichlids of Lake Victoria is well documented, though its impacts on other piscivorous fauna and human fish consumers are less known. The spot-necked otter *(Lutra maculicollis)* is a key predator in the inshore and littoral zones, where the aquatic communities are dominated by cichlidae, mainly *Oreochromis niloticus* and numerous species of *Haplochromis.* This zone is also the mainstay of subsistence fishermen, i.e., those who cannot access deep-water fisheries due to their inability to afford fishing boats or larger fishing nets. Our research in Kisumu, Kenya has found that adult perch and otters compete for the same size-class of fish (8-10cm) in deeper water. This has led to increased direct competition between otters and fishermen for fish resources in the inshore and littoral zones. This competition is revealed in the declining fish catch (Perch; 6.5% per annum, Tilapia 10% per annum), rising market price for fish (Perch 55% per annum, Tilapia 50% per annum) over the last six years. It is also illustrated by the increase in 'net-raiding' by otters and the rising percentage of crab *(Potamonautes niloticus)* in the otters'diet. There are also socio-economic and human health impacts, which are still being researched by different groups.

NOTES

Invasion of the Asian Clam *Corbicula fluminea* in Lake Constance

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Clams of the genus *Corbicula* belong to the most invasive species, which successfully established worldwide in a wide range of freshwater ecosystems. Originating from southeast Asia *Corbicula fluminea* was introduced to North and South America as well as Europe. Within 15 years the clam conquered the whole River Rhine from its mouth to the border of Switzerland. In Germany it shortly replaced the zebra mussel as dominant mollusc in large rivers. In the early 2000s, *Corbicula* invaded Lake Constance, which is bordering Germany, Switzerland and Austria. This is the first study that comprehensively attends the invasion of Asian clams in a prealpine lake and surveys several aspects of its ecological consequences:

a) Currently, *Corbicula* reaches abundances of up to 3500 ind. > 5mm/m^2 in sandy areas of Lake Constance. Dispersal and velocity of propagation of the Asian clam is characterised. Furthermore, we describe age and size distribution as well as population dynamics of the newly established Asian Clam population.

b) Severe low water levels and cold periods caused mass mortalities among the Asian clam populations in Lake Constance, which leave high abundances of valves on the otherwise relatively unstructured soft bottom sediments. Mortality by predation is negligible compared to the abiotic effects.

c) We show that dead valves of the Asian clam increase availability of hard surface in primarily soft bottom habitats considerably, whereas living clams that burrow in the sand do not. To date, it remains unclear if *Corbicula* affects other bivalves and benthic invertebrates. Therefore we tested in experiments on habitat choice if the ecosystem engineering via shell production (biogenic hard substrate built by dead *Corbicula* valves) is a refuge for the benthic macroinvertebrate taxa, which dominate the littoral zones of Lake Constance. Seven out of ten taxa preferred the dead valves compared to bare sand.

d) To show if the results of the habitat choice experiments are also observable *in situ*, we studied Asian clam effects on littoral communities of sandy habitats by using sand-filled enclosures. We chose three treatments replicated four times each: bare sand, sand with *Corbicula* valves (2000 valves/m^2, respectively 1000 dead ind./m^2) and sand with live clams (1000 ind./m^2). After 2 months of exposure total benthic community did not show treatment effects. However, among individual taxa (> 1% of total abundance) e.g., the mayfly *Caenis* showed increased densities in the dead valve treatment, compared to the other treatments. Other taxa like nematodes, oligochaetes, molluscs and chironomids did not show treatment effects. Thus, valves may provide valuable resources for species preferring structured habitats. Additionally, juvenile *Corbicula* had significantly lower abundance in the treatment with live adult clams, possibly due to a chemical cue.

e) Laboratory growth experiments revealed that zebra mussels that are attached to *Corbicula* reduced the growth rate of Corbicula significantly, whereas zebra mussel growth was not affected.

In conclusion, compared to ecosystem engineering effects of *Corbicula* via shell-production impact of living Asian clams seem to be of less importance.

NOTES

Successful Control of Zebra Mussels in a Fouled Waterworks Using Microencapsulated BioBullets

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The widespread invasion of bivalve molluscs such as the zebra mussel, *Dreissena polymorpha*, golden mussel, *Limnoperna fortunei*, and false mussels, *Mytilopsis* spp., has made them some of the world's most economically and ecologically important pests. Despite the development of numerous control methods, chlorination remains the only widespread and licensed technique throughout the world. Mussels are able to sense chlorine and other toxins in their surrounding environment and respond by closing their valves, thus enabling them to avoid toxic effects for up to three weeks. Furthermore, prolonged dosing of chlorine in raw water produces ecotoxic trihalomethanes (THMs) by reaction with organic material in the water. We have developed a novel, environmentally safe and effective method for controlling the biofouling mussels; the BioBullet. Our method uses the encapsulation of an active ingredient (such as KCl) in microscopic particles of edible material. The mussels' natural filtering ability then removes and concentrates the particles from the water, without stimulating the valve-closing response. By using the mussels' filtering behaviour to concentrate BioBullets the absolute quantity of active ingredient added to the water can be reduced substantially. Our approach allows us to engineer the particles to break-up and dissolve completely within a few hours, thus eliminating the risk of polluting the wider ecosystem. We have demonstrated that the effectiveness of a toxin in the control of biofouling filter-feeders can be enhanced greatly by using our technique. Furthermore, successful industrial trials indicate that the BioBullet provides a viable and more appealing control option than those currently in use.

NOTES

Update on *Pseudomonas fluorescens* Strain CL145A as a Zebra Mussel Control Agent

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The bacterium *Pseudomonas fluorescens* strain CL145A is a leading candidate for the biological control of zebra mussels. Cells of this bacterial strain contain a natural product, which is lethal to zebra mussels when ingested. Dead cells are equally as effective against zebra mussels as live cells, providing clear evidence that the mussels die from a toxin, not from infection. Future commercial products based on this microbe will contain dead cells, thus further reducing environmental concerns.

The progress to date in moving toward commercialization will be reviewed, including mass production through large-scale fermentation, efficacy trials, non-target testing, and product shelf-life experiments. The entire genome of strain CL145A has recently been sequenced, and the project's current major focus is the identification of the gene(s) that produce(s) the natural product lethal to zebra mussels. Successful identification of the gene(s) would lead to further research to produce cells of higher toxicity and efficacy using techniques such as: 1) controlled manipulation of the gene(s) to over express the toxin, or 2) selecting strains that overexpress the biotoxin after random mutagenesis. The lack of non-target impact when treating with dead cells may allow this green technology to also be used for zebra mussel control in open waters, such as lakes and rivers. Thus far, however, the research focus of the project has been the control of zebra mussels in pipes to reduce the use of the polluting biocides that are currently being used in power plants.

NOTES

A Comparative Study of Zebra Mussel Control Methodologies in the Lake Ontario Region

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Since the early 1990s, zebra mussels have troubled water users in the Great Lakes region of North America. Many users have implemented zebra mussel control strategies using sodium hypochlorite. We have studied the treatment methodologies employed by various large water users in the Lake Ontario region. The focus of the paper is to present the overall effectiveness of these methodologies. It also compares the status of the equipment and control strategies with the available options considering the improvements in technology.

The paper summarizes the lessons learned over the past 15 years in the Lake Ontario, Lake Erie, Lake St. Clair areas.

NOTES

The Use of Ozone to Control Zebra Mussels, Ontario Power Generation, Lennox Generating Station

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Zebra mussels made their first appearance in North American waters in 1988. Since then, it has been a constant challenge to keep them under control. The ability of large colonies of zebra mussels to reduce the effective diameters of pipes and conduits and impede cooling water flow, can have significant impact on electrical generating stations.

In 1990, Ontario Power Generation (then Ontario Hydro) initiated a zebra mussel research program in which twenty different control technologies, including ozone, were evaluated. Chlorination was the preferred strategy used to manage zebra mussel macrofouling during the 1990s. Subsequently, ongoing concerns of toxicity and increasing regulatory controls resulted in the initiation of a pilot project in 1999 to use ozone for the control of zebra mussels at the Lennox Generating Station. Lennox G.S. is a 2160 megawatt dual fuelled (natural gas/residual fuel oil) generating station located near the east end of Lake Ontario, 200 kilometres east of Toronto, Ontario.

Ozone has been used as a disinfectant for drinking water for nearly a century.. Its application for the control of zebra mussels has been limited to date. In terms of contact time, at comparable residual levels, ozone outperforms chlorine. Lewis et al (1993) indicated that a minimum of 5-h contact time was required at 0.5 mg/l for 100% mortality of veligers and post veligers. One of the main advantages of ozone is that it dissipates rapidly in water so there are no downstream environmental impacts. Drawbacks are high capital cost of ozonation equipment and some maintenance difficulties.

The Lennox G.S. ozone system was put into service in September 2000 as a pilot program. The system was to remain in service for two years, during which time; data would be gathered to determine the efficacy of the system. The ozone system continues to be in operation today and has been successful in achieving a sufficient mortality rate to prevent macrofouling of the water intake systems at the plant.

The presentation will include an overview of our seven year operational experience with the ozone system, and will highlight:

- A brief technical description of the system.
- Operational, maintenance, and industrial hygiene challenges encountered.
- Regulatory licensing, including pest control products registration.
- Efficacy study results.
- Environmental monitoring.
- Non safety adverse effects (corrosion)

NOTES

Control of Golden Mussel by Ozonation of Cooling Water in Power Plants

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Invasive bivalves are on the move provoking worldwide problems with plugged piping and heat exchangers, wherever water out of rivers and lakes is used for cooling purposes. The control of this "large scale biofouling" is a big challenge due to the high resistance of bivalves against common disinfection methods.

Chlorination was the common method for many decades to prevent biofouling in different applications such as cooling towers, water for industrial use and municipal water works. Since the early 1990s two major incidents forced the industry to look for alternative methods: invasion of zebra mussel into lakes and rivers in North America causing problems with fast growing mussel layers in piping and heat exchangers and the increasing sensibility concerning ecological problems caused by chlorination by-products.

Ozone is known as the strongest oxidant available for water treatment and features various ecological advantages. No chemical precursors are required to be stored or handled, and it reacts to harmless oxygen. Due to its high reactivity ozone will be consumed rapidly by all kind of organics present in natural water coming out of rivers and lakes. Furthermore, ozone undergoes fast self-decomposition depending on temperature and pH. For that reason it is not possible to yield high residual concentration of ozone and it is not possible to protect widespread water distribution systems using this kind of water.

Nevertheless our tests showed that even a small dosage of 0,3 ppm ozone avoided growth of golden mussel *Limnoperna fortunei* efficiently. Between March and July 2005 the cooling water of one heat exchanger bloc in hydroelectric power plant Itaipu (Paraguay/Brazil) was treated with ozone on a trial basis. Growth of mussels was monitored in special bio-boxes, where settlement of veligars was measured over periods of 60 days. The total number of settled veligars was decreased by 50 % and the number of living veligars was reduced by 90 %. The results also correspond with the expertise of the heat exchangers. Already 2-3 months after the last cleaning there appeared thick coverings and even blockage of whole channels with mussels. 2-3 months after the ozone treatment the heat exchangers were considerably cleaner and all channels were free.

It is remarkable that 0,3 ppm ozone did not increase any risk of corrosion. Due to the high level of organic load in the treated water the ozone was reduced within seconds. We are coming to the conclusion that high concentrations of biozides are not required to combat growth of mussels efficiently. It seems to be sufficient to shock the mussels' larvae, for that reason they are not interested any more to settle down in piping, heat exchangers, and other fittings. Using low concentration of ozone enables the design of systems with best ecological compatibility.

NOTES

Proactive Approach to Zebra Mussel Treatment at a Spanish Nuclear Power Plant: Case Study

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The Garona power plant, located on the Ebro River, is a 468 MWe, single unit, BWR nuclear plant with a once through cooling system. In 2006, the plant was advised that an unexpected presence of zebra mussels had been found upstream of the plant intake. In response to this imminent threat, the plant management established an interdisciplinary zebra mussel response team. The objective was to take advantage of a planned station outage in the spring of 2007 and position the plant to respond effectively to the arrival of the zebra mussels before the mussels could arrive in sufficient numbers to hinder station operation. The team reviewed options, selected the treatment strategy and implemented mitigation measures before the 2007 zebra mussel breeding season.

The presentation will describe the review process undertaken, the selection criteria used to select the appropriate treatment strategy and the monitoring program that was put in place.

NOTES

On-site Evaluation of Fouling Release Coatings for the Protection of Cooling Circuits Against Macro-organisms

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The prevention of the colonization of cooling circuits in power plants by macro-organisms (mussels, oysters, barnacles,…) is generally effected by biocides as natriumhypochlorite. Alternative techniques such as thermal shocks, fine filtration or the application of toxic antifouling paints are sometimes also realized. The only curative method, actually used in combination with chlorinations, is to stop the power plant and to clean the colonized surfaces. This method is efficient but very expensive.

Non-toxic, fouling release coatings could be a preventive, environmentally friendly and cost-effective technique to prevent the colonization of cooling circuits. Since 2002 Laborelec has undertaken a test campaign with five different commercially available anti-fouling coatings. The coatings were applied on concrete panels and installed in different cooling water systems (seawater and freshwater) and followed during the testing period. Based on these tests, the four best anti-fouling coatings were selected for a full-scale test under real conditions. In May 2004, during an overhaul of a unit of the Electrabel EEMS Power Plant (seawater cooled), the four coatings were applied on the concrete walls of the cooling circuit to evaluate the impact and fouling of oyster and mussel fouling. Several inspections have been performed until 2006. The experience of three years will be presented.

A technico-economic evaluation and a comparison with other alternatives have been made.

NOTES

Zebra Mussels in Russia: Past, Present and Toward its Control in Service Water Systems

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Fouling freshwater dreissenid bivalves, zebra (*Dreissena polymoprha* Pallas) and quagga mussels (*D. rostriformis bugensis* Andrusov) belong to specific faunal complex "native" to the Ponto-Caspian region. Many representatives of this complex are evolutionarily predisposed for invasion success to inland and coastal waters. In Eastern Europe invasions of Ponto-Caspian species, especially of zebra mussels, often occurred rapidly following the development and intensification of cargo shipping traffic, construction and exploitation of waterways (last quarter of 19th century), and creating cascades of water reservoirs (second half of 20th century). Artificial and disturbed natural ecosystems, including cooling ponds of power plants, seem to be more vulnerable to zebra mussel invasions then pristine ones. Forming fouling communities and having the capacity for rapid colonization of target systems, dreissena and other macrofoulers (e.g., bryaozoan *Plumatella* spp.) can cause commercial losses in a variety of industries and utilities. Of those, it is the power generation facilities, supplied with service water from lakes and reservoirs harboring established zebra mussel populations that are the most infested.

In our country the common approach aimed to mitigate the fouling problem is based on a combination of reactive strategies applied at the facility (e.g., physical cleaning, thermal and chemical treatment of existing fouling) with the introduction of plantivorous and molluscivorous fishes. The latter is believed to directly and indirectly control zebra mussel populations in the source water body. However it is realized that in the present state this approach is not as efficient as expected either in preventing zebra mussel development in the entire service water system, or in the source water body, and thus proactive strategies are required. Following this requirement we have developed a long-term program for technical fouling prevention at power generation facilities. The program is to first address zebra mussel control and is based on establishing adequate mainstream and sidestream monitoring of larval stages (the first phase of program) and consideration of peculiarities of each service water user at a specific power plant. The entire action plan includes: 1) optimization of chlorination with its gradual substitution by more ecologically friendly means in cooling circuits, continuously consuming large volume of water, and 2) development or use of available efficient solutions, alternative to chlorination, in smaller users (e.g., fire protection systems). Assessment of the efficiency of selected control strategies and their further verification are expected to be performed following the results of established side-stream monitoring. Mainstream and sidestream monitoring for zebra mussel control is now under establishment at the Kalininsk power plant.

NOTES

An Electric Barrier to Prevent Aquatic Invasive Species Dispersal in a Commercial Navigation Canal

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Constructed in 1910, the Chicago Sanitary and Ship Canal forms an aquatic link between the Great Lakes and the Mississippi River drainage. Today the canal is an important navigation corridor and carries waste and storm water away from Lake Michigan, Chicago's source of drinking water. The Chicago Sanitary and Ship Canal aquatic nuisance species dispersal barrier project was authorized by National Invasive Species Act of 1996. This Act directed the US Army Corps of Engineers to investigate the feasibility of creating a dispersal barrier for aquatic nuisance species in the Sanitary and Ship Canal. An advisory panel comprised of regional stakeholders assessed available technologies and recommended use of a graded field, DC electric barrier. The project began with a temporary demonstration barrier built in April 2002. This original barrier is nearing the end of its design life. The first half of a new, larger and more powerful barrier has been completed. When fully constructed, the new barrier will be better able to affect small fish as well as large fish. Funding shortfalls and navigation safety continue to pose challenges for operation of the new barrier. This presentation will provide a brief history of the Canal; discuss options and hurdles for creating a dispersal barrier in a navigation canal, Asian carp monitoring efforts and the critical role this man-made waterway plays in controlling the spread of aquatic invasive species between the Great Lakes and Mississippi River.

NOTES

Non-native Armored Catfishes in Florida: Description of Nest Burrows and Burrow Colonies with Preliminary Assessment of Shoreline Impacts

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Non-native populations of the Neotropical family Loricariidae, the Suckermouth Armored Catfishes, have been introduced and become established in many tropical and subtropical regions of the world. In Florida, members of the loricariid genus *Pterygoplichthys*, the sailfin suckermouth catfishes, are now common in most drainages in the central and southern parts of the Florida peninsula. In certain rivers, canals, and lakes, these fishes are abundant. Breeding adult *Pterygoplichthys* excavate and maintain burrows in shoreline soil. These burrows are used mostly as spawning and nesting sites. The burrows, especially in colonial groups, are thought to cause or exacerbate bankline erosion in canals and rivers. However, there is little published information on the burrows of loricariid catfishes and no quantitative data are available to adequately evaluate any association between presence and abundance of burrows and increased erosion. The purpose of the present study was to provide baseline information on the burrows of *Pterygoplichthys* in Florida and to provide a preliminary assessment of shoreline conditions (e.g., bank stability and erosion).

NOTES

Do Introduced Pumpkinseed Sunfish Have an Impact on Native Species in European Streams?

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The North American sunfish, pumpkinseed *Lepomis gibbosus*, is widely introduced in Europe, but little is known of its movements, microhabitat use and impacts (on native species) in European watercourses. In this paper, we review the available data (both published and new original results) on the distribution, dispersal and demonstrated impacts (to native species) of pumpkinseed introduced to European watercourses. Assessments at the individual, population and fish assemblage levels suggest that this species is having a greater impact in Iberia than elsewhere in Europe, particularly at the fish assemblage level, but that recent research reveals that this introduced species may have a more important role as a non-native parasite host in Europe than was previously believed.

NOTES

Aspects of Successful Invasion of English Inland Waters by Introduced Topmouth Gudgeon, *Pseudorasbora parva*

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The introduction and dispersal of the Asiatic cyprinid, topmouth gudgeon *Pseudorasbora parva*, in the UK have been attributed to contaminated shipments of fish (in particular golden orfe *Leuciscus idus*) as well as natural dispersal processes. We examined this hypothesis by testing for associations between the distribution of *P. parva* in England and licensed movements of native and non-native species of fish, which were principally to still water ecosystems. The establishment success of *P. parva* in different types of ecosystem (still waters, streams) and natural dispersal from these water bodies into (and within) receiving still waters was examined to assess propagule pressure and dispersal patterns (*via* drift sampling), in-stream distribution patterns (point abundance sampling by electrofishing), microhabitat overlaps between *P. parva* and native fish species, and the level of biological resistance (stomach flushing of brown trout *Salmo trutta*, dissection of chub *Leuciscus cephalus*). The distribution of *P. parva* in England was found to be associated with the movement pathways of golden orfe as well as some species of ornamental non-native fishes. The rate of *P. parva* displacement (propagule pressure) from source into the receiving stream varied in a diel pattern and according to season. The in-stream distribution of *P. parva* varied according to distance from source still-waters, with microhabitat overlaps observed between *P. parva* and native species (brown trout, chub, bullhead *Cottus gobio*, stone loach *Barbatula barbatula*). Both, brown trout and chub, were observed to prey on *P. parva*, but predation intensity (biological resistance) appeared to be insufficient to eliminate the non-native species. Indeed, persistence was facilitated by the regular and continuous dispersal of *P. parva* (propagule pressure) from the source still waters into the stream.

NOTES

Distribution of Racer Goby *Neogobius gymnotrachelus* Along the Cross-section of a Dam Reservoir on the Lower Vistula River (Central Poland)

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Racer goby is one of the four *Neogobius* fish species native to the Ponto-Caspian region, which continue to expand their range in European rivers since the early 1990s. Racer goby appeared in the lower Vistula River in 2000 and spread rapidly. Such small, bottom-dwelling fish have been usually collected from shallow, nearshore zones. Little is known of their habitat use in deeper, offshore areas of rivers in its native and non-native ranges. Therefore, we used traps to examine the distribution of racer goby along the entire cross-section of the middle part of the Włocławek Reservoir in the lower Vistula River. This reservoir is river-like (retention time 4-5 days), channel-shaped and provides suitable heterogeneity of habitats for such a study. Along its cross-section, there are shallow (< 5 m) lentic, flooded areas with different types of substrata and variable macrophyte coverage, as well as considerably deeper (up to 12 m) and more lotic parts belonging to the old river bed (main channel). In the growing season of 2005, we deployed traps made of used car tyres. The traps (five at each site) were placed on the bottom at five sites located along the 1.9 km long cross-section: 0.5 and 1.5 m deep (nearshore, sandy bottom areas with or without macrophytes, respectively), 2.5 and 4-5 m (open water, flooded areas with muddy bottom) and 10-12 m (the old river bed). Twenty-three samples were taken from April to October, every 7-11 days. We collected 426 fishes (1.4-27.9 cm standard length, SL) belonging to eight species, including 380 racer goby (1.4-10.0 cm SL).

Racer goby occurred along the entire reservoir profile, but their size structure, as well as spatial distribution, varied seasonally. In spring, during the spawning period, the largest individuals were collected. At this time, fish were the most abundant in the nearshore area overgrown by macrophytes (1.5 m depth), while they were completely absent from the old river bed. During summer, the size structure of racer goby was shifted to the smallest class (fry), which was uniformly distributed along the entire profile. In autumn, racer goby were of intermediate size and they were concentrated in the nearshore places overgrown with macrophytes. The smallest number of fish was caught in the main channel. No differences among the other sites were noticed. Apart from the occurrence of macrophytes, which are probably suitable shelters for racer goby, and differences in depth and hydrodynamical properties, the distribution of fish observed in our study can be accounted for by changes in the near-bottom oxygen concentration and interactions with another *Neogobius* species (monkey goby, *N. fluviatilis*). Racer goby avoided areas with oxygen concentration < ca. 2 mg dm^{-3} and traps inhabited by monkey goby, being probably a stronger competitor due to its larger size.

NOTES

Modification in the Reproduction Strategy – Reason for the Round Goby (*Neogobius melanostomus*) Invasion Success in the Gulf of Gdańsk?

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Invasion by the round goby (*Neogobius melanostomus*), the Ponto-Caspian fish, has been observed in the Gulf of Gdańsk from 1990. Gobies were of small importance during the first few years of the invasion, but soon they became the dominant of the shallow water fish community. The invasion in this area involves a number of different species and a stable and complex ecosystem. This situation implies some important questions. How was such successful invasion possible? Are the invaders behaving the same in the native area and in the invaded region? We are trying to answer certain questions focusing on the spawning behavior and the reproduction effectiveness. The round goby spawns in waters of depth down to 20 metres, mostly in the shallowest areas. Males guard eggs attached to hard elements of the bottom. In the area of native occurrence, the Ponto-Caspian region, effectiveness of reproduction is correlated with sex ratio in the spawning population. When the number of females is greater than the number of males the effectiveness falls down. Nests are big, many females lay eggs into one nest (round gobies are multiple spawners). Guarding and ventilation of nests is difficult, and a lot of developing eggs die. In native areas, the numbers of males and females are mostly equal and spawning success is excessive. Males guard territory around the nest of about two-metres diameter. Reproduction takes place during all warm periods of the year. In the Gulf of Gdańsk, spawn typically prolongs from the middle of April to the end of September. The bottom in that area is sandy and the spawning places are limited. Eggs are attached to any solid element on the bottom. In suitable places, almost all hard elements on the bottom are used for nests. In such situations, distances from nests are shrink to the minimum. Often nests join one to another. Sometimes, large parts of hard elements are totally covered by fish eggs and it is impossible to separate specific nest. The highest number of nests is observed in the most inner, shallow water part of the Gulf. In that area, round goby eggs cover all suitable places. The other variation typical for the Gulf of Gdańsk population, correlated with reproduction, is domination of males in number. Currently, the observed sex ratio is two or three males to one female. The nests are small. Their guarding effectiveness is high. Both described factors result in the highest ever observed reproduction success. It promotes the successful invasion. Taking into account frequent invasions of the round goby in various European and North American regions, the presented phenomena may be employed for quick prediction of invasion potential in early stages of settlement. Domination of males in number results in high reproduction effectiveness and successful invasion.

NOTES

Alien Fish Species in Southeast Asia: Pathways, Biological Characteristics, Establishment and Invasiveness

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The top two reasons for the introduction of species in the Southeast Asian region is aquaculture (32%) and aquarium (52%). Although the species are meant to be confined to culture and aquarium facilities, some have escaped to natural waters, established themselves (54% for the aquaculture species, 21% for the aquarium species) and have become invasive.

Of the 494 fish introductions to Southeast Asia, 191 have been reported as established in the wild, 57 have not established and the remaining 246 have unknown status of establishment. These comprise of 292 species. The biological characteristics of the species from the three groups are discussed and the potential establishment of the unknown species is explored.

Results reveal significant differences in average maximum length, longevity in the wild, degree of parental care and species resilience between the established and the unestablished species groups. Established species were predominantly r-strategists, smaller, with higher productivity and more often from other tropical countries compared to the group that did not establish itself. The suit of biological and ecological characteristics of the group with unknown establishment, however, were similar to the established group indicating a high degree of establishment potential or their probable unreported presence in the wild.

Some of the Southeast Asian countries are among the top ten freshwater aquaculture producers in the world. Results also provide insights on the various introduction pathways.

NOTES

Invasive Fishes and their Effects on the Native Fish Fauna of the Upper Rio Grande Basin, USA

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The introduction and range expansion of alien fishes in the Upper Rio Grande basin is probably the single most devastating factor to the persistence of native fish assemblages today. Currently, relict populations of native forms are confined to remote middle to high elevation streams, most of which occur on US Forest Service lands. A history of the basin, its native fish fauna, and current conditions relative to extirpation of native fishes due to alien fish species is presented along with management recommendations for the conservation and repatriation of native fish assemblages.

NOTES

Predicting the Impacts of Introduced Mussels on Aquatic Communities

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Dreissenid mussels (the zebra mussel *Dreissena polymorpha* and the quagga mussel *Dreissena bugensis*) have invaded lakes and rivers throughout North America and Europe, where they have been linked to dramatic changes in benthic community diversity and abundance. To examine the predictability of these impacts, we used meta-analysis to develop statistical models of *Dreissena* effects on benthic macroinvertebrates across a broad range of habitats and environmental conditions.

Our results revealed patterns robust to variation in methods across the primary studies. In the presence of *Dreissena*, benthic invertebrate communities increase in abundance and taxonomic richness. However, community evenness (excluding *Dreissena*) declines, owing to disproportionate effects on certain taxonomic and functional groups. *Dreissena* has strong positive effects on the densities of scrapers and predators, particularly leeches (Hirudinea), flatworms (Turbellaria) and mayflies (Ephemeroptera). Gastropod densities generally increase in the presence of *Dreissena*, but large-bodied snails tend to be displaced from mussel-covered substrate. *Dreissena* is also associated with declines in sphaeriid clams and other filter-feeding taxa, as well as burrowing amphipods (*Diporeia* spp.), but have strong positive effects on gammarid amphipods. The strength of these effects varies with sediment particle size across sites, revealing that macroinvertebrate community response is context dependent.

The effects of *Dreissena* are remarkably concordant with those of ecologically-similar species, suggesting universality in the interactions between introduced mussels and other macroinvertebrates in freshwater and marine systems.

NOTES

Drastic Change of Peracaridan Assemblage in Lake Dusia, Lithuania, After the Introduction of Ponto-Caspian Aliens

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During the early 1980s, after deliberate translocation and establishment of Ponto-Caspian species, Lake Dusia was inhabited by 10 peracaridan species: glacial relicts *Mysis relicta*, *Pontoporeia affinis* and *Pallasiola quadrispinosa*; natives *Gammarus lacustris* and *Asellus aquaticus*; and Ponto-Caspian species *Paramysis lacustris*, *Chelicorophium curvispinum*, *Pontogammarus robustoides*, *Obesogammarus crassus* and *Chaetogammarus warpachowskyi*.

A drastic change in the peracaridan assemblage over the period of 40 years since establishment of non-native species was observed. The native amphipod *G. lacustris* and glacial relict species have gone extinct. The isopod *A. aquaticus* recently is absent from the shallow waters with high densities of Ponto-Caspian amphipods, and occurs at low quantities only in depths between 3 and 10 m. The Ponto-Caspian amphipod *C. curvispinum* was not detected either. Hence, the current peracaridan assemblage of Lake Dusia consists of five species: Ponto-Caspian mysid *P. lacustris* and amphipods *P. robustoides*, *O. crassus* and *C. warpachowskyi*, and the native isopod. The extinction of native littoral amphipods and current pattern of occurrence of *A. aquaticus* definitely have resulted from the predatory impact of the most numerous alien amphipod, *P. robustoides*. The decrease of glacial relict peracaridans in Lake Dusia had begun due to deterioration of oxygen conditions in the profundal waters. When the deep-water refuge during periods of thermal stratification became unavailable or only temporarily accessible, and glacial relicts were forced to relocate to the shallower waters and spatially overlap with aliens, their extermination most probably proceeded via predation from introduced Ponto-Caspian peracaridans. Evidence of the negative impact that alien peracaridan species have on native species, and the ecosystem change in Lake Dusia will be discussed.

In conclusion, the outcome of a deliberately shaped peracaridan assemblage in Lake Dusia suggests that the long-term co-survival of peracaridan species with different evolutionary history when their habitats substantially overlap should not be expected in a lake of such size and environmental complexity as Lake Dusia. The survival at least of any one of the glacial relict species if oxygen conditions in the profundal waters would remain unchanged still can be hypothesized. However, it seems that the co-existence of peracaridans of differing origin might be sustained only through environmental heterogeneity, which must provide a refuge for inferior species, or produce habitats across which superiority of interacting species should reverse.

NOTES

Invaders Are Not a Random Selection of Species

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We examined the distribution of freshwater exotic invertebrates in Europe and North America across a wide range of taxa, feeding habits and tolerance to organic pollution. A database with information on species that are known to be invaders in Europe or invaders elsewhere but of European origin (75 species) and invaders in North America or invaders elsewhere but of North American origin (65 species) was analyzed and compared with the native species richness on both continents. 1) The distribution of exotic species across taxa was not random. Crustacean and molluscan invaders dominated on both continents, and comprised 72% of all aquatic exotic invertebrate species in Europe and 86% in North America. In contrast, crustaceans and molluscs together formed only 11% of the biodiversity of all native freshwater invertebrates in North America (22,183 species total) and 18% in Europe (11,613 species total). 2) Although aquatic insects are the most diverse group on both continents, numbers of invasive species among insects was disproportionally low. 3) Many native species (35.5%) are intolerant of significant amounts of organic pollution (using the rating scale developed by Hilsenhoff and used by the US EPA). In contrast, all exotic species are tolerant to significant amounts of organic pollution. However, similar to non-invaders (3.8% of 880), less than 3% of 105 exotic species can tolerate severe organic pollution. 4) The distribution of species among feeding groups is also different for exotic species than for native species. Suspension feeders are disproportionally more abundant and predators are less abundant among exotic species than among native invertebrates.

Therefore, the ongoing spread of exotic species affects the biodiversity of selected taxa, shifts communities toward greater tolerance to organic pollution and increases the numbers of suspension feeders, thereby enhancing benthic pelagic coupling in waterbodies with high densities of invaders. Because these processes are very similar in Europe and North America, we suggest that the observed patterns may have a common global effect.

NOTES

Invasibility of Small Lakes and Impact on a Non-indigenous Plant

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The fate of a non-indigenuos plant species, *Ceratophyllum demersum*, and the recipient native plant community in 46 small and clustered lakes in southern Sweden was used to test the influence of the plant community composition, lake size, shoreline grazing by cattle, distance to nearest roads, and nutrient status on invasibility and impact. The lakes where surveyed in 1971 and 35 years later. *C. demersum* was not present in 1971 but found in about half of the lakes in 2006. The contribution of the lake characteristics to invasibility was evaluated by multivariate statistic. The impact of *C. demersum* on the native plant community composition in relation to the lake characteristics was examined by a combination of RDA (constrained principal component analysis) and BACI (Before After Control Impact) methods.

NOTES

Invasive Species in Ireland: Risk Assessments, Policy Development and International Co-operation

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The island of Ireland is an example where a co-ordinated joint approach to achieve effective management and prevention of species invasions is needed. International co-operation between both jurisdictions, Northern Ireland and the Republic of Ireland is vital as there are protected sites, which span the border, need for a co-ordinated response to new invasions, and early eradication and management of existing invasive species. Recognising the need to tackle invasive species impacts throughout Ireland, an all-Ireland review of invasive species was commissioned by both Governments and completed by Quercus in March 2004.

In May 2006 a three-year project began to take forward the implementation of key recommendations from the review. The outputs of the project include: 1) risk assessments, management strategies and contingency plans; 2) rapid response facilitation; 3) a stakeholder engagement programme including development of codes of practise and development and delivery of education and awareness programmes; 4) a review and recommendation of monitoring, surveillance and recording programmes; and 5) a review of legislative provisions and recommendations for improvement. The project also links to an initiative currently being undertaken in Britain, the GB Programme Board through cross-membership of the steering groups.

A risk assessment protocol for potential and established invasive species was developed which takes a systematic approach to identifying species of most concern and prioritisation of actions to ensure the most effective use of limited resources. The first stage categorised species into high, medium and low risk, 385 established species were assessed with 41 categorised as high risk and 180 potential invaders were assessed with 26 categorised as high risk. There were significantly more freshwater species classified as high risk than marine and terrestrial species. The second stage involved a more comprehensive assessment, which enabled ranking of high risk species. The aim of the process was to identify the top ten established species (or groups of species) of concern and top ten potential species of concern for which policy would be developed.

The risk assessment process also included stakeholder involvement in review of the outputs and the prioritisation of species for which policy would be developed. Stakeholder groups included scientists, managers, policy makers, industry and NGO's. Management strategies are currently being prepared for Floating Pennywort (*Hydrocotyle ranunculoides*), the tunicate (*Didemnum* spp.) and rats on offshore islands. Exclusion strategies/contingency plans are currently being developed for non-native crayfish species, Japanese Kelp (*Undaria pinnatifida*) and large browsing mammals such as Muntjac and Roe Deer. Plans currently under development have an emphasis on rapid practical action, eradication where feasible and stakeholder engagement in formulation and implementation. This paper will present the outputs to date.

NOTES

Beyond the Lacey Act: Improving the Enforcement of Aquatic Invasive Species Regulations

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Despite the great risk to ecosystem function arising from the introduction of aquatic invasive species (AIS), current United States law addressing accidental or unlawful introductions is inadequate, and pending legislation needs to include measures that help make AIS enforcement a top priority. This paper provides a brief overview of the current process governing AIS law enforcement, discusses the process' shortcomings, and recommends changes.

The United States Fish and Wildlife Service (Service) has some regulatory authority over the introduction of non-native species, and the Lacey Act of 1900 (18 USC. 42) serves as the strongest enforcement tool at the Service's disposal. The act provides two avenues to regulate the introduction of AIS: 1) it contains an injurious wildlife provision that lists particular species banned for interstate commerce and possession, and 2) it grants the Service enforcement authority if a species is imported or possessed in violation of state or foreign law.

While the Lacey Act is a strong regulatory mechanism to address AIS introductions, it has several limitations. The process for adding prohibited species to the list is slow, cumbersome, and reactionary when in fact, it should be quick, streamlined, and precautionary. Furthermore, the list does not reflect species prohibited by individual states, thereby creating a patchwork of regulations that undermines effective management and enforcement. Penalty provisions for both civil and criminal infractions under the Lacey Act are universally weak and only address intentional introductions. The impending invasion of Asian carp into the Great Lakes Basin illustrates the ineffectiveness of the Lacey Act process for listing injurious species.

Efforts to prevent further AIS introductions must occur more proactively, be comprehensive, and receive strong financial commitment from all levels of government for enforcement. In the short term, the Service should recognize and exercise its mandate to lead the application of existing statues to protect aquatic ecosystems, including devoting greater resources to the Lacey Act listing and enforcement provisions. AIS legislation should be comprehensive and should clearly empower the federal government to address prevention, early detection, rapid response, control, management and coordination of AIS. Proposed legislation (the *National Aquatic Invasive Species Act* – NAISA) would address many of these recommendations. While NAISA is the most promising response to AIS, its enforcement provisions should be strengthened to improve implementation of the Lacey Act and other regulatory processes it establishes, such as enforcement for its proposed screening process for proposed new importations. Moreover, NAISA should make it clear that the burden of proof of no ecosystem harm should fall on the importer. If improved and passed, NAISA would be a major enhancement to the process to prevent AIS introductions and enforce regulations

NOTES

Assessment of Sea Lamprey *(Petromyzon marinus)* Populations in the Laurentian Great Lakes Basin

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Although native to the Atlantic coasts of North America and Europe, the sea lamprey (*Petromyzon marinus*) is an invasive species in the Laurentian Great Lakes. Sea lampreys have contributed to considerable destruction of Great Lakes fisheries since their spread throughout the five lakes in the 1930s. An integrated control program for sea lampreys was developed in the 1950s and continues to depress sea lamprey abundance to enable rehabilitation of the once devastated Great Lakes fishery. This control program for sea lampreys is dependent upon measures of sea lamprey abundance, both to direct the application of control efforts, and to evaluate its effects. Control efforts are directed through the assessment of the stream-dwelling larval stage, and use data on lamprey density, size structure, and habitat quality to prioritize the application of lampricides to natal streams to kill sea lampreys before they are recruited to the lake population. Larval assessment data are also used to direct the placement of barriers that block the migration of spawning-phase sea lampreys and deny access to spawning habitats, limiting recruitment of larvae to the stream. The effects of sea lamprey control efforts are evaluated by estimating the abundance of spawning-phase sea lampreys that migrate into streams to spawn each spring. Trapping efforts on select Great Lakes tributaries provide mark-recapture estimates of spawning run abundance. These mark-recapture estimates are used as model input, along with measures of drainage area, larval production, and years since lampricide application, to derive lake-wide estimates of spawning-phase sea lamprey abundance. Lake-specific estimates of spawning-phase sea lamprey abundance are compared with established, acceptable targets of sea lamprey abundance as a measure of the success of the sea lamprey control program in the Great Lakes. We present the history, cost, and benefit of the two assessment programs for invasive sea lampreys in the Laurentian Great Lakes.

NOTES

Fighting the Sea Lamprey in the Great Lakes: 50 years of AIS Management

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In 1956, the governments of Canada and the United States implemented a bi-national program to control the invasive sea lamprey, *Petromyzon marinus*, in the Laurentian Great Lakes. The program was implemented in response to mortality inflicted by sea lampreys to native stocks of lake trout, *Salvelinus namaycush*, and lake whitefish, *Coregonus clupeaformis*. Early attempts at control included the installation of mechanical and electromechanical weirs in nursery streams to block spring spawning migrations and to trap and remove spawning-phase sea lampreys, however, results were mixed. Following study of the sea lamprey life cycle, researchers concluded that because larvae are concentrated in their nursery streams for at least three years prior to metamorphosis and emigration to the lake, the larval phase would be most vulnerable to control. The discovery that 3-trifluoromethyl-4-nitrophenol (TFM) selectively kills sea lamprey larvae altered the direction of the program and treatment of infested Lake Superior tributaries began in 1958. Rapid and dramatic reduction in sea lamprey abundance in Lake Superior led to an expansion of lampricide control to tributaries to the other Great Lakes, where it remains the primary means of suppression. Based on integrated pest management (IPM) theory, the current program integrates the application of lampricide with alternative methods, including: constructing barrier dams in streams to block spawning migrations; trapping and disposal of migrating adults, and; chemically sterilizing and releasing spawning-phase males to compete with wild males on the spawning grounds. Successful sea lamprey management has resulted in greater survival of stocked salmonids, supporting sport, commercial, and aboriginal fisheries throughout the Great Lakes basin. In Lake Superior, a self-sustaining population of lake trout has been restored, while some natural reproduction has been evident in lakes Huron, Michigan, and Ontario. However, during the last decade, sea lamprey abundance has increased in many areas of the Great Lakes and recent efforts have focused on increased suppression through more effective and frequent lampricide treatments. Future management will integrate the current management program with the use of synthetic pheromones to potentially attract spawning-phase sea lampreys into traps or to streams lacking adequate spawning and nursery habitat.

NOTES

A Study of an Unidentified Energy Field to Determine Its Potential Value in Excluding Fish from Water-Intakes, Ship Canals, etc.

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Over several years an energy field, generated by a device using proprietary technology, was tested relative to its direct or indirect affects on materials, organisms, mitigating environmental impacts, or effects on native and/or non-indigenous aquatic nuisance species. In situ tests of the device, in salt and freshwater and unrelated to fish exclusion, were conducted by the technology's developer (B.R. Cameron). Aspects of the technology are now being commercialized though the characteristics of the energy field are poorly understood. Regardless, the field appears atypical of the type of energy fields (e.g., sound, electric) often used at sites for fish diversion or exclusion to mitigate fish entrainment / impingement or block fish passage through ship-canals. While running his tests the developer and/or his team members observed that resident fish appeared to simultaneously avoid areas where devise was operating. Subsequently, he and others completed informal, *in-situ* tests (uncontrolled) specifically to observe resident fish behavior. Fish avoidance was again observed. This information was provided to, and discussed with A.G. Smythe and others, now senior scientists at the Shaw Group. It was suggested simple, short term and controlled flume tests be conducted to document and quantify the effects in a lab-type environment.

A study plan was developed, a flume-like apparatus was constructed (including both a treatment and a control flume), and a grid placed in the flumes. Multiple species of juvenile to young-adult fish were tested in groups (cyprinids, and a salmonid species). The objective was to see if differences in fish behavior could be observed, including residency (e.g., hovering-type activity) relative to location of the energy transducers (a dummy transducer was used in the control-flume). The transducers and water pump intakes were located at the same end of the low-flow flumes (water return at the opposite end).

With the device off, fish behavior appeared similar in treatment and control tanks, and they generally moved randomly throughout the flume, at times some fish apparently preferring to hover near the limited structure (e.g., baffle plates or transducers in treatment and control flumes). When the device was turned on, fish in grid-areas, closest to the transducer moved away, and moved relatively slowly. No fish ever returned to these exclusion areas (or zone) with the device on (i.e., 100% exclusion). Once the zone was vacated fish redistributed across the other grid-areas, though the numbers of fish/area generally increased moving towards the opposite end. However, after redistribution there was no obvious change in swimming behavior, and some movement was observed among all areas not in the exclusion zone.

Study details will be presented. Negotiations have begun for a full-scale exclusion study at a power plant intake. This study tentatively scheduled to begin in spring, 2007

NOTES

Use of Rotenone to Eradicate the Round Goby (*Neogobius melanostomus*) in Pefferlaw Brook

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The round goby (*Neogobius melanostomus*), native to the Black and Caspian seas region was introduced to the Laurentian Great Lakes in 1990, most likely from the ballast water of ships. In July 2004, goby were first discovered in Pefferlaw Brook, a tributary to Lake Simcoe, the largest inland lake in southern Ontario, Canada with a fishery valued at $200 million-a-year. Invasion via natural migration from the Great Lakes system was unlikely, due to distance from the source and the series of boat locking systems connecting Lake Simcoe. Also extensive surveillance indicated goby were only present in the brook. Transport of baitfish from the Lower Great Lakes was suspected as the most likely vector of introduction. Since the discovery, the Ontario Ministry of Natural Resources (OMNR) worked with Fisheries and Oceans Canada and other partners to document the distribution of round goby and investigate options for preventing the spread to Lake Simcoe. By August 2005, the goby distribution had extended to the mouth of the brook and OMNR proposed to treat the inhabited section of the stream with rotenone, a non-selective piscicide, to prevent the round goby from becoming established in the lake. In addition, treatment would permit proponents of the eradication plan to gain experience and knowledge in preventing future introductions and controlling aquatic invasive species elsewhere. An implementation plan was drafted that detailed stream characteristics and strategies for treatment. Pre-treatment work included a flow study to investigate stream hydrology using a tracer dye and a toxicity test to determine the susceptibility of the round goby to varying concentrations of rotenone. Based on data collected from the study, Fisheries and Oceans Canada's sea lamprey management program (DFO) developed a treatment plan and completed the application over a three-day period in October 2005. Low stream discharge encountered during the scheduled treatment time period was insufficient to effectively treat the upper section, and flows were augmented by manipulating a stop-log dam. The varied hydrology of the brook dictated that we use application techniques for both standing and flowing waters. Although this was the first application of rotenone conducted by DFO, the experience gained could form the basis of a rapid response model. We present the technical aspects of the application, results and recommendations for future treatments.

NOTES

Potential Economic Impacts of Zebra Mussels on the Hydropower Facilities in the Columbia River Basin

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Estimates of the potential economic impacts of zebra mussels in the Western United States vary widely. The purpose of this analysis was to estimate costs to the Federal Columbia River Power System's (FCRPS) hydroelectric projects in the event of a zebra mussel infestation.

We estimated the hydropower maintenance costs associated with zebra mussels by examining the Bonneville Dam First Powerhouse, costs associated with Asian clam (*Corbicula fluminea*) control at Bonneville, and a survey of zebra mussel mitigation costs at other hydropower generation facilities in North America.

We found that the one-time cost for installing zebra mussel control systems at hydroelectric projects could range from hundreds of thousands of dollars to over a million dollars per facility. The estimated cost for a hypothetical zebra mussel mitigation strategy, based upon two response scenarios (a sodium hypochlorite (NaOCl) injection system and anti-fouling paint), at 13 select hydroelectric projects, was $23,621,000. The cost per generator was $62,599 for the NaOCl system, and $81,000 for antifouling paint (not including labor). Removal, painting, sandblasting and installation could potentially double the costs for antifouling paint treatment.

We estimated that if a NaOCl system was installed at an "average" size Columbia River Basin facility and assuming intermittent use, annual operating costs would likely not exceed $100,000. Operating costs will vary depending on the facility, degree of infestation, environmental permits, etc.

This investigation found that once utilities initiate long-term mussel control programs, the programs usually become part of routine maintenance at annual, biennial, or longer intervals, depending on how rapidly the mussels recolonize the systems. Based on infestation and impacts responses elsewhere in the Eastern US, Canada, and Europe, there is no reason to believe that zebra mussels would cause a severe/disruptive economic impact/consequence/hardship to the FCRPS. Impacts to fish and wildlife resources, of course, is another matter.

A detailed management plan is needed to determine the best zebra mussel mitigation and control strategies for the FCRPS. It should detail key agency contacts and coordination; control technologies; permit requirements; costs for the hydroelectric and nuclear facilities, transportation, upstream and downstream fish passage system; and the environmental impacts of likely mitigation technologies. Engineers, biologists and other relevant experts with hands-on experience in developing zebra mussel mitigation strategies should be sought out and utilized.

NOTES

Technology, Psychology and Bullfrog Eradication

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Populations of the American bullfrog (*Rana catesbeiana*) have been popping up around the globe since the mid to late 19th century, but the rate of transport and release has greatly accelerated over the past 50 years. There are now well-established feral populations in western North America, Europe, Asia, South America, the Caribbean, and on some Pacific Islands. The incentive to introduce this species outside of its natural range is mostly driven by the vain notion that it can be successfully and profitably farmed for its large, meaty legs. This on-going entrepreneurial experiment has mostly been a bust because bullfrogs are difficult to contain, are cannibalistic, feed ravenously but – at least in temperate climates – grow slowly, and do not thrive in artificially crowded conditions. Disappointed erstwhile farmers quickly come to realize that bullfrogs are not so easily domesticated, and the bullfrogs simply hop off and take over the countryside. Each female produces upwards of 20,000 eggs per year and the tadpoles are distasteful to most predators, so tadpole mortality due to predation is remarkably low. Adult bullfrogs bully their way into naïve ecosystems and quickly become a dominating force through their sheer numbers, their prodigious and varied appetite and then, once firmly established, adults begin cannibalizing their own juveniles. Along the way a wide assortment of freshwater organisms and even species that visit water margins only briefly to drink or to reproduce are all vulnerable to bullfrog predation and competitive exclusion.

Historically, attempts at managing or even eradicating bullfrog populations have not shown much success. However, it is the contention of this study that biologists have been asking the wrong questions and then employing ineffective techniques. There are barriers here that involve the psychology of biologists and their inadequate understanding of the psychology of bullfrogs.

A research and development program is underway on southern Vancouver Island, on Canada's west coast which aims to prove that bullfrog populations can be eradicated when the right tools are at hand. Success also requires a sustained moral and financial commitment, and the application of these technologies must be approached more from a militaristic perspective than from the various schools of traditional biology.

Results from fieldwork in 2006 and 2007 will be presented and the innovations developed by this program in passive trapping and manual capture will be explained.

NOTES

Distribution, Density, and Population Dynamics of Invasive Applesnail *Pomacea Insularum* in Southeast Texas

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Channeled-type applesnails are aquatic invaders in many subtropical areas and are important agricultural pests, especially for crops such as rice and taro, which are water intensive. These invasive snails were introduced into North America in the late 1970s, and a reproducing population of channeled-type applesnails was first found in Texas in 1989. We documented the distribution and spread of *Pomacea insularum* in southeast Texas during 2005-2006. A GIS analysis of the spatial distribution of these invasive snails revealed that snails were clustered and concentrated in the southern outskirt of the Houston metropolitan area. Parameters including human population, land use/land cover, transportation corridors, air temperature, soils type, bedrock type, and water chemistry were spatially related to snail distributions in order to test for second-order effects.

Based on repeated monthly samples, the density of snails in natural waterbodies (streams and ponds) are typically low (max up to 44 snails/m^2), but much higher densities were recorded in canals that bring water to rice fields. We also found that depending on the nature of waterbody, *P. insularum* can exhibit two different types of population dynamics: relatively stable in natural waterbodies, and boom-and bust dynamics in artificial (agricultural) environments. These invaders have the potential to impact coastal ecosystems and the rice industry in Texas and the southern United States, but these impacts are likely to depend on the agricultural methods.

NOTES

Biological Control of the Invasive Aquatic Weed *Eichhornia crassipes* in Tamiraparani River Basin (India)

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The invasive aquatic weed, *Eichhornia crassipes* is native to South America and has spread to at least 50 countries around world in last 100 years. It exploits its freshwater habitat to the fullest use and solar energy-efficiently and is enormously productive. It is the only floating aquatic weed dominates over all the plant species in any freshwater habitats. As a successful invader of communities of native species, it competes favourably and can cause the reduction or elimination of other plant species.

In India *E. crassipes* an aquatic weed was first introduced in Bengal in early 1890s. *E. crassipes* had become a very serious problem and action was demanded in early 1900s. It usually forms a dense impenetrable cove,r which alters the microenvironment below the water surface. Chemical and mechanical methods of control of *E .crassipes* faced few major disadvantages to the water bodies and human beings. Where the biological control measures aims at finding suitable organisms, preferably though not necessarily associated with the weed either individually or in combination with other organisms to the extent of controlling its population.

Through a pilot study we have isolated weevils *Neochetina* bruchii and *N. eichhorniae*. Both laboratory and field trials were conducted on host range relationships, starvation, introduction and reintroduction of pests. We have observed that the weevils damaged only the *E. crassipes* which is the actual host plant. From the field studies it was found that *N. bruchii* and *N. eichhorniae* preferred the weed for their feeding and oviposition. These weevils can be able to coexist because of a shift in the abundance of their preferred oviposition sites cause by the seasonal development of the plants.

In general the field release and observation of weevils at three sites selected in the Tamiraparani basin suggests that weevils have successfully established themselves. The bio-control of weeds by weevils is natural, effective will no harm to any other plants and definitely these two species would probably complement each other if introduced elsewhere.

NOTES

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

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Until now, the bioinvasion considered to be the most important and dramatic was that of the dreissenids, *Dreissena polymorpha* Pallas and *D. bugensis* Andrusov. Unfortunately the golden mussel has taken first place in the ranking of the bioinvaders in continental waters. Today, *Limnoperna fortunei* has already traveled the whole south, southeast and center-west of Brazil going up the Paraguay River, and has reached the port of the city of Cáceres, MT, in the northwest limit of the Pantanal in Brazil. Although we have registered the presence of this alien here, the population is not yet actively installed. This prompted us to create an action strategy to monitor and control the spread of the golden mussel, not only to the other sub-basins, but to the Amazon Basin. In this way we involved federal, state, municipal and non-governmental organizations using different approaches:

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

NOTES

Golden Apple Snail: Global Invasion and Management

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Golden apple snail (GAS), *Pomacea canaliculata* is a major aquatic plant pest across Southeast Asia, especially in direct-seeded and flood-prone rice ecosystems. This freshwater molluscs that is common in rice paddies and irrigation canals, is listed in the 100 world's worst invasive alien species list by the Global invasive species database/ Invasive species specialist group (GISD/ISSG). Aside from wrecking havoc to farmer's major investments through increased yield loss, added control expenses and silent loss of biodiversity caused by misuse of pesticides in an attempt to control GAS, it also poses hazards to human health by being a potential host of various parasites and diseases such as the *Angiostrongylus cantonensis*, a nematode that can cause *eosinophilic meningitis* in humans. In addition, it reduces water quality and thus is an environmental pest.

At Philippine Rice Research Institute (PhilRice) we are experimenting on chemical rice seed coating with biorationals as one of the eco-friendly GAS management option. In this project, we identify chemicals that will either inhibit / repel / or change the behavior of GAS in direct-seeded rice culture. We do not aim to kill the GAS directly, but to reduce or avoid GAS feeding on the newly sprouted rice. The results of this project will be discussed highlighting the importance of developing such sustainable, environment-friendly, community driven and cost-effective management options to manage future GAS invasions.

NOTES

Presenter Biosketches

Hernando Acosta

Hernando Acosta is a biologist with interests in invasive species and the application of GIS and computer modelling to marine biosecurity. He did a Bachelors of Biology and a postgraduate in GIS in Colombia. He has also completed a MSc in Environmental and Marine Science in New Zealand, where he is now completing his PhD developing a biosecurity risk assessment model for the Golden-Tasman Bay region

David Aldridge

Dr. David Aldridge heads Cambridge University's Aquatic Ecology Group. His research interests focus on the ecology and conservation of unionid mussels and the biology and control of invasive mussels (notably zebra mussels and Asian clams). He has been Vice President of the Malacological Society, is member of the IUCN Mollusc Specialist Group and advisor to many British conservation steering groups. He provides a zebra mussel consultancy service to industry, managing projects for five major water companies and heading the UK Water Network project on zebra mussels.

Borys Aleksandrov

Borys is a marine ecologist/hydrobiologist. He is a member of the Ukrainian National "Man and Biosphere" Committee of UNESCO, and from 1996 to present he has been with the National Academy of Sciences of Ukraine including in the UNESCO International Coordinating Council on management of the trans-frontier Danube Delta Biosphere Reserve (Romania/Ukraine). During 2001-2004 was involved with biological observation and ballast water risk assessment in the Odessa port within the framework of the GEF/UNDP/IMO International GloBallast programme on overcoming barriers for efficient regulation and management of ballast water in developing countries. Borys is currently the Chairman of the Advisory Group "Conservation of Biodiversity" within the Secretariat of the Black Sea Commission. In 2007 he was involved in the 6th ALARM Framework Programme as the leader of bioinvasion experts from the Odessa Branch, Institute of Biology of the Southern Seas. They were involved in the programme as the new partner (TTC) TERENA (Trans European Research and Education) Technical Community.

Kęstutis Arbačiauskas

Dr. Kęstutis Arbačiauskas heads the Group of Invasive and Endangered Species at the Institute of Ecology of Vilnius University. He reads lectures on Animal Ecology at Vilnius University. His research interests focus on the ecology of native and alien crustaceans, aquatic food webs, impacts of invasives, and conservation of endangered aquatic species. He is an expert member of the Lithuanian Invasive Species Commission, a member of Societas Internationalis Limnologiae (SIL) and the Lithuanian Hydrobiological Society. He provides consultancy on assessment of ecological status of inland waters, dispersal and control of invasive species and leads the State monitoring program on invasive species in inland waters.

Sarah Bailey

Sarah Bailey is a Zooplankton Research Scientist with the Department of Fisheries and Oceans Canada. Her past work includes quantification of the risk posed by residual sediments in NOBOB vessels, as well as evaluating mechanisms to reduce that risk. In addition to evaluating current and potential treatment strategies for ballast water management, she is now conducting a research program to measure the rate of secondary spread of aquatic invasive species via domestic ship traffic.

Anna Barańska

Anna Barańska received a MSc in Marine Biology in 2006 from the Institute of Oceanography at the University of Gdańsk, Poland. She completed her Master Thesis on the diet components of invasive rockpool prawn *Palaemon elegans*. She is in the first year of her PhD studying the role of *P. elegans* in the Baltic ecosystem. Her research interests focus on crustacean biology and ecology and the role of crustaceans in marine ecosystems.

Mélanie Béguer

Mélanie Béguer is currently doing a PhD within the Estuarine Ecosystems Research Unit at the *Cemagref* Bordeaux, France. (This unit studies the global functioning of estuarine fish communities within estuaries.). Her PhD, funded by EDF, aims to model the population dynamics of two shrimp species in the Gironde Estuary (*Palaemon longirostris,* a native species and *P. macrodactylus,* an exotic one). The impact of the nuclear power station of Blaye (Gironde estuary) on these two species' mortality, is also investigated.

Helena Berglund

Helena is a PhD student in the Department of Ecology at Lund University where she works on problems concerning ecosystem vulnerability to NIS. She has a background in biology, mainly ecology, and mathematics. Her PhD-project involves finding methods to estimate resilience or inherent vulnerability to NIS and to understand which characteristics of a system that affects it. To accomplish this she has assembled data from international databases and, more locally, the material that will be presented at this conference.

Kathleen Beyer

Kathleen Beyer has recently finished her PhD research into the ecological implications of non-native fish introductions with the International Fisheries Institute at Hull University, UK. Her research interests include life history traits, eco-morphology, and dispersal of invasive fishes as well as potential impacts of non-native fishes on native communities, for example in regards to resource use. She is also interested in the role that invasive species play in the introduction and dissemination of parasites and the potential for biotic resistance within native ecosystems. Kathleen currently works as a Senior Aquatic/Fish Ecologist with APEM in Oxford, UK.

Amit Bhatt

Amit Bhatt has a degree in mechanical engineering; his interests include disinfection and safety of water treatment systems. He has worked in the field of turnkey execution of food projects and on applications for commercial and industrial water treatment systems. Amit now works as an Applications Engineering Specialist with ProMinent Fluid Controls Ltd., Canada

Angela Bobeldyk

Angela is a fourth-year PhD student at the University of Notre Dame. She is interested in the spread and impact of aquatic invasive species in lotic ecosystems of the Great Lakes region. Her previous research has included studies on the secondary spread of zebra mussels through lake-outflow streams and effect of Chinese mystery snails on nutrient recycling. Today Angela will be discussing the effect of rusty crayfish on streams in the Upper Peninsula of Michigan and northern Wisconsin and a collaborative project with The Nature Conservancy.

Irella Bogut

Irella Bogut obtained the BSc degree in Biology-Chemistry (1996) at the Department of Biology, J.J. Strossmayer University Osijek, Croatia. Since 1997 she has been working at the same Department, at the Division of Water Ecology. She obtained MSc (2000) and PhD (2005) in Ecology, both from the Faculty of Natural Sciences, Zagreb, Croatia. She is a part of the research team that is exploring interactions of the Danube with inland waters of the Kopački rit Nature park that is on RAMSAR list of wetlands of international importance. Irella is focused on benthic invertebrates in sediments and on macrophytes.

Stephen M. Bollens

Steve Bollens currently serves as Professor and Director of Sciences at Washington State University (WSU) Vancouver, as well as Interim Director of the WSU system-wide School of Earth and Environmental Sciences (SEES). He has previously held permanent or visiting faculty positions at the Woods Hole Oceanographic Institution, San Francisco State University, and the University of Washington. His research is broadly concerned with aquatic ecology, including animal behavior, population dynamics, community ecology and ecosystem dynamics. Dr. Bollens' research often has an applied aspect to it, touching upon such areas as invasive species, conservation biology, restoration ecology, fisheries oceanography, and global change.

Philip J. Boon

Dr Boon spent the first part of his career working as a freshwater ecologist at Newcastle University and the University of the West Indies, and the second as a scientific adviser for the Nature Conservancy Council and for Scottish Natural Heritage (SNH). In his present job with SNH he manages a group of staff responsible for their research programme, for work on environmental trends, and for providing technical support to our staff around Scotland. His role also involves continued input on freshwater conservation, especially as a member of the UK's Technical Advisory Group on

the Water Framework Directive (WFD). He also coordinates work on the Directive for the UK's conservation agencies, collaborates with the European Committee for Standardization on methods for WFD application, and chairs the Alien Species Group, a UK committee responsible for providing advice on how problems of alien species might be addressed under the Water Framework Directive.

Johanna Bradie

Johanna Bradie is an MSc student at the University of Windsor. She is interested in preventing the influx of invasive species through ballast water management. Johanna is investigating the efficacy of NaCl brine as a new treatment option for ballast water.

Terry Brady

Terry Brady is an Environmental Advisor with Ontario Power Generation's Lennox Generating Station located on the north shore of Lake Ontario near Kingston, Ontario, Canada. Mr. Brady, who possesses an educational background in civil engineering technology, has worked for 25 years in various business units within the provincial public power company, including Nuclear Construction, Transmission and Distribution Systems, and Fossil Generation. Since 2003, his role with respect to zebra mussel control has been one of a regulatory nature in which he provides oversight and monitoring services to the station, ensuring that compliance with the environmental certificate of approval and pesticides regulations are maintained.

Etienne Branquart

Etienne Branquart is responsible of the Belgian Forum on Invasive Species (ias.biodiversity.be), a structure that favours gathering of scientific information on biological invasions in Belgium and acts as the Belgian national node of the IUCN Invasive Species Specialist Group.

Lyubov E. Burlakova

Lyubov E. Burlakova, MS, Biophysics; PhD., Hydrobiology. Dr. Burlakova's research interests & areas of expertise include Aquatic Invasive Species: Ecology, Spread and Role in Ecosystems; Biodiversity and Conservation of Freshwater Ecosystems; Ecology of Freshwater Benthic Communities. Appointments include Research Scientist, Great Lakes Center, Buffalo State College, Buffalo, NY, September 2007- Present; Adjunct Professor, Research Scientists, Project Director, Stephen F. Austin State University, Nacogdoches, TX, 2001 – August 2007; Research Ecologist, University of the State of New York Museum Field Research Lab, 2001; Assistant Professor; Scientist, Belarusian State University, 1985 – 2000.

Joseph Caffrey

Dr. Caffrey is a Senior Research Officer with the Central Fisheries Board. The Board is a statutory body, which has primary responsibility for the co-ordination of protection, conservation, management and development of inland fisheries. He has conducted applied research with the Board for the past 30 years and specialises in the areas of Aquatic Plant Management and Recreational Fisheries Development.

Dr. Caffrey currently heads-up the Coarse Fish Unit within the Board and has been responsible for a number of multi-million euro EU sponsored projects. A significant proportion of this money was spent on angling development in inland waterways and the improvement of habitats and infrastructure to better promote angling. Aquatic invasive alien species are currently threatening important habitats in Ireland. Dr. Caffrey is heading up research in this area on behalf of the Irish Fisheries Boards.

Dr. Caffrey has considerable experience in the area of aquatic plant ecology and has written numerous scientific and peer reviewed papers on this and related themes He is the primary editor of, and a contributor to, three books dealing with Aquatic Plant Biology, Ecology and Management, published in 1966, 1999 and 2006. He also convened a major international conference on Aquatic Vegetation in Dublin in 1994. This event was attended by 270 delegates from 35 countries worldwide. Dr. Caffrey is a Committee Member of the Aquatic Research Unit of the European Weed Research Society (EWRS) and also of the European Inland Fisheries Advisory Commission (EIFAC).

Robert Calamusso

Bob began his fisheries career in Alaska working with native salmonid stocks. His work consisted of conducting inventory and monitoring programs. Thereafter he was employed by the Montana Department of Fish Wildlife and Parks, where he worked with salmonids throughout the western portion of the state. While in Montana he also studied the ecology of native and non-native Missouri River fishes. For the past 15 years he has worked throughout the Southwestern USA conducting research and management activities to determine the extent of loss of native fishes due to invasive species and other anthropogenic activities.

Ana Cristina Cardoso

Dr. Ana Cristina Cardoso is an aquatic ecologist. Her expertise is in ecological status assessment systems, eutrophication assessment and benthic invertebrate ecology in lakes and coastal waters. She is doing the first steps in research on the ecological impacts of invasive alien species in the aquatic ecosystems. Currently, she is involved in starting up a steering group on this issue within the context of the implementation of the European Water Framework Directive, with the main objective of drafting guidance on how to take into account the impact of alien species in the ecological assessment systems, and in the water body type for specific biological reference conditions.

Christine Marie V. Casal

Christine has been with the FishBase project of the WorldFish Center since 1995 developing the introductions database (in close collaboration with FAO's DIAS) and reports associated with global fish species movement and their impacts. Lately, she has been involved with the development of the abundance database in FishBase with colleagues from the University of British Columbia, documenting changes in species abundances in fish species in specific areas over the years. She has presented and published a number of papers on topics related to fish introductions and the biological characteristics of invasive fish species.

Peter A. Chang, III

Dr. Chang is a naval architect and hydrodynamicist at the Naval Surface Warfare Center in Carderock, MD. Since 2003 he has been the technical manager for a computational and experimental effort to develop an experimentally-validated computational tool to predict the efficacy of ballast water exchange. He holds a BSc and MEng from the University of California and a PhD from University of Maryland.

John F. Christmas

John Christmas is a PhD Candidate at George Mason University in the Environmental Science and Policy Department. He is also the President of the Franklin Environmental Group Ltd., a non-profit corporation that is devoted to charitable, educational, and research efforts relating to aquatic invasive species. He is a Biology Instructor at Northern Virginia Community College.

John Clayton

Dr. John Clayton is a Principal Scientist at NIWA (National Institute of Water and Atmospheric Research) and has worked on New Zealand lakes for 35 years. John's speciality is applied research and technical consultancy on Biosecurity and Biodiversity of aquatic plants including problems, control and management options. Research is currently focused on high-risk species, including novel methods of control for *Ceratpophyllum* (coontail or hornwort) and *Didymosphenia* (a newly invasive filamentous diatom). John has surveyed >100 lakes and with the aid of SCUBA has developed original survey methods using plants as a tool for assessing lake ecological conditions.

Alfred F. Cofrancesco, Jr.

Dr. Alfred F. Cofrancesco is the Civil Works Technical Director for Environmental Engineering and Sciences at the US Army Engineer Research and Development Center, Vicksburg Mississippi. His research focuses on the management of invasive species and he oversees the Corps of Engineers Invasive Species Research Programs. Dr. Cofrancesco represents the Corps of Engineers on the Aquatic Nuisance Species Task Force, Federal Interagency Committee on Management of Noxious and Exotic Weeds and has served since 1991 as Chairman of the USDA-APHIS, Technical Advisory Group for Biological Control Agents of Weeds. He holds a PhD in Biology from the University of Southern Mississippi

D. Bruce Conn

Dr. Bruce Conn is Professor of Biology and Dean of the School of Mathematical and Natural Sciences at Berry College in Mount Berry, Georgia, USA, and Associate in Invertebrate Zoology at the Museum of Comparative Zoology of Harvard University in Cambridge, Massachusetts, USA. His research centers on the biology of various invertebrate groups, and includes primarily work on parasites and reproduction. Bruce and his wife, Denise A. Conn, have conducted research for more than 20 years on dreissenid mussels and several other invasive species, from the Laurentian Great Lakes and major rivers of North America to freshwater areas of Ireland, Spain, Poland, France, and England.

Elizabeth J. Cook

Dr. Elizabeth Cook is an applied marine biologist who has published on a variety of topics ranging from sea urchin nutrition to environmental impacts of aquaculture to marine invasive species. Within the Scottish Association for Marine Science (SAMS), she heads the Marine Invasives Research Group and is a lecturer in Marine Biology. She also co-ordinates the Marine Aliens Programme (www.marlin.ac.uk/marine_aliens) and the Invasive Alga project. She is currently a member of the non-native species working group (Scottish Executive) and conducts annual surveys of the 10 largest marinas in Scotland in her search for invasive species.

Gordon H. Copp

Dr. Gordon Copp is a Canadian currently based in England. Following a BSc in Biology/Environmental Studies (Trent University, Peterborough, Ontario), Gordon undertook post-graduate training in environmental sciences (IHE, Delft, Netherlands), a PhD in fish biology (Université de Lyon, France), and was awarded a 'Habilitation à diriger la Recherche' in ichthyology (Université de Toulouse, France). Gordon's past research experience includes doctoral studies of larval and juvenile fish biology in large river flood plains (Lyon, France), post-doctoral studies of 0+ fish recruitment in the River Great Ouse (FBA, England), and nine years on the faculty of the University of Hertfordshire (England). Gordon is currently a senior researcher at Cefas, working mainly on the risks and impacts of non-native fishes.

Alexandra Marçal Correia

Alexandra M. Correia is an auxiliary investigator at the Universidade de Lisboa (UL), Museu Nacional de História Natural (MNHN). She concluded her Biology PhD in 1996 and her Biology degree in 1990 at UL. Alexandra has been investigating the effects of invasive species on the global functioning of wetlands through the study of population dynamics and trophic interactions of introduced and native populations. Particularly, she has been using the red swamp crayfish (*P. clarkii*) as a biological model. Presently, she is conducting an integrative study of the ecological and genetic processes presented by introduced and native populations of *P. clarkii*, as well as the interspecific interactions of this species with native and other invasive species from invaded wetland communities.

Becky Cudmore

Becky Cudmore is the national Manager for Fisheries and Oceans Canada's Centre of Expertise for Aquatic Risk Assessment for Aquatic Invasive Species. She coordinates and advises on national risk assessments conducted in Canada. She has also conducted risk assessments for Asian carps and northern snakehead to Canada and to North America. Becky is currently work on assessing the risk of live trade in Canada and is also involved in several aquatic invasive species research projects looking at the ecology of aquatic invasive fishes.

Carolynn Culver

Dr. Carrie Culver is the Marine Advisor for the University of California Cooperative Extension Sea Grant Extension Program in Santa Barbara and Ventura Counties, California. She received her PhD in Ecology, Evolution and Marine Biology from University of California, Santa Barbara. While working on her PhD, she developed a successful eradication program for a marine pest; a South African sabellid worm that infested abalone and other gastropods. Since then she has been actively engaged in research and outreach activities of marine, estuarine and freshwater aquatic invasive species.

Márcia Divina de Oliveira

Márcia has been a research scientist at the Center for Agricultural Research in the Pantanal (EMBRAPA) since 1995. She has worked with aquatic biological invasions since 1998, when the golden mussel, an invasive species, came to the Pantanal wetland. She is monitoring its density along the Paraguay River and connected lakes and has studied growth rates and natural limiting factors to its development.

Aldona Dobrzycka-Krahel

Dr. Aldona Dobrzycka-Krahel is a marine ecologist. She obtained her MSc in 1993 and PhD in 1998 from the University of Gdańsk, Poland. She is currently employed with the Department of Experimental Ecology of Marine Organisms, Institute of Oceanography at the University of Gda sk, Poland. Her research interests are biology and ecology of non-indigenous crustacean species in the Baltic Sea.

Concha Durán Lalaguna

Since 1997 Concha has worked in the Ebro Hydrographic Confederation. Currently her work is focused in the completion of the Water Framework Directive, and also in works related to the invasion of zebra mussel in the basin of the river Ebro. She is the technician directly responsible in the Ebro Hydrographic Confederation. She is responsible within the European Union, of the group of Intercalibración IC GIG Alpine (with Austria, Germany, France, Italy and Slovenia) for the implementation of the Water Framework Directive, and the Spanish Representative in the European workgroup on Invasive Alien Species and Water Framework Directive.

Anna Dziubińska

Anna Dziubińska is a PhD student at the Institute of Oceanography, University of Gdańsk, Poland, in the Department of Experimental Ecology of Marine Organisms. She received her MSc in 2006 in oceanography. She completed her Master Thesis on the influence of temporal variability of disturbance on the structure and biodiversity of fouling communities in the Gulf of Gdańsk, Southern Baltic Sea. The main area of her current research is the succession process of marine fouling communities and relationship between organisms composing these assemblages.

Brian Elliott

Brian has worked in the marine environmental field for the last 20 years. He graduated with a Joint Honours BSc Degree in Marine Biology and Oceanography from UCNW, Bangor and a MSc in Marine Resource Development and Protection from Heriot Watt University. He has worked in the fields of environmental consultancy, environmental management, marine and coastal conservation, environmental education in Eastern Europe, estuary management on the Humber Estuary and maritime pollution incident response for the UK Government.

In early 2003, Brian joined the UK Maritime and Coastguard Agency's Environmental Quality Branch where he has been the UK policy lead for numerous environmental issues concerning shipping. Presently he is the UK policy lead for Ballast Water, Biofouling and Air Pollution Issues. As such he is responsible for leading the development of the Ballast Water Management Strategy for the North East Atlantic and has been the Chairman of the IMO's Ballast Water Management Working Group for the last two years.

Richard Everett

Dr. Everett, a marine biologist by training, coordinates the US Coast Guard's research activities on the prevention of biological invasions via the operations of ships, and provides technical assistance in developing and implementing regulatory and operational programs. He holds a BA in Biology from the University of California, Santa Cruz, and a PhD in Zoology from the University of California, Berkeley. Following post-doctoral positions at the Oregon Institute of Marine Biology and the Smithsonian Environmental Research Center, he was a Senior Staff Biologist with the US Fish and Wildlife Service.

Jill Finster

Jill Finster is a Communications and Policy Associate at the Great Lakes Fishery Commission. She assists with development and implementation of the communications program and commission policies. She also serves as the Secretariat

Liaison to the Great Lakes Law Enforcement Committee. In this role, she provides support to committee members and facilitates the development of inter-jurisdictional Combined Enforcement Teams. Jill received a joint Masters degree from the School of Criminal Justice and the Department of Fisheries and Wildlife at Michigan State University. Her research focused on the regulation and enforcement of injurious species within the Great Lakes Basin. She has a BA in Criminal Psychology and Women's Studies from the University of Michigan and an MS in Fisheries and Wildlife from Michigan State University.

Nadine C. Folino-Rorem

Nadine is an aquatic biologist with a Master's and PhD in marine invertebrate zoology now conducting research in freshwater ecology. Her work focuses on the invasive history, systematics and ecology of the euryhaline hydroid, *Cordylophora*. The systematics and invasive history work is in collaboration with John Darling, EPA, Cincinnati, Ohio, while the association of *Cordylophora* with zebra mussels is being addressed in collaboration with James Stoeckel, Miami University, Ohio. In addition, collaborative with Martin Berg, Loyola University Chicago, Illinois to addresses the predatory role of *Cordylophora* in Lake Michigan to assess potential effects on fish prey availability.

Pam Fuller

Ms. Fuller is the program leader for the US Geological Survey's Non-indigenous Aquatic Species Program, which maintains a nationwide database, and a web site of aquatic invaders. She is author of the summary book "Non-indigenous Fishes Introduced into Inland Waters of the United States" which reviews the introductions of more than 500 species and looks at spatial and temporal patterns of these introductions. She has been involved in numerous national and international invasive species research activities and work groups, particularly in the field of invasive species information management. She has collaborated with the Smithsonian Environmental Research Center to develop NISbase – a distributed query system for aquatic invasive species databases.

Bella Galil

Bella S. Galil is a Senior Scientist with the National Institute of Oceanography, Israel Oceanographic and Limnological Research, Haifa, Israel. Her main fields of study are alien species in the Mediterranean; the impact of anthropogenic changes on the benthic populations in coastal and deep waters along the Mediterranean coast of Israel; decapod crustacean taxonomy and biology (Polychelidae, Calappidae, Leucosiidae); and conservation of marine biodiversity. She has published more than 150 scientific papers.

Liam Gavin

Liam Gavin has been working with the Western Regional Fisheries Board (WRFB) since 1996 where he is a fisheries officer, with responsibilities for the development and protection of the Lough Corrib as a natural resource and to utilise its full potential in a sustainable approach. Liam has studied and completed a higher certificate in Fisheries Management in Institute of Technology Sligo. His final year project was based on the quantitative abundance of *Lagarosiphon major* on Lough Corrib.

Francesca Gherardi

Francesca Gherardi, PhD, teaches Zoology, Conservation Biology, and Applied Ethology at the University of Florence, Italy. Dr. Gherardi is the author of more than 130 articles published in international journals. She has been the editor of *Crayfish in Europe as alien species* (Balkema, 1999), *Biodiversity conservation and habitat management* (Encyclopedia of Life Support Systems, UNESCO, 2002), and *Biological invaders in inland waters: profiles, distribution, and threats* (Springer, 2007), and is currently part of the editorial board for *Aquatic Invasions*, *Biological Invasions*, *Ethology Ecology and Evolution*, and *Journal of Crustacean Biology*. She is a member of the *Invasive Species Specialist Group* (IUCN).

Dan Gilson

Dan Gilson is a project manager with the Prince William Sound Regional Citizens' Advisory Council (RCAC) in Valdez, Alaska, USA. He has been assisting RCAC for six years with the council's work on non-indigenous species and oil spill response. The RCAC began working in conjunction with the US Fish and Wildlife Service and the Smithsonian

Environmental Research Institute on Non-Indigenous Species issues beginning in 1996 and cosponsoring research on ballast water exchange and invasive species introduction. Most recently, the council is leading an effort to monitor invasives, including tunicates and European Green Crab.

Dr. Stephan Gollasch

Dr. Stephan Gollasch was involved in the first European ship sampling programme on ballast water, tank sediments and ship hull fouling (1992-1996). His PhD is worldwide the first thesis based on ballast water sampling. As an independent consultant he is today involved in various projects related to biological invasions (e.g., ballast water treatment, ship sampling, risk assessment). Recently, he was involved in the development of ballast water management scenarios for several European Seas. Ongoing contracts also include onboard efficacy tests of ballast water treatment systems.

Ana M. González-Tizón

Dr. Ana M. González-Tizón is an associate professor in the Department of Cell and Molecular Biology of the University of La Coruña. She is an expert on mollusc cytogenetics (chromosomes, banding, FISH), identification of molecular markers (microsatellites, RAPDs, RFLPs, ISSRs, mitochondrial DNA, nuclear ribosomal genes), population genetics, phylogeography and evolution of marine organisms. Furthermore, she has worked on the assessment of bivalve species/populations and identification of manufactured products. At present, her research work involves marine mollusc invasions and conservation genetics.

Michal Grabowksi

Michal Grabowski, PhD, has been adjoint professor at the University of Lodz, Poland since 2000. His education includes a BSc. from the University of Wolverhampton (UK); a MSc at the University of Lodz, Poland; PhD research at the University of Southern Mississippi, USA; and a PhD from the University of Lodz, Poland. His research interests include biogeography and ecology of invasions in aquatic environments, phylogeography of aquatic biota, and Amphipoda, Mysidacea, Decapoda, gobiid fishes. He continues to author numerous research papers.

Thaddeus Graczyk

Dr. Thaddeus Graczyk is an Associate Professor in the Department of Environmental Health Sciences in the Johns Hopkins Bloomberg School of Public Health in Baltimore. His past and current research interests are focused on human, zoonotic, protozoan and helminthic parasitoses, molecular diagnostic methods for parasitic infections; identification of human parasites in environmental samples, molecular epidemiology and transmission cycles of waterborne pathogens, and hostparasite interactions. Overarching research objectives include improvement of the public health through better recognition of epidemiology and epizootiology of parasitic infections. He serves as PI for multiple projects investigating recovery of human waterborne pathogens by molluscan shellfish.

Jonathan F. Grant

Jonathan F. Grant serves as Test Director for Naval Research Laboratory's Ballast Water Treatment Test Facility (BWTTF) located in Key West, FL. He has been involved with the facility since its inception in 2003, where initially he was responsible for design and implementation of the instrumentation, control and data acquisition facilities. His responsibilities grew along with the facility to include the development and assessment of test methods and biological instrumentation, and preparation of the facility test plan to implement the draft Environmental Technology Verification protocols. Most recently, he was responsible for directing execution of the Environmental Technology Verification Pilot Test at the BWTTF. Mr. Grant is Vice President of Battenkill Technologies, Inc., a small business that provides scientific, engineering and software R&D services and products to the US Federal Government and their contractors. He has extensive experience in developing measurement and control systems for unique laboratory and field applications.

The Right Honourable Herb Gray

The Rt. Hon. Herb Gray represented the federal riding of Windsor West in the Canadian House of Commons from June 1962 to January 2002. He was elected a record thirteen consecutive times and also set a record for continuous days of service in the House of Commons — 39 years, six months and 26 days.

Mr. Gray ceased to be Deputy Prime Minister and resigned from the House of Commons in January 2002 to become the full-time Chair of the Canadian Section of the International Joint Commission – an autonomous international organization created by the Boundary Waters Treaty between Canada and the United States dealing with trans-boundary issues concerning water and air. He graduated from the School of Commerce of McGill University, Montreal, Canada and Osgoode Hall Law School, Toronto, Canada. He is a member of the Ontario Bar. Mr. Gray worked extensively as Deputy Prime Minister, as a Minister, and as a Member of Parliament in the fields of parliamentary affairs; economic and industrial development; foreign investment; finance; consumer protection; competition; international trade; federal law enforcement; the environment and climate change; and Canada-US border issues. In November 2001 he received the first John Fraser award for Environmental Excellence from the Sierra Club of Canada.

In January 2002 The Governor General of Canada bestowed on Mr. Gray the title "Right Honourable" making him one of only 16 Canadians to currently hold this title. Mr. Gray is also a Companion of the Order of Canada – the highest designation of the Order of Canada.

Hassan Hasan

Hassan Hasan is PhD student at the Muséume National d'Histoire Naturelle in Paris. His interests include crustacean decapods, marine biology, invasive (or lessipsian) species, and inventory of biodiversity.

Michael D. Hasson

Mr. Hasson has been the Technical Manager for Ecochlor since January 2004. Prior to Ecochlor, Mr. Hasson was a self-employed consultant to the water treatment industry, focused primarily on liquid/solid applications. He has 25 years of experience in the water treatment business across a broad range of applications including drinking water treatment, industrial and domestic waste water treatment, industrial water re-use applications, and process applications such as pulp and paper making. Mr. Hasson had previously worked with Mr. Tom Perlich, President of Ecochlor, as a process specialist for Vulcan Performance Chemicals.

Deniz Haydar

Deniz Haydar is a PhD candidate at the University of Groningen in the Netherlands. She is currently writing her dissertation, which she is hoping to defend in spring 2008. The main topics of her thesis are the homogenization of invertebrate populations on a regional scale through shellfish translocations, and the influence of historical shipping on dispersal of species across the North Atlantic Ocean.

Elise Michele Heinz

Elise Michele Heinz is a research student and Biological Sciences tutor at Middlesex University, UK. Her doctoral research utilises microsatellite polymorphisms to track genetic speciation of the invasive amphipod shrimp *Crangonyx pseudogracilis* in British freshwater populations to generate both specific and generic predictive models. Previous published research has examined the concurrent validity of a littoral biological exposure scale using multivariate statistical analyses.

Rob Hengeveld

Beginning as a demographic ecologist or population dynamist, of the Leiden School in the late 1960s, Rob developed into a ecological biogeographer during the 1970s. At the end of that decade when invasion research took shape, he included that approach into his biogegraphical studies, leading to the book *The Dynamics of Biological Invasions,* which came out earlier than *Dynamic Biogeography* although that was written earlier. Since then, he deepened his studies of invasions research, using, developing and applying the mathematical approach of the group of Leiden biomathematicians to invasion research. This culminated in a study on the application of the invasion models to the field of range dynamics in biogeograhy. In his opinion, therefore, invasions are a normal aspect of the dynamic spatial adaptation to the ever changing climatic conditions across a species range, and ecology explains why they occur. Invaders, as a consequence, do not form a special category of species, distinct from sedentary, non-invading species. This is the line he developed through the years since the early 1980s and up to the present.

John Hesselschwerdt

John Hesselschwerdt is a graduate biologist at the University of Constance, Germany working on his PhD thesis about "The influence of the invasive amphipod *Dikerogammarus villosus* on leaf litter decomposition and the benthic community in Lake Constance". One main topic is the interaction of invasive and recent gammarids. The studies are participating the CRC 454 Bodenseelithoral of the Deutsche Forschungsgesellschaft, the EC-Interreg IIIA project ANEBO (Aquatische Neozoen im Bodensee) and the international working group of aquatic neozoans in southern Central Europe (AKAN). Further studies with invasive gammarids were accomplished at the Balaton Limnology Research Institute, Hungary.

Joanna Jaszczołt

Joanna Jaszczołt is a PhD student in the Institute of Oceanography, at the University of Gda sk, Poland. Her first degree in Marine Biology was completed in the Department of Experimental Ecology of Marine Organisms in the Institute of Oceanography. She completed her Master Thesis on reproduction and growth of American crayfish *Orconectes limosus* in brackish waters. She is in the first year of her PhD studying alien decapod crustaceans. Her research interests focus on crustacean biology and ecology and the future application of marine crustaceans into aquaculture.

Jamileh Javidpour

Jamileh is a PhD student of the Leibniz Institute of Marine Science focusing on eco-physiology of the Ctenophore population of the Baltic Sea, which is the first study after 30 years in this area. Jamileh was able to identify and recognize *Mnemiopsis leidyi*, the new invader of the Baltic and North Sea, which had a bad reputation in its exotic habitat. Jamileh's recent study shows how the lower level of an invaded ecosystem could control population of invader top predators.

Douglas Jensen

For nearly 14 years, Doug Jensen has been the Aquatic Invasive Species Program Coordinator at the University of Minnesota Sea Grant Program in Duluth, Minnesota, USA. He has conducted monitoring, outreach and research with focuses on control. He has also provided leadership to international levels. Doug produced several educational resources including the videotape, *Stop Exotics, Clean Your Boat*, featuring John Ratzenberger from the popular TV show *Cheers*. Currently, he working to co-lead *Habitattitude™,* a national campaign aimed to prevent the release of unwanted aquarium fish and plants, and implementing the national *Stop Aquatic Hitchhikers!* campaign in three U.S. states, results which he'll present at this conference. He is also working to help develop a statewide invasive species plan for Minnesota. Before Sea Grant, Doug was a researcher at the US Environmental Protection Agency laboratory in Duluth. He nearly has an MS of Education and has a BS in Biology from the University of Minnesota Duluth.

Ravindra C. Joshi

Dr. Ravindra C. Joshi is the Chief Science Research Specialist at the Office of Executive Director, Philippine Rice Research Institute, Philippines. Dr. Joshi specializes on invasive alien species that affect rice production globally. One of his major research focuses is on the freshwater snails, the golden apple snails, *Pomacea* spp. […..considered one of the World's 100 worst invasive alien species, by the International Union for the Conservation of Nature, and Invasive Species Specialist Group]. Dr. Joshi's research on this alien mollusk, started since its first reported rice crop damage in the Philippines during the late 1980s. One of his most recent contributions is publication of a comprehensive book "Global Advances in the Ecology and Management of Golden Apple Snails" edited by Dr. Joshi and Dr. L.S. Sebastian.

Tomasz Kakareko

Tomasz received his MSc and PhD degrees in environmental biology from Nicolaus Copernicus University in 1996 and 2000. Currently he is an assistant professor at the university in the Department of Hydrobiology. His research is focused on fish ecology in a dam reservoir on the Vistula River, with particular emphasis on non-indigenous *Neogobius* species. Recently, in cooperation with his friends, hydrobiologists and zoologists, he conducted laboratory and field studies on factors affecting distribution and feeding habits of *N. gymnotrachelus* and *N. fluviatilis* in the reservoir, as well as their interactions with other organisms (e.g., Ponto-Caspian amphipods, *Dreissena polymorpha*).

Alexander Y. Karatayev

Alexander Y. Karatayev, BA, Biology; PhD, Hydrobiology; Doctor of Sciences, Hydrobiology. His research interests & areas of expertise include ecology, biology, parasitology and spread of aquatic invasive species and their role in aquatic ecosystems; biodiversity, conservation and management of freshwater ecosystems; taxonomy, biology, ecology and productivity of benthic and periphyton communities; ecology of cooling water reservoirs. His appointments include Professor, Director of Great Lakes Center, Buffalo State College, Buffalo, NY, September 2007- Present; Professor, Biology Department, Stephen F. Austin State University, Nacogdoches, Texas, 2001 – August 2007; Research Ecologist, University of the State of New York Museum Field Research Lab, 2000-2001; Chair, General Ecology Department; Chief, Aquatic Ecology Department, Scientist, Belarusian State University, 1977-2000.

Tarja Katajisto

At present, Dr. Katajisto is working on the project "The strategy and success of invasive species in the Baltic food web´. I concentrate on recruitment of *Cercopagis pengoi* from benthic resting eggs after winter. Dr. Katajisto worked with similar questions for his PhD, which was finished last year. He studied the occurrence and role of resting eggs in the life cycles of calanoid copepods, two native and one invader species, in the Baltic Sea. His home institutions have been and are Tvärminne Zoological Station and Finnish Institute of Marine Research.

Timothy R.E. Keeney

Timothy Keeney is the Deputy Assistant Secretary for Oceans and Atmosphere at the National Oceanic and Atmospheric Administration in Washington, DC. Responsibilities include Co-Chair of the Aquatic Nuisance Species Task Force and Co-Chair of the National Invasive Species Council. Previous positions held include Commissioner for the Department of Environmental Protection for the State of Connecticut and Director of the Department of Environmental Management for the State of Rhode Island. Mr. Keeney has a BS degree in Economics from the Wharton School of Business, University of Pennsylvania and a J.D. degree from the School of Law at the University of Connecticut.

Daniel Kelner

Dan received an MS in Biology in 1994 from the University of Wisconsin-Eau Claire in Aquatic Ecology. For the past 13 years Dan has worked as a malacologist for a private consulting firm, the State of Minnesota Department of Natural Resources, and the US Army Corps of Engineers. As a member of an inter-agency team, Dan has been involved for the past five years in inventory, monitoring, and propagation studies designed to contribute to the conservation and recovery of two federally endangered mussel species threatened by zebra mussels.

Åsa Kestrup

Åsa Kestrup is a PhD student in the Department of Biology at McGill University, Montreal, Canada under the supervision of Dr. Anthony Ricciardi. Åsa received her MSc degree at Lund University, Sweden in 2003, in which her research tested the effects of multiple indigenous predators on the invasive golden apple snail in Laos. She has also done fieldwork throughout Sweden as well as in Poland, Greece, Uganda, and the Dominican Republic. Her doctoral research examines environmental factors affecting the species richness and dominance of invaders in aquatic ecosystems.

Daniel Kluza

Dr. Daniel Kluza is a marine risk analyst with Biosecurity New Zealand. His work on non-indigenous species focuses on stressor-response relationships, ecological risk assessment, and predicting potential geographic distributions. Daniel holds a BA in Zoology from Connecticut College, and an MS in Wildlife Biology from the University of Massachusetts at Amherst. He earned his PhD in Ecology and Evolutionary Biology at the University of Kansas.

Jarosław Kobak

Since completing his PhD in 2001, Jaroslaw has worked at the Nicolaus Copernicus University, Toru , Poland in the Department of Invertebrate Zoology. His scientific interests focus on zebra mussel biology. He has investigated factors affecting settlement of larvae and their subsequent distribution on substratum, as well as behaviour of metamorphosed individuals. His studies deal with mussel attachment strength, locomotion and aggregation behaviour in response to such factors as light, gravity, predators, conspecifics and substratum type. His current research concerns interactions between mussels and other organisms, particularly Ponto-Caspian gammarids. During the ICAIS, he will present the first results of this study.

Alicja Konopacka

Alicja Konopacka has a PhD in Zoology, and is a senior lecturer at the Department of Invertebrate Zoology and Hydrobiology at the University of Lodz in Poland. Her research interests focus on the identification and distribution of non-indigenous crustaceans (particularly freshwater and marine amphipods of Ponto-Caspian origin), their life strategies and habitat preferences. Together with Krzysztof Jazdzewski, Michal Grabowski and Karolina Bacela she is a member of the Non-indigenous Species Working Group of the University of Lodz.

Pavel Kozák

Dipl. Ing. Pavel Kozák, PhD is the vice director and head of the Department of Aquaculture and Hydrobiology of the Research Institute of Fish Culture and Hydrobiology at Vodňany, University of South Bohemia, Czech Republic. He is a member of the International Association of Astacology and the Crustacean Society. His areas of interest are the study of native and non-native crayfish biology and crayfish breeding under controlled conditions. He obtained his PhD at the University of South Bohemia, where he now teaches the subject "Crayfish biology and breeding". His PhD thesis was focused on biology of signal crayfish.

Jenny Leal-Flórez

Jenny graduated as a Biologist at the University of Antioquia, Medellín, Colombia in 1996. She obtained a MSc in Aquatic Tropical Ecology from the University of Bremen and the Center for Marine Tropical Ecology (ZMT) in Bremen, Germany in 2001. She is currently a PhD Candidate at the same German institutions, studying the role of introduced fish in the Ciénaga Grande de Santa Marta Estuary, Northern Colombia. She has research experience in fresh water and estuarine fish ecology and teaching experience in Ecology and Aquatic Biology at the University level. Her research interests fall mainly within the fields of fish ecology in special relation to exotic species, but also aquatic resource management and biodiversity conservation.

Jennifer Lenz

Ms. Jennifer M. Lenz graduated from the University of Texas at San Antonio with a BS in Biology in 1999, and from the University of North Texas with a MS in Biology in 2002. During her studies, she worked for the US Army Corps of Engineers doing biological control research. She thoroughly described the reproductive morphology of a control agent for Hydrilla, and subsequently developed a system for identifying reproductive status and history. Ms. Lenz also spent two years in an Entomology PhD program at the University of California-Riverside. There she continued her studies in Biological Control, focusing on crop pests.

Erkki Leppäkoski

Professor Erkki Leppäkoski received his PhD in Zoology in 1975 from the University of Turku, Finland. He was a marine biologist at Kristineberg Marine Research Station, Sweden from 1966-72. He was Professor of Ecology and Environmental Research at Åbo Akademi University since 1977 and retired in 2005. His scientific interests include introduced (alien) species in brackish-water seas and coastal waters of Europe, transfer and introduction of species, especially by ships, risk assessment for marine alien species in the Nordic area and o board treatment of ballast water. He is the Chief Editor for *Invasive Aquatic Species of Europe: Distribution, Impacts and Management* (583 pp), published by Kluwer Academic Publishers in 2002

Rob S.E.W. Leuven

Dr. Rob Leuven studied aquatic ecology and aquaculture. He is an associate professor at the Department of Environmental Science, Radboud University Nijmegen and a member of the Dutch Commission for Environmental Impact Assessment. His PhD thesis (1988) concerns the impacts of acidification on aquatic ecosystems. His recent research has been focused on ecology and sustainable management of large rivers. Current projects deal with aquatic invasions, ecological risk assessment, biodiversity conservation and ecological rehabilitation of riverine ecosystems. Rob Leuven was project leader of several large research projects commissioned by the World Bank, European Commission and several Dutch ministries, municipalities, advisory boards and non-governmental organisations.

Frances E. Lucy

Dr. Frances Lucy is a lecturer at the Institute of Technology, Sligo in Ireland, where she teaches ecology, fisheries management, conservation and water pollution. Actively involved in zebra mussel research, she is fortunate to work with a range of international scientists, many of whom she met at this ICAIS conference series.

Hugh MacIsaac

Hugh MacIsaac is a professor and Fisheries and Oceans Canada Invasive Species Research Chair at the University of Windsor. He is also the Director of the Canadian Aquatic Invasive Species Network. He has worked on invasive species for 17 years, and is interested in vectors and pathways of invasion, invasion theory, and developing invasion models.

Catriona Maguire

Cathy Maguire is principal researcher at EnviroCentre and visting research fellow at Queens University Belfast. She has a BSc (Hons) in Environmental Biology, MSc in Applied Environmental Sciences and a PhD in Freshwater Ecology. She is the project manager for the Invasive Species in Ireland project run by EnviroCentre and Quercus and jointly funded by Environment and Heritage Service and National Parks and Wildlife Service. The project consists of risk assessments for potential and established invaders, development of management plans, exclusion strategies and contingency plans; legislation review and revision; stakeholder engagement and development of codes of practice and education and awareness programmes.

Nicholas E. Mandrak

Nick Mandrak is a Research Scientist with Fisheries and Oceans Canada, and leads the Species at Risk Programme for the Great Lakes basin and a national Centre of Expertise for Risk Assessment of Aquatic Invasive Species. His research interests are the biodiversity, biogeography and conservation of Canadian freshwater fishes. Nick has recently completed risk assessments on Asian carps and snakeheads with Becky Cudmore. He is a member of the NSERC Canadian Aquatic Invasive Species Network for which he is conducting risk assessments of the major pathways of invasive freshwater fishes.

Lucie Maranda

Lucie Maranda received her BSc and MSc in biology from Université Laval, Québec, Canada and her PhD in oceanography from University of Rhode Island, USA. She is a marine research scientist at the Graduate School of Oceanography at the University of Rhode Island. Her research encompasses two fields: 1) Control of invasive species via treatment of ballast water and the use of selected materials with antifouling capacities and 2) Ecology of harmful algal blooms with an emphasis on the population dynamics of epiphytic species and their links to shellfish contamination.

Sergey E. Mastitsky

Sergey Mastitsky received his PhD degree in aquatic ecology in 2004. Currently he is working as an Assistant Professor at the General Ecology Department, Belarusian State University. His research interests include ecology and parasitology of zebra mussels and other aquatic invasive species and their role in aquatic ecosystems. Sergey is a chief editor of the on-line database "Aquatic invaders of Belarus: Alien Species Database".

Alexey Maximov

From 1985 to 2001 Alexey Maximov worked in different organizations of the Federal Service of Russia for Hydrometeorology and Environmental Monitoring and specialized in the field of monitoring of benthic macrofauna. Since 2001 he has been a research scientist at the Zoological Institute of the Russian Academy of Sciences (St.-Petersburg). His main research interests are related to long-term changes in bottom communities especially in the Baltic Sea. Since the mid-1990s, because of the increasing role of alien species, his attention focuses on the effects of biological invasions. He holds doctor's degree from Zoological Institute.

Daniel McClary

Dr. Dan McClary (MSc, PhD) is the principal marine scientist in the Auckland, New Zealand office of Golder Associates. He has over 17 years professional experience in environmental science, consulting and education, specialising in marine biosecurity, benthic ecology and effects assessment. Dan is a marine biosecurity scientist with specific expertise

in vector management, development of incursion response tools, port surveillance and risk assessment. Dan is a past president of the New Zealand Marine Sciences Society, and is currently Chairman of the Editorial Advisory Board of the NZ Journal of Marine and Freshwater Research.

Vincent Médoc

Vincent Médoc is a second-year PhD student in Biology and Ecology at the University of Metz, France. He joined the laboratory to investigate the inter-specific relationships between exotic and native invertebrates in aquatic systems. His research interests focus on the outcome of predator-prey interactions when the prey is infected with a manipulator parasite. Within the tested host-parasite system, the benthic crustacean *Gammarus roeseli* serves as an intermediate host for the acanthocephalan *Polymorphus minutes,* which benefits from behavioural changes to reach its avian definitive host. He currently attempts to underline the selective role of non-host predators in parasite's transmission strategies.

Marjolein Messiaen

Marjolein started her PhD about 'Modelling invasive macroinvertebrates in rivers' in 2005. To date, she has analysed samples of the Flemish Environment Agency whereby special attention was paid to invasive macroinvertebrates (mainly belonging to the crustaceans and molluscs). Recently, she has been developing different models to explain the obtained monitoring results. Her laboratory – Aquatic Ecology – has experience in the development of ecological models for the prediction of macroinvertebrates such as Artificial Neural Networks, Classification Trees, Fuzzy Logic, etc. to support decision-making in river management.

Michael Millane

Michael Millane is a PhD student based in the School of Biology and Environmental Science in University College Dublin. He has an Honours degree in Biology from NUI Maynooth. In addition, he has a Masters degree in Applied Environmental Science also from UCD. He has previously worked as a Fishery Assistant with the Central Fisheries Board and as a Fishery Officer at the Eastern Regional Fisheries Board. His current work is being supported by the Central Fisheries Board and Shannon Regional Fisheries Boards, as well as through a grant from the Irish Research Council for Science Engineering and Technology.

Dan Minchin

Aquatic alien species, their impacts, distribution and management, are Dan's areas of interest. He is presently supported by the EU 6th Framework Programmes DAISIE and ALARM and is a member if the IUCN Invasive Specialist Group. He has been working recently on *Dreissena polymorpha*, *Elodea nuttallii* and the tunicate *Didemnum* sp. His interest in species transmissions involves the spread of alien species by small craft at sea and through navigable waterways. He is a founding member of the Lough Derg Science Group that looks at local management issues based on international experience.

Dan Molloy

Dan Molloy is an aquatic biologist with the New York State Museum and is the Director of its Cambridge Field Research Laboratory. His research focuses on the biology, ecology, and systematics of aquatic invertebrates and their endosymbionts. His lab also maintains an active research program evaluating environmentally-safe, biocontrol agents for the management of aquatic pest species, such as zebra mussels.

Philip B. Moy

Since 1999 Phil has been the Fisheries and Non-indigenous Species Specialist for the University of Wisconsin Sea Grant Institute. He works with Great Lakes commercial, sport and charter anglers as well as inland lake groups to address fisheries and aquatic invasive species concerns and provide research information to Great lakes user groups. He holds a doctorate in zoology from Southern Illinois University at Carbondale. Before coming to Wisconsin Sea Grant, Phil was the Fisheries Biologist for the Chicago District Army Corps of Engineers and remains involved with the Chicago dispersal barrier project as Co-Chair of the Dispersal Barrier Advisory Panel.

Peter Neimanis

Peter has worked for the Australian Quarantine and Inspection Service (AQIS) for 10 years with the last seven in the Seaports Programme. The Seaports Program conducts quarantine clearances and surveillance of international vessels, associated crew, passengers and baggage at Australian ports to monitor, assess and manage bio security risks associated with vessels, passengers and crew to reduce the risk to Australia's animal, plant, marine and human health status. Peter has fulfilled the role of Ballast Water Decision Support System (BWDSS) Administrator for the last 4 years. The BWDSS is a risk assessment tool that forms part of the current Australian mandatory ballast water management requirements. More recently, Peter has been directly involved in the day to day support of the mandatory ballast water requirements – providing training, decision support and operational advice to inspecting AQIS Officers. Peter has been managing the biofouling project since July 2005 and in that time has directly contributed to the development of the Australian Biofouling Protocol, training for AQIS officers, legislative amendments, consultation with affected industry parties and wider communication strategy issues.

Bruce N. Nelson

Mr. Nelson is responsible for directing the Naval Research Laboratory's efforts for the development and evaluation of systems for performing automated enumeration and classification of zooplankton and phytoplankton in support of the Ballast Water Treatment Test Facility operations. This involves the design of complete systems for performing these functions as well as conducting extensive laboratory evaluations on these and other systems potentially applicable systems. Mr. Nelson has extensive experience in camera, sensor and optical system design and a strong track record of implementing advanced computational algorithms in these systems so that they can perform functions that are normally performed by human operators or analysts. He has designed complete systems for automated coatings quality assessment in ballast tanks and for inspecting rounds being demilitarized for residual explosives. Mr. Nelson is President of Battenkill Technologies, Inc., a small business that provides scientific, engineering and software R&D services to the US Federal Government and their contractors.

Leo G. Nico

Leo Nico is an ichthyologist hired in 1993 by the United States Department of Interior (USDOI) to conduct research on non-indigenous fishes. Prior to his USDOI employment, Leo's specialty was South American freshwater fishes, particularly their ecology and taxonomy. Consequently, he was already knowledgeable of many fishes introduced into Florida—having worked on these same fishes in their native ranges. One of Leo's most memorable experiences involved participation in ten major scientific expeditions (1984-2000) into remote regions of the upper Orinoco and Amazon basins—some funded by the Venezuelan government and others by the National Geographic Society. As a USDOI biologist, Leo has researched and published on a variety of invasive fishes including Asian carps, Asian swamp eels, South American armored catfishes, African and American cichlids (e.g., tilapias), among others. His research is focused on the southeastern USA, but recent projects have also involved fieldwork in Hawaii, Asia, and South America (e.g., Galapagos). He co-authored a 1999 book on non-indigenous fishes of the USA and senior-authored a book in 2005—a risk assessment and biological assessment of the Black Carp. Nico holds a master's degree (1982) from Southern Illinois University-Edwardsville and a PhD (1991) from the University of Florida. Advanced degrees were based on research in South America on life histories of annual killifishes and the trophic ecology of piranhas.

Pierre Y. Noël

Pierre Noël is senior researcher in CNRS, the (French) National Centre for Scientific Research. He is Curator of the Crustaceans in the Paris Muséum National d'Histoire Naturelle. His areas of interest include Crustaceans (since 1972), marine biology, invasive species, inventory of biodiversity, nature conservation. He is also an expert for the Ministry for Foreign Affairs (Convention on Biological Diversity) and the French Ministry of Ecology and Sustainable Development (black tides, biological invasions). Noël received his MS, PhD and "Dr ès sciences" zoology degrees from Université Pierre et Marie Curie, Paris 6.

Ruurd Noordhuis

Ruurd has been working as an aquatic ecologist at the Institute of Inland Water Management and Wastewater Treatment since 1990. His work is mostly on the ecology of the lakes of the IJsselmeer area, from studies aimed at use

of zebra mussels in water quality management to analysis of biological monitoring data (including macrozoöbenthos) for evaluation of changes. With a colleague he started a yearly monitoring programme of macrozoöbenthos on stones in the banks of a number of lakes in the area ("Borderlakes").

Mordecai O. Ogada

Dr. Ogada's scientific background is in carnivore ecology. He did his PhD on the effects of the Louisiana crayfish invasion on the ecology of African Clawless otters in Kenya, and this started his interest in invasive species. He is currently a research associate in the Zoological Sciences Department in the National Museums of Kenya, studying the effects of competition from the invasive Nile perch and over-fishing on the diet and ecology of the spot-necked otter in the Lake Victoria basin in Kenya. He is also developing cheap, sustainable techniques for monitoring aquatic ecosystems in Kenya.

Sergej Olenin

Prof. Sergej Olenin is the lead researcher at the Coastal Research and Planning Institute, Klaipeda University, Lithuania. He has initiated a regional information project on aquatic bioinvasions "The Baltic Sea Alien Species Database", which has been on-line since 1997. Currently he coordinates development of the European Alien Species Database (within EU project DAISIE) and studies impacts of alien species on aquatic ecosystems and aquaculture (within EU projects ALARM and IMPASSE). His main research areas are bio-pollution assessment methods, biogeography and ecology of invasive aquatic species. Prof. Olenin published over 20 research papers on aquatic bioinvasions, and co-edited a book and special journal issues on aquatic alien species in Europe.

Stan Orchard

Stan was a conservation biologist/herpetologist with the Natural History Section of Royal British Columbia Museum from 1981-1999 and was the National Co-ordinator for Canada for the IUCN/SSC Task Force on Declining Amphibian Populations in Canada (DAPCAN) from 1994-1999. In 1994 he co-founded the Canadian Amphibian and Reptile Conservation Network (CARCNet) and served as Chairman from 1994 to 1999. In 1998 he was invited to Australia by the WWF to (over four years) design and manage the world's largest privately-funded amphibian conservation program – now an independent organization known as 'Frogs Australia'. In 2003, he resurrected plans to develop the tools and strategies to effectively control and eradicate populations of invasive alien amphibians.

Marina Orlova

Dr. Orlova is a Senior Research Scientist of the Laboratory of Freshwater and Experimental Hydrobiology at the Zoological institute, of the Russian Academy of Science. Her current fields of basic and applied research are evolutionary and ecological background of aquatic invertebrates related to patters of their range extension; bivalves, their taxonomy and ecology; structure and functioning of benthic assemblages in brackish and freshwater ecosystems (Baltic Sea, Ponto-Caspian Seas and estuaries, Aral Sea, cascades of reservoirs; large lakes); biological invasions and their monitoring; nuisance bivalves, their biology and practical meaning, risk assessment and control, use for treatment of environment contaminated with radionuclides.

Mykola Ovcharenko

Mykola Ovcharenko is a doctor of Biological Sciences and Assistant Professor with interests in systematic, ultrastructure, developmental cycles and geographic distribution of Microsporidia and other intracellular parasites of aquatic animals, cyto- and histo-pathology of invertebrate hosts, and the role of parasites in distribution of native and not native species of invertebrate hosts. Dr. Ovcharenko is a member of the Ukrainian Society of Protozoologists and the Polish Parasitological Society.

Dianna K. Padilla

Dr. Padilla has two major areas of research: the functional ecology of marine plants and invertebrate animals, and invasion biology in aquatic systems. She is especially interested in the role of human activities in influencing the spread of exotics, the characteristics of invertebrate invaders that influence their success and impacts, and the impacts of exotic species on native ecosystems including reserves, and their impacts on food webs and community structure. She is also collaborating with international scientists to predict the global spread of aquatic invertebrate invaders.

Vadim Panov

Dr. Vadim Panov is a senior research scientist at the Zoological Institute in St. Petersburg, Russia. His research interests include biology of aquatic invasive species, specifically invasive crustaceans, and development of approaches to management of risks posed by introductions of these species. Currently he is involved in two projects of the European Commission Sixth Framework Programme for Research and Technological Development (Integrated Project ALARM and Strategic Targeted Research Project DAISIE), coordinating research activities related to biological invasions in European inland waters. Since 2005, Dr. Panov has served as Co-Editor of a new European on-line journal "Aquatic Invasions".

Esteban Macelo Paolucci

Esteban obtained a Bachelor of Biological Sciences Degree in 2002 from the Department of Biological Sciences, School of Exact and Natural Sciences, University of Buenos Aires. He is currently doing a doctorate at that university and planning to graduate in 2009. He is researching the environmental impacts of introduced bivalves, *Limnoperna fortunei*, in the Río de la Plata basin and their effects at the ecosystem level. In He is interested in the interaction of *L. fortunei* with toxic cyanobacteria and an ecophysiology level analysis of the environmental impacts of *L. fortunei*.

Bivan Patnaik

Mr. Patnaik is the Regulatory Coordinator for the US Coast Guard's Environmental Standards Division and has held this position since 2002. His responsibilities include: managing regulatory teams consisting of attorneys, environmental analysts, economists and technical writers; reviewing proposed legislation and regulations, leading interagency working groups, and coordinating with International government organizations, Federal agencies, State agencies, and other stakeholders. He is also the Secretariat for the International Standards Organization's Subcommittee for Ship's Technologies-Marine Environmental Protection. Prior to his employment with the Coast Guard, he was a consultant to both the US Coast Guard and the US Environmental Protection Agency. He has a BS in Biology from Virginia Commonwealth University, and an MS in Environmental Policy from Johns Hopkins University.

Kent A. Peterson

Kent Peterson serves as CEO of Fluid Imaging Technologies, Inc, an instrumentation firm providing image-based analysis of microorganisms, cells and particles in a fluid medium for numerous applications and markets. Prior to FIT, he served in a number of high-growth, high technology firms, as well as multinational organizations. Kent serves on a number of Boards and is active in community affairs. He is credited with a number of technical publications and speaking engagements. Mr. Peterson is an honors graduate from Boston University's Graduate School of Management, and a member of American Mensa Society.

Stephen Phillips

Stephen Phillips is a program manager at the Pacific States Marine Fisheries Commission where he has worked for over 15 years. For the last seven years his main responsibility has been management of PSMFC's Aquatic Nuisance Species Project. Prior to the ANS project, Mr. Phillips worked as a habitat biologist for the PSMFC. Mr. Phillips received his Bachelor's in Biology from Baldwin Wallace College, Berea, Ohio in 1979 and a Master's of Fisheries Science from Oregon State University in 1987.

Lise-Marie Pigneur

Lise-Marie graduated in biology at the University of Namur, Belgium and specialized in freshwater ecology. For her Master's thesis she studied taxonomy and biology of the African elephantfish (Mormyridae, Congo River). She was stuck by the difficulty of defining species and to even discriminate between two species. Then, she started working as a teaching assistant at the University of Namur. For her PhD thesis, she decided to work on Asiatic clams in the River Meuse watershed. In order to identify species and to locate the origins of these invasive clams, she started using molecular techniques such as gene sequencing.

Manfred Pöckl

After studying the life history of the indigenous *Gammarus fossarum* and *G. roeseli* in Austrian streams and rivers, Manfred Pöckl graduated in 1990 from the University of Vienna with a PhD. During the first study campaign on the

fauna and flora of the Austrian Danube in the 1980s, he had a closer look at species of amphipods, isopods and mysids. During 1985 he paid a study visit to the Institute of Zoology of the University of Amsterdam and met with Dr. Sjouk Pinkster and Dirk Platvoet in order to learn the skills in amphipod taxonomy. Since his graduation, Dr. Pöckl has been teaching undergraduate students how to identify Crustacea-Malacostraca. He is also fascinated with indigenous crayfishes and likes to use the fascination of this group in order to teach the general public about the threats they are exposed because of non-indigenous species and pathogens they are transmitting. During the next winter term (2007/08) Dr. Pöckl will give a lecture on "biological invasions in inland waters" at the University of Vienna. As a global threat to bio-diversity this topic has to have priority equal in rank with climate change.

Alan John Power

Alan is the director of the University of Georgia Marine Extension Service's Shellfish Research Laboratory in Savannah, Georgia. He recently provided the first integrated risk assessment of increased shipping activities in the South Atlantic Bight region and documented the first occurrences of *Perna viridis*, *Mytella charruana*, and *Megabalanus coccopoma* in Georgia. He received the Coastal America 2006 Partnership Award for his role as science committee chair for "Aquatic Invaders", an educational tool kit that was developed for zoos and aquariums across the United States.

Élizabeth Powles

Élizabeth Powles is a Policy Development Officer with the Invasive Alien Species Section at the Canadian Food Inspection Agency (CFIA). Since her arrival at CFIA in November 2006, Ms. Powles has been working on the development of a policy on invasive aquatic plants. Prior to this, Ms. Powles worked as a Program Advisor on aquatic invasive species at Fisheries and Oceans Canada. Ms. Powles has a Masters in Biology from the University of Windsor, Ontario. Her Masters thesis focused on the potential range expansion of the invasive aquatic plant Trapa natans (European water chestnut) into the Great Lakes.

Dandu Pughiuc

Capt. Dandu Pughiuc spent eight years at sea serving on different types of vessels. In 1985 he joined the Romanian Maritime Administration within the Ministry of Transport. During his 12 years in the public service he dealt with maritime training, maritime fleet operations and between 1994 and 1997 served as Chief Inspector, Head of the Maritime Safety Administration. He joined the International Maritime Organization in March 2000 as Chief Technical Adviser for the Global Ballast Water Management Project (GloBallast) and in March 2004 was appointed Head, Marine Biosafety Section in the Marine Environment Division of IMO. Capt. Pughiuc is a graduate from Constanta Maritime Institute, holds a Master of Science degree from the World Maritime University of Malmo, Sweden and a Master Mariner licence for sea-going vessels.

Dr. Sanjeevi Rajagopal

Dr. Sanjeevi Rajagopal earned a PhD (Doctor of Philosophy) degree from University of Madras in 1991 and a DSc (Doctor of Science) degree from the University of Nijmegen, Netherlands in 1997. He joined the Department of Animal Ecology and Ecophysiology, Radboud University Nijmegen, Netherlands in June 1994. He is presently analyzing genetic diversity of European populations (Baltic, Atlantic and Mediterranean coasts) of Mytilus spp. determined by PCR-based AFLP fingerprinting. He is also involved in the development of novel (CO_2), environmentally sound (heat treatment), chemical (chlorination) and non-chemical technologies (biological control) for the control of macro-fouling in raw water systems. In March 1994, he was selected for Group Study Exchange Programme (best Young Scientist) by the Rotary International (District 3000), Illinois, USA and visited Argentina, Paraguay and Brazil as a Rotary International Ambassador of goodwill and understanding. He is an Advisory Member of Groupo Ecologista, University of Misiones, Argentina and a Member of numerous societies, including The Marine Biological Association of the United Kingdom and The British Ecological Society, England.

Ricardo Ramalho

Ricardo Ramalho is presently a PhD Student of Biological Sciences at the Ecology Department of Évora University, Portugal. His functional area of specialization is Ecology of Invasive Species and his thesis subject is Ecology of the Red Swamp Crayfish (*Procambarus clarkii*, GIRARD). Ricardo graduated in Biology at the Coimbra University, Portugal in February of 2004 and he received a PhD grant from the National Foundation of Science and Technology (FCT)

in November 2004 to develop research on Red Swamp Crayfish dispersal and population regulation. He is also a graduated researcher at the Institute of Marine Research (IMAR)

Ravichandran Ramanibai

Dr. Ramanibai is an environmental biologist with specialisation in hydrobiology and 23 years of experience in research and teaching in the Department of Zoology, at the University of Madras. Dr. Ramanibai teaches principles of Ecology, Environmental Impact Assessment and Aquatic biodiversity for post-graduate students. Current areas of research interests include aquatic biodiversity, especially taxonomic studies, implications of water quality on planktonic diversity and biological control of aquatic weeds.

Leel Randeni

Leel Randeni is a Senior Environmental Management Officer attached to the Environment Education and Promotion Division, of the Ministry of Environment and Natural Resources, Sri Lanka. Leel has a BSc degree in Agriculture and a MSc in Environmental Economics from the University of Peradeniya, Sri Lanka, then obtained a Post-Graduate Diploma in Applied Sociology from Colombo University of Sri Lanka in 2004. The Ministry of Environment is the National Focal Point for Sustainable Development. Leel's main research areas are Ecological Economics and Sustainable Development.

Sujith Ratnayake

Sujith is a Senior Environmental Management Officer attached to the Biodiversity Secretariat (BDS) of the Ministry of Environment and Natural Resources, Sri Lanka. Sujith obtained a BSc special degree in Agriculture from the University of Peradeniya in 1994 and completed an MSc on Forestry and Environmental Management in 1998 from the University of Sri Jayawardenapura, Sri Lanka. Sujith was a United Nations University Fellow of the Biodiversity Conservation programme in 2003/2004 at Ghent University Belgium. BDS is the national focal point for the implementation of the Convention on Biological Diversity. Sujith is in charge of the Agro biodiversity, Bio Economic and Policy Planning Unit of the BDS.

David F. Reid

Dr. David F. Reid received a PhD in oceanography from Texas A&M University and has been a research scientist with the US federal government since 1969. In 1985 he moved to Ann Arbor, Michigan where he works for the National Oceanic and Atmospheric Administration (NOAA). His recent research focus is on aquatic invasive species, especially the ballast vector. He is Program/Project Leader or Co-Leader for a number of research projects related to the transport of aquatic organisms in ballast tanks of ships.

Anthony Ricciardi

Dr. Anthony Ricciardi is a professor of environmental science at McGill University, Montreal, Canada, where he holds a Quebec Strategic Professorship and teaches a course on invasion biology. His research lab examines the causes and consequences of aquatic invasions (http://redpath-staff.mcgill.ca/ricciardi/). He and his students are currently working on projects that aim to predict the ecological impacts of introduced species using statistical modeling, meta-analysis and field experiments. He is a member of the Canadian Aquatic Invasive Species Network - a research group that is assessing the risk and mechanisms of species introductions to Canadian inland and coastal waters.

Gretchen Rollwagen-Bollens

Dr. Gretchen Rollwagen-Bollens is a zooplankton ecologist, with a focus on the role of microzooplankton (heterotrophic planktonic protists <200 µm) in pelagic food webs. She has investigated microzooplankton distribution, composition and trophic dynamics in a range of aquatic environments, from the open ocean to estuaries to freshwater rivers and lakes. She is especially interested in how microzooplankton impact energy flow through the lower food web, and how the introduction of non-indigenous microzooplankton may impact aquatic ecosystems. She has a BA in Biology from Harvard University, a MS in Biological Oceanography from the University of Hawaii, and a PhD in Integrative Biology from the University of California, Berkeley. Dr. Rollwagen-Bollens is currently a Clinical Assistant Professor at Washington State University.

Matthias Rothe

Dr. Rothe studied chemistry at University of Heidelberg, and graduated from the Institute of Biological Chemistry Heidelberg. For nine years he was the Technical Manager of a company for water treatment in swimming pools, for two years was a Technical Consultant for ProMinent Heidelberg, four years as Product Manager for Disinfection- and Oxidation-Systems with ProMinent Heidelberg, and since 2006 has been the Director of Product Management ProMinent ProMaqua Heidelberg. ProMinent is one of the leading manufacturers of metering pumps and plants for water treatment solutions using all common techniques such as chlorine dioxide, ozone, UV-radiation, chlorine electrolysis and membrane technology. ProMaqua is the ProMinent subsidiary responsible for engineering and delivery of complete water treatment solutions.

Sonya Santavy

Ms. Santavy graduated with biology degrees from the University of Western Ontario and the University of Guelph, and began working in genetic ecology in 1988. Her focus quickly changed to aquatic invasive species when a benthic grab in Lake St. Clair resulted in the discovery of the first zebra mussel infestation in the Great Lakes. Ms. Santavy left her career in 1995 to raise her family and last year returned to the field of aquatic invasive species with Transport Canada and Fisheries and Oceans Canada. In her current role, she manages the Canadian National Ballast Water Database and coordinates the biological sampling of ballast tanks to ensure the efficacy of ballast water exchange for ships entering the Great Lakes.

Mariusz R. Sapota

Mariusz Sapota is an associate professor with the University of Gdansk Institute of Oceanography. He is an expert of the North European and Baltic Network on Invasive Alien Species (NOBANIS). His research interests focus on the biology and ecology of fish from shallow marine waters and the biology and control of invasive species (notably fish, especially round goby). Currently, he is leading the research project concerning the mechanisms of a sex differentiation and their influence on population dynamics of round goby.

Sigmund Sevatdal

Dr. Sigmund Sevatdal has been working in VESO (Centre for Veterinary Contract Research and Commercial Services Ltd.), a company owned by the Norwegian state. His work has been documentation and creating a dossier on the active substance rotenone and the rotenone containing piscicide product CFT Legumine according to EU Directive 98/8/EC. VESO is. The rotenone dossier was accepted as complete by the EU Commission last year, and the evaluation will be finished in 2010. VESO is involved in eradication of invasive aquatic species, especially the salmon parasite *Gyrodactylus salaris* and the minnow (*Phoxinus phoxinus*) in Norway, and commond carp – *Cyprinius carpio* in Spain. Sigmund Sevatdal`s earlier work has not been on invasive species, but sea lice (*Lepeophtheirus salmonis*) resistance to chemotherapeutics in Norwegian and European salmon farming industry, and salmon tapeworm (*Eubothrium crassum*) resistance to treatment agents in Norway. Sigmund Sevatdal holds a master degree from the University of Bergen, Norway and a PhD from the Norwegian School of Veterinary Science.

Linda Shaw

Linda Shaw has been a biologist with the National Marine Fisheries Service (NMFS) in Juneau, Alaska, USA, since 1991. She began working on invasive species issues while on a detail assignment to NMFS headquarters in 2004, where she co-authored a paper on invasive species threats to marine managed areas. Linda represents NMFS on the multi-partnered Alaska Invasive Species Working Group and the Shorezone coastal habitat mapping project. Her presentation shows how a mapping project can be leveraged to create tools for invasive species management.

Kirsty Smith

Kirsty Smith works as a junior scientist in the Biosecurity and Biotechnology group at the Cawthron Institute, Nelson, New Zealand. She is involved in the development of molecular tools for the detection, enumeration and compliance testing of invasive marine pests and harmful algal blooms for both biosecurity and seafood safety sectors.

A. Garry Smythe

Garry received a Bachelors degree in Biology, and Master of Science in Natural Science and Mathematics from the State University of New York at Buffalo. He is a Senior Scientist at Shaw Environmental Inc. His primary work is on environmental assessments driven by government regulations. Since the 1970s Garry has worked with native and non-indigenous aquatic species including mollusks, fish, and plants. He has conducted many research studies related to monitoring AIS and to evaluate control technologies; these controls typically intended to alter impact to infrastructure and/or the environment.

D. Menno Soes

Menno Soes is a trained biologist in animal taxonomy, animal ecology and aquatic ecology with main interests in fish, land- and freshwater molluscs and macrozoobenthos. From 2002 onwards Menno has been working for Bureau Waardenburg, an independent research and consultancy agency in the fields of environment and ecology. In this broad area of relationships between animals, plants, people and their environment, their activities cover the full trajectory of research and monitoring, environmental planning and design, nature conservation and management, and impact assessment.

Todd Steeves

Todd Steeves, MS, has worked in the Department of Fisheries and Oceans – Sea Lamprey Control program for 18 years, beginning as a summer student in 1988 to his recent appointment as the head of assessment. He is a member of several international committees that integrate the management of sea lampreys in the Great Lakes with other fisheries management goals to optimize fishery management efforts. He is a member of the American Fisheries Society and International Association of Great Lakes Research. His research interests include fisheries stock assessment and invasive species biology.

Brian Stephens

Brian Stephens, BSc., has worked with Fisheries and Oceans Canada – Sea Lamprey Control Centre for the past 22 years. Most recently, he has supervised lampricide control operations as part of a bi-national program of integrated sea lamprey management throughout the Great Lakes basin. He is a member of the Great Lakes Fishery Commission's Lampricide Control and Assessment Task Forces. He is also part of an authorship committee responsible for the creation and annual revision of the 'Standard Operating Procedures for the Chemical Control of Sea Lampreys'.

Paul Sullivan

Paul Sullivan, MSc, is a manager with Fisheries and Oceans Canada and heads the Control Section at the Sea Lamprey Control Centre in Sault Ste. Marie, Ontario, Canada. In support of a bi-national program of integrated sea lamprey management, he oversees operations related to the application of lampricides and the construction and maintenance of low-head barriers in sea lamprey nursery streams in the Canadian waters of the Great Lakes and the New York waters of Lake Ontario. He is the current chair of the Great Lakes Fishery Commission's Lampricide Control Task Force, and a member of the Lake Huron Technical Committee and the Sea Lamprey Barriers Task Force. His interests include freshwater fish biology, habitat utilisation by larval lampreys, and the management of invasive species.

Carol Swinehart

Carol Swinehart has been Michigan Sea Grant's Extension communicator since1984, working in media relations, producing Great Lakes educational publications and television programs, conducting public awareness and marketing efforts, and writing program materials. Since 2004, she has played an increasing role in aquatic invasive species, working on the 2002 update of Michigan's ANS Management Plan, helping develop Michigan's rapid response plan for Hydrilla and leading its Hydrilla Hunt, and writing the Recreational Activities Team report for the Great Lakes Regional Collaboration's AIS Strategy. Most recently, she's coordinated Michigan's pilot Clean Boats, Clean Waters program and facilitated stakeholder involvement in developing Michigan's process for recommending additions or deletions from the state's list of aquatic invasive species. She serves as an alternate representative for Great Lakes Sea Grant Extension on the Great Lakes Panel on ANS. She holds bachelor's and master's degrees from MSU.

Mark Swinton

Mark Swinton is currently a doctoral student at Rensselaer Polytechnic Institute in Troy, NY under the direction of Dr. Charles Boylen. They are currently attempting to better understand Eurasian Watermilfoil's ability to alter nutrient and trophic dynamics associated with a milfoil invasion. Mark received a BS in Marine Biology from Roger Williams University in RI and his Biology MS from SUNY Albany. Professionally, Mark has designed, built and ran both a tilapia fish farm and hatchery in Florida, and has consulted for the Albany Engineering Corporation in New York.

Francisco Sylvester

In 1998 Francisco graduated in Biological Sciences from the Universidad Autónoma de Madrid, Spain. From 1999-2002 he worked at the Argentine National Environmental Agency on the control and management of natural protected areas and national parks nominated for the UNESCO World Heritage List. In 2006 he obtained a PhD in Biology, from the University of Buenos Aires, Argentina, on "Feeding biology and ecology of the invasive mussel *Limnoperna fortunei* (Mytilidae) in the lower Paraná river and Río de la Plata". Since March 2007 he holds a postdoctoral fellowship at the Great Lakes Institute for Environmental Research, University of Windsor, Canada to work on overseas hull-fouling, non-indigenous species.

Anna Szaniawska

Since 2005, Professor Anna Szaniawska has been the head of the Department of Experimental Ecology of Marine Organisms in the Institute of Oceanography at Gdansk University. The main scientific interest of the Department concerns biology, ecology and ecophysiology of marine invertebrates (both native and non-native), and biocalorimetry/bioenergetics, aquaculture and socio-economic importance of marine ecosystems. The current professional foci of professor Szaniawska include invasive and engineering species in the Baltic Sea (the role they play in the ecosystem, vectors of their introduction, their adaptational mechanisms), as well as ecophysiology of marine crustaceans and aquaculture.

Joana Flor Tavares

Joana Flor Tavares is a graduate student in Marine Policy at the University of Delaware. She works as a research assistant in the project "Consideration, assessment and modeling of the introduction of non-native species from marine transportation ballast water". She is specifically interested in the biological variables and uncertainties that underlie the challenge of managing ballast water, topic of her upcoming Master's thesis. She holds a degree in oceanography from the Federal University of Rio Grande, Brazil, where she studied the occurrence of potentially harmful microalgae in coastal aquaculture. Other professional interests of hers are ecosystem-based management and sustainable development.

John C. Taylor

Dr. John Taylor teaches logistics and transportation at Grand Valley State University in Grand Rapids, Michigan. His research interests are in the area of Great Lakes marine shipping, intermodal transportation, and US-Canada-Mexico cross-border transportation. Dr. Taylor's articles have appeared in numerous journals including Transportation Journal, Regulation, and the International Journal of Logistics. He has recently published major policy reports on the cost benefits of ocean shipping on the Great Lakes, and on Michigan highway funding. He is a former member of the US Congress's National Commission on Intermodal Transportation, and the National Motor Carrier Advisory Committee to the U.S. Department of Transportation.

Trinidad Ruiz Téllez

Since 1986 Trinidad Ruiz Téllez has held a Pofessor of Botany position at the University of Extremadura (Spain), where she is an active researcher and teacher on phytosociology and vascular plant diversity. She participates in Research in Biology of the Conservation Group of the University of Extremadura (GIC-Uex). She hash ongoing activity in the field of conservation of biodiversity in research projects financed by public funds, and transfer of technology and information to society by collaboration agreements and administrative contracts, mostly with the Guadiana Water Authority of the Ministry of the Environment.

Teodora A. Trichkova

Teodora Trichkova graduated the Biological Faculty of Sofia University, major in Biology. Since her graduation, she has been working as a research scientist at the Hydrobiology Department of the Institute of Zoology, Bulgarian Academy of Sciences. She has been involved in several research projects on the distribution, biology, ecology and risk assessment of invasive invertebrate and fish species in the Danube and in the Bulgarian inland water basins. Some of her recent work is related to the distribution, shell morphometry, and quantitative characteristics of zebra mussel populations in infested reservoirs.

Gerard van der Velde

Gerard studied biology at Leiden University and in 1974 obtained a PhD student from the Laboratory for Aquatic Ecology, University of Nijmegen. He became an associate professor at the same laboratory, currently at the Department of Animal Ecology and Ecophysiology, at the Institute for Water and Wetland Research, Radboud University Nijmegen. He is a visiting professor at the Vrije Universiteit Brussels, Belgium, lecturing on tropical coastal marine ecology. He is a member of the sea team of the National Museum of Natural History Naturalis, Leiden, president of the Dutch Malacological Society, a member of the Scientific Council of the International Centre for Ecology of the Polish Academy of Sciences, and a member of the Scientific Council of the International Marine Centre, Sardinia, Italy. He took part on several marine expeditions and was involved in research on marine coastal ecosystems in the Indo-Pacific and the Caribbean and on the ecological rehabilitation of rivers and wetlands. He is author of more than 260 international publications on aquatic ecology and (co)promotor of 21 PhD theses. He was in the editorial boards of Aquatic Botany and Aquatic Ecology and still in those of Biological Invasions, Crustaceana and Chemistry and Ecology. The main topics of his group are biological invasions and biofouling, riverine, estuarine and tropical coastal ecosystems, macroinvertebrates and fish.

Marcel J.W. Veldhuis

Marcel Veldhuis, a senior scientist at the Royal Netherlands Institute for Sea Research, was trained as a marine phytoplanktologist and has participated in numerous (EU) projects studying the role of Harmful Algal Blooms in coastal waters. Because ballast water from ships is occasionally the source of newly introduced HABs he started a research program to examine the efficacy of newly developed ballast water treatment technologies in view of the ballast water Convention of the IMO (2004). Next to developing methods to examine viability of remaining organisms in ballast water he is also involved in development of advanced counting techniques for organisms.

Lieve Verelst

Lieve is a graduate of Civil Engineering from the Catholic University of Leuven, Belgium. Since 1988 she has been active at LABORELEC – the technical competence centre in energy processes and energy use. Laborelec is a part of the Suez Group, but is still mainly active for Electrabel and Suez Energy Europe (European power plants of the Group). Lieve is Technology Manager "Environment" for the Sustainable Process Technology product line. She is especially involved with cooling water treatment and the related problems of macro- and micro-fouling: supporting and consulting the power plants with their specific problems, evaluating alternatives by small-scale pilot tests, looking for environmental alternatives, as well physical and chemical alternatives, and evaluating their technical, economical and environmental impact. Consultancy towards new power plant designs for biofouling protection possibilities became a new hot topic. Lieve also evaluates the impact of pathogenic organisms as *Legionella* bacteria and the amoeba *Naegleria fowleri* in cooling water (analyses, risk analysis and management plan).

Hugo Verreycken

Hugo Verreycken studied Biology at the University of Louvain. He graduated in 1986 and started research on the ecology of freshwater fish in the Laboratory of Ecology and Aquaculture of the same University. In 1992 he became fisheries biologist at the Research Institute for Nature and Forest. Here Hugo was responsible for the Aquaculture Division from 1992 to 2000. Research was carried out on the optimisation of the culture of indigenous fish for reintroduction and stocking purposes. Currently Hugo is monitoring the non-indigenous fish species in Flanders, Belgium and is responsible for the management of a fish database. This database, which includes data on all indigenous and non-indigenous freshwater fish species in Flanders, is available (in Dutch) through the Internet since 2007.

Jessica Ward

Jessica Ward is a PhD student in the Department of Biology at McGill University, Montreal, Canada, under the supervision of Dr. Anthony Ricciardi. Her doctoral research investigates predictable patterns in the effects of non-indigenous animals on aquatic communities. She is conducting field experiments in the Saint-Lawrence River and using meta-analytical techniques to examine patterns of variation in the ecological effects of exotic mussels. Her research further extends the application of meta-analysis toward developing and testing hypotheses in invasion biology, and includes a published meta-analysis on the suppression of introduced plants by native herbivores.

Rowan Ward

Rowan Ward served as a regional inspector with the Australian Quarantine and Inspection Service (AQIS) for over 12 years, much of it as a Seaports officer. In the remote Cape York Peninsula area he established and managed a district office and undertook extensive public relations with Aboriginal communities and other local land managers. Here he also implemented and managed a regional scientific pest monitoring program that provided an early-warning capacity for pests and diseases such as Screw Worm Fly, the mosquito *Aedes albopictus*, and Japanese encephalitis. Later, working with the AQIS Seaports Program in Central Office, Canberra, his primary focus was the development of protocols for dealing with the quarantine risk posed by illegal foreign fishing vessels in northern Australia. Since joining the Invasive Marine Species Program in late 2005 Rowan has been developing various elements of the National System for the Prevention and Management of Marine Pest Incursions. He currently coordinates the development of the operational procedures for the National System and the supporting IT database and is working closely with colleagues on the development of Australia's proposed new ballast water legislation. Rowan holds a Bachelor Degree in Environmental Science from Central Queensland University and an Associate Diploma in Rural Techniques from the University of Queensland.

Barnaby J. Watten

Dr. Watten holds the position of Branch Chief, Restoration Technologies, US Geological Survey Leetown Science Center, Kearneysville West Virginia. He is a past president of the Aquacultural Engineering Society and a past president of the Bioengineering Section of the American Fisheries Society. He conducts research in the general area of environmental engineering with an emphasis on gas transfer, hydraulics and chemical processes including acid neutralization. Research projects include development of control methods for aquatic invasive species including the Asian clam and the New Zealand Mud snail based on manipulation of dissolved gas tension.

Stefan Werner

Stefan Werner is conducting PhD studies at the University of Constance, Germany on "*Corbicula fluminea* in Lake Constance" financed by the CRC 454 Bodenseelithoral of the DFG. Main topics are population dynamics of the recently established Asian clam in Lake Constance and its effects on benthic community. Furthermore he participates the EC-Interreg IIIA project ANEBO (Aquatische Neozoen Bodensee) and the international working group of aquatic neozoans (AKAN) in southern Central Europe. A paper about invaders (zebra mussel) was published in Freshwater Biology 50, 1412-1426 and a chapter (co-author) in the book 'The Zebra Mussel in Europe' will be published this year.

Christopher J. Wiley

To encompass the scientific, engineering and ship safety and policy aspects of the Aquatic Invasive Species Program on the Great Lakes, Chris straddles two Canadian Federal Government departments. He is the Aquatic Invasive Species Coordinator for the Department of Fisheries and Oceans, Central and Arctic Region as well as the Environmental Issues Manager for Transport Canada Ontario Region. Chris spent fifteen years as Chief Engineer on ships worldwide; serving on Icebreakers, Tankers, Cruise and Passenger Ships, Supply Vessels and Mega Yachts. He joined the Canadian Federal government in 1993 and has had responsibility for a variety of diverse files ranging from Senior Marine Surveyor (Machinery), Regional Director of Technical Services for the Canadian Coast Guard, Manager of a number of multi-national Arctic Science Programs, (SHEBA, TUNDRA, NORTHWATER) and Executive Assistant to the Regional Director General of DFO. He has had regional involvement in the Ballast Water file since 1994. He has a BSc in Chemistry from the University of Toronto, a MSc in Maritime Management from Maine Maritime Academy and holds a First Class Combined Certificate of Competency as a Marine Engineer.

Wei Ying Wong

Wei Ying Wong is a cultural ecologist working on how different groups of people understand and represent environmental issues. She is specifically interested in the interaction of society and science in the production of knowledge about invasive species. Her dissertation research underscores the importance that factors such as religion, perception of nature, and historical and social developments, play in the understanding of invasive species. Wei Ying will continue working with communities around the issue of invasive species as a postdoctoral fellow at the University of Stellenbosch, South Africa.

David A. Wright

Professor Wright is a graduate of the University of Newcastle-upon-Tyne where he received a PhD in comparative physiology in 1973 and was awarded a Doctor of Science degree by that university in 2001. Since 1979 has been Professor of Environmental Toxicology at the University of Maryland, Center for Environmental Science. He has conducted research into problems associated with non-indigenous species for the past 18 years and has authored over 60 papers and presentations on the subject. He directs the Baltimore Harbor Ballast Water Treatment Demonstration project and has conducted several ballast water treatment trials, both dockside and shipboard.

David Yard

David Yard is a Senior Marine Safety Inspector with the Marine Safety directorate of Transport Canada. Mr. Yard deals with the development and enforcement of regulations relating to pollution from ships, the coordination of joint enforcement protocols with Environment Canada, and acts as a technical advisor on issues relating to the Marine Oil Spill Preparedness and Response Regime. Mr. Yard has been involved in marine pollution prevention, preparedness, and response issues since the late 1980's and represents the Federal Government at regular Canadian Marine Advisory council (CMAC) and International Maritime Organisation Marine Environmental Protection Committee meetings.

Anastasija Zaiko

Anastasija Zaiko, MS, is a research assistant at the Klaipeda University, Coastal Research and Planning Institute, Lithuania. Her research interests include aquatic invasive species, their impact to ecosystem, interactions with the native organisms. Her current PhD research project is focused on zebra mussel ecological impacts, particularly its effect as ecosystem engineer species. She is the member of BMB NEMO (Non-indigenous Estuarine and Marine Organisms) working group, and technical assistant of the Baltic Sea Alien Species Database.

Philine zu Ermgassen

Philine zu Ermgassen was awarded the TB Woods Prize for Plant Sciences upon graduating from the University of Cambridge in 2005. She then continued with a NERC funded PhD in the Department of Zoology at the same institution. Her thesis explores interactions between non-native aquatic species, and possible impacts of these interactions in facilitating the spread of non-natives.

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