13th International Conference on Aquatic Invasive Species

September 20 to 24, 2004

Lynch West County Hotel
Ennis, County Clare, Ireland

HOSTED BY

Sligeach
Institute of Technology Sligo

Conference Host

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Glenn Rhett, US Army Engineer Research & Development Center

David F. Reid, National Oceanic and Atmospheric Administration (NOAA)

Pam Thibodeaux, US Fish & Wildlife Service

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Control Methods for Ecosystem Protection: Aquatic Plants

Development and Use of Databases

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Biology, Physiology and Ecology of Invasive Bivalves

Invasion History

Biology and Ecology of Dreissenids

Vectors and Corridors for Introductions

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Monday September 20

Plenary Session

International Cooperation Towards Science, Policy and Information Exchange

SESSION CHAIR:
Pat Timpson, Head, School of Science, Institute of Technology, Sligo

8:30
Introductory Remarks
Pat Timpson, Head, School of Science, Institute of Technology, Sligo, Ireland

8:45
Pat the Cope Gallagher, Minister of State, Department of Environment and Local Government, Ireland

9:00
Vectors, Detectors and Inspectors
Dan Minchin, Marine Organism Investigations, Ireland

10:00
Break

10:30
Managing the Global Invasive Species Problem – Some Lessons Learned From Experience with National, Regional and Global Programmes
Greg Sherley, Principal Regional Scientist, New Zealand Department of Conservation, New Zealand

11:00
Invasive Aquatic Species and Ships Across the Sea – the IMO Response, Reflections and Direction
Jean-Claude Sainlos, Director, Marine Environment Division, International Maritime Organization, England

11:30
Two Nations, One Ecosystem, Working Together on Aquatic Invasive Species Management and Control
The Rt. Hon. Herb Gray, Chair, Canadian Section, and The Hon. Dennis Schornack, Chair, United States, International Joint Commission

12:00
Luncheon

SESSION CHAIRS:
Irene B. Brooks and Allen I. Olson, Commissioners, United States Section, International Joint Commission

1:30
Directions in Policy and Action on Aquatic Invasive Species in the United States
Timothy R.E. Keeney, Deputy Assistant Secretary of Commerce for Oceans and Atmosphere, NOAA

1:50
Integrating Science With Policy: The Canadian Experience
John Cooley, Regional Director General, Fisheries and Oceans Canada, Canada

2:10
Invasive Species in Ireland
Jamie T.A. Dick, Quercus, Queen's University, Belfast, Northern Ireland

2:30
Introduced Aquatic Species in Europe — An Attempt at an Inventory
Stephan Gollasch, GoConsult, Germany

2:50
Break

3:20
Aquatic Invasive Species in South Africa – Environmental Impacts and Management Responses
Charles L. Griffiths, University of Cape Town, South Africa

3:40
Post-border Management of Non-native Marine Species in New Zealand
Maria Cassidy, Ministry of Fisheries, New Zealand

4:00
The Aquatic Nuisance Species Task Force: A Mechanism to Coordinate Efforts to Combat Aquatic Nuisance Species in Order to Protect US Waters
Everett Wilson, US Fish and Wildlife Service, ANS Task Force, Executive Secretary, USA

4:20
European Cooperation in Research, Information Exchange and Management of Aquatic Invasive Species
Vadim Panov, Zoological Institute of the Russian Academy of Science, Russia

4:40
Summary Remarks
Robert Gourd, Commissioner, Canadian Section, International Joint Commission

5:00
Poster Session

Tuesday, September 21

Concurrent Session A

Shipping: Updates on the Issues

SESSION CHAIR:
David F. Reid, National Oceanic and Atmospheric Administration

8:30
A Global Perspective on Shipping as a Vector for New Species Introductions
Stephan Gollasch, Go Consult, Germany

8:50
Bioinvasions in North America's Great Lakes and the Shipping Vector
Edward L. Mills, Cornell University, USA

9:10
Vectors for Introduction of Alien Macroalgae in Europe: Hull Fouling
Frédéric Mineur, Queen's University Belfast, Northern Ireland

9:30
Quantifying the Efficacy of Mid-ocean Ballast Water Exchange: An Experimental Approach
Emma Verling, Smithsonian Environmental Research Center, USA

9:50
Ballast Water Management: Toward Understanding Treatment Efficacy
Gregory M. Ruiz, Smithsonian Environmental Research Center, USA

10:10
Break

Shipping: Advances in Science

SESSION CHAIR:
David F. Reid, National Oceanic and Atmospheric Administration

10:40
Modeling of Ballast Water Flow Dynamics to Understand Ballast Water Exchange
Stephan Verosto, Naval Sea Systems Command Carderock, Surface Warfare Center Division, USA

11:00
Transfer of Nonindigenous Species to the Laurentian Great Lakes in Residual Ballast Water From No-Ballast-On-Board (NOBOB) Vessels
Colin D.A. van Overdijk, Great Lakes Institute for Environmental Research, University of Windsor, Canada

11:20
Modeling the Risk of Invasion by Diapausing Eggs in Residual Ballast Sediments
Sarah A. Bailey, Great Lakes Institute for Environmental Research, University of Windsor, Canada

11:40
Viability of Invertebrate Diapausing Eggs Exposed to Saltwater: Implications for Great Lakes' Ship Ballast Management
Derek K. Gray, Great Lakes Institute for Environmental Research, University of Windsor, Canada

12:00
Luncheon

Concurrent Session B

Biology of Invading Fishes

SESSION CHAIR:
Joseph M. Caffrey, Central Fisheries Board

8:30
The Spread of Dace – an Invasive Fish Species in Ireland
Brian Hayden, Central Fisheries Board, Ireland

8:50
Preliminary Results on the Movements and Microhabitat Use of Introduced Pumpkinseed (*Lepomis gibbosus*) in Small English Streams
Salius Stakenas, Centre for Environment, Fisheries & Aquatic Science (CEFAS), England

9:10
Risk Assessment of Introduced Black Carp in the United States: Potential Geographic Range and Ecological Impacts
Leo G. Nico, US Geological Survey, FISC - Center for Aquatic Resources Studies, USA

9:30
Invasive Freshwater Fish and Water Clarity Decline in New Zealand, North Island Lakes
David Rowe, National Institute for Water and Atmospheric Research, New Zealand

9:50
Aquatic Invasive Species Impacts Upon the Lake Erie Sport Fishery
Fred L. Snyder, Ohio Sea Grant, USA

10:10
Break

10:40
Complex Interactions Between Native and Invasive Fish: The Simultaneous Effects of Multiple Negative Interactions
Russell Rader, Brigham Young University, USA

11:00
Occurrence of an Introduced Freshwater Fish, the Rio Grande Cichlid *(Cichlasoma cyanoguttatum)*, in Estuarine Habitats of Southeastern Louisiana, USA: Can We Assume that Estuaries are Effective Barriers to Expansion?
Martin T. O'Connell, University of New Orleans, USA

11:20
Early Life Interactions Between Native Cyprinids and Invasive Sunbleak Leucaspius deliniatus in a Three-lake System
Kathleen Beyer, University of Hull, England

11:40
***Heterosporis* Sp. (Microspora): A New Parasite From Yellow Perch *(Perca flavescens)* and Walleye *(Stizostedion vitreum)* in Minnesota, Wisconsin and Lake Ontario, North America**
Dan Sutherland, University of Wisconsin - La Crosse, USA

12:00
Luncheon

Concurrent Session C

Global Management Efforts

SESSION CHAIR:
Geoffrey Hicks, Department of Conservation, New Zealand

8:30
Guilty Until Proven Innocent or Innocent Until Proven Guilty? The Further Development of Criteria for Assigning Introduced Versus Endemic Status
Marnie Campbell, Ministry of Fisheries, New Zealand

8:50
Guilty Until Proven Innocent or Innocent Until Proven Guilty? The Practical Biosecurity Management of Cryptogenic Species
Chad Hewitt, Ministry of Fisheries, New Zealand

9:10
Italian Project on Aquatic Invasive Species in Italian Seas
Franco Andaloro, Central Institute of Research Applied to the Sea (ICRAM), Italy

9:30
The Proposed Australian System for the Prevention and Management of Marine Pest Incursions
Jacinta Innes, Department of Agriculture, Fisheries and Forestry, Australia

9:50
Status, Environmental Considerations for Invasive Seaweeds for the Pacific Coast of North America
Hans Herrmann, Commission for Environmental Cooperation of North America

10:10
Break

Prediction Modeling and Risk Assessment

SESSION CHAIR:
Sharon Gross, US Geological Survey

10:40
Developing Technologies for AIS Risk Assessment for US Army Corps of Engineers Projects
Alfred F. Cofrancesco, Jr., US Army Engineer Research & Development Center, USA

11:00
Life-history Variation and the Spread of Aquatic Nonindigenous Species Across Ontario Lakes
Jim Muirhead, Great Lakes Institute, University of Windsor, Canada

11:20
Emerging Threats: Potential Geographic Distributions of Temperate Aquatic Invasive Species
Daniel A. Kluza, US Environmental Protection Agency, USA

11:40
Watershed Characteristics and Nonindigenous Fish in Mid-Atlantic Streams
Michael W. Slimak, US Environmental Protection Agency, USA

12:00
Luncheon

Concurrent Session A

Shipping: Advances in Science

SESSION CHAIR:
Richard Everett, United States Coast Guard

1:30
US Coast Guard Shipboard Technology Evaluation Program
Richard Everett, US Coast Guard, USA

1:50
The US Ballast Water Technology Demonstration Program: Progress Report
Pamela Thibodeaux, US Fish & Wildlife Service, USA

2:10
Evaluation of Filtration Components for Ballast Water Treatment
Edward J. Lemieux, Naval Research Laboratory, USA

2:30
Evaluation of a New Method for Control of Aquatic Invasive Species: Effects of Carbon Dioxide and Stack Gas Supersaturation on LT_{50}
Barnaby J. Watten, US Geological Survey, USA

2:50
Rapid Deoxygenation of Ballast Water: Effectiveness and Applicability of a Bio-reactive Process
Yves de Lafontaine, Environment Canada, Canada

3:10
Break

3:40
Treatment of Ships' Ballast Water Using the Strong Dielectric Barrier Discharge
Mingdong Bai, Dalian Maritime University, China

4:00
Development, Verification and Installation of an Electro-ionization Technology for Ballast Water Treatment on a Cruise Ship
C.E. Bud Leffler, Marine Environmental Partners, USA

4:20
Engineered Biomimetic Surfaces to Reduce *Ulva* Zoospore Settlement
Anthony Brennan, University of Florida, USA

4:40
Acute Toxicity of SeaKleen (Menadione) to Zooplankton Diapausing Eggs
David Raikow, NOAA, Great Lakes Environmental Research Laboratory, USA

5:00
Development of Full-Scale Ballast Water Treatment Systems for the Control of Aquatic Nuisance Species
Tom Mackey, Hyde Marine Inc., USA

5:20
Design Optimization and Test of an Onboard Treatment of Ballast Water (TREBAWA) – Combination of Hydroclone and UV
Tony Leigh, Willand U.V. Systems Ltd., England

5:40
Shipboard Demonstration of Chlorine Dioxide as an Effective Ballast Water Treatment on the M/V Atlantic Compass
Tom Perlich, Echochlor Inc., USA

6:00
An Economical Ballast Water System – Combined Effects of Hypoxia (De-Oxygenation), Hypercapnia and a Low pH by Inert Gas Infusion
Mo Husain, MH Systems, Inc. USA

Concurrent Session B

Invasion Biology of Crustaceans

SESSION CHAIR:
Alfred F. Cofrancesco, US Army Corps of Engineers

1:30
Relationship Between Body Length and Egg Volume in a Mass Invader *Chelicorophium curvispinum* (Sars, 1895) (Crustacea: Amphipoda)
Sanjeevi Rajagopal, University of Nijmegen, The Netherlands

1:50
Colonization by Alien Amphipods on Stone Substrata Hung in the River Rhine
Marielle van Riel, University of Nijmegen, The Netherlands

2:10
Mud Fixation by the Ponto-Caspian Amphipod *Chelicorophium curvispinum* (Sars, 1895)
Gerard van der Velde, University of Nijmegen, The Netherlands

2:30
Population Dynamics and Development of the Invasive Caprellid Amphipod *Caprella mutica*
Elizabeth Cook, Scottish Association for Marine Science, Scotland

2:50
The Nonindigenous Cladoceran *Cercopagis pengoi* in the Northern Baltic Sea: Some Remarks on its Distribution and Energetic Significance
Eila Lahdes, Finnish Institute of Marine Research, Finland

3:10
Break

3:40
If They Can't Meet You, They Can't Eat You: Simulation Grid Experiment to Investigate Body-size Related Habitat Choice in the Freshwater Amphipod *Dikerogammarus villosus* Sowinsky (Crustacea) and its Introduction Into a Freshwater Lake in The Netherlands
Dirk Platvoet, Institute of Biodiversity and Ecosystem Dynamics, The Netherlands

4:00
Invasive Gammarids in Poland – Migration in Progress
Krzysztof Jazdzewski, University of Lodz, Poland

4:20
Invasive Amphipods as a Food Resource for Local Fishes in the Vistula River
Michal Grabowski, University of Lodz, Poland

4:40
Biological Invasions in European Inland Waters: A Case Study of the Red Swamp Crayfish, *Procambarus clarkii*
Francesca Gherardi, Università de Firenze, Italy

5:00
The Invasion and Spread of the Chinese Mitten Crab in Europe from a Multidisciplinary Perspective
Leif-Matthias Herborg, University of Newcastle Upon Tyne, England

Concurrent Session C

Policy and Prevention

SESSION CHAIR:
Ron Pierce, Fisheries and Oceans Canada

1:30
Passing Successful Invasive Plant Legislation in the State of Maine: Making a Difference at the Local, State and National Level in an Age of Political Cynicism with Grassroots Activism…One Vote Counts
Shippen Bright, Maine Lakes Conservancy Institute, USA

1:50
Cooperative Federalism: Regional Aquatic Nuisance Species Panels in the United States
John Christmas, George Mason University, USA

2:10
Developing Essential Resources for Rapid Response to Aquatic Invaders in the Northeastern US and Atlantic Canada
Jay Baker, Northeast Aquatic Nuisance Species Panel, USA

2:30
Aquatic Invasive Species in the Pacific Northwest
Stephen Phillips, Pacific States Marine Fisheries Commission, USA

2:50
Novel Application of a Novel Tool: Using a US Endangered Species Act Safe Harbor Agreement to Reduce the Use of Mosquitofish
Doug Duncan, US Fish and Wildlife Service, USA

3:10
Break

Education and Outreach

SESSION CHAIR:
John Faulkner, Environmental Heritage Service, Northern Ireland

3:40
County Heritage Plans as a Tool for Raising Public Awareness
Siobhán Geraghty, North Tipperary County Council, Ireland

4:00
Effective Strategies that Work to Prevent the Spread of Aquatic Invasive Species by Recreational Boaters
Douglas A. Jensen, Minnesota Sea Grant, USA

4:20
Integrating an Aquatic Invasive Species Unit Into School Curricula
MaryAnn McGarry, Maine Lakes Conservancy Institute, USA

4:40
Employing a Volunteer Network to Help Control Purple Loosestrife: Implementation and Impact
Natalie Carroll, Purdue University, Department of Youth Development and Agricultural Education, USA

5:00
Overcoming Obstacles in the Control of Water Chestnuts in an Urban Setting
Alicia Zoeller, Holyoke Conservation Commission, USA

5:20
Outreach and Communications: Vital Components of the Asian Carp Rapid Response Plan
Kristin TePas, Illinois Natural History Survey, Illinois-Indiana Sea Grant, USA

5:40
Habbitattitude! A National Campaign to Prevent the Introduction of Aquatic Invasive Species by Aquarium and Water Garden Owners
Douglas A. Jensen, Minnesota Sea Grant, USA

Wednesday, September 22

Concurrent Session A

Shipping: Policy

SESSION CHAIR:
Bivan Patnaik, United States Coast Guard

8:30
The GEF/UNDP/IMO Global Ballast Water Management Programme: Reflections, Achievements, Progress and Plans
Steve Raaymakers, International Maritime Organization, England

8:50
US Coast Guard Ballast Water Management Program: Battling Aquatic Invasions Through Regulations
Bivan Patnaik, US Coast Guard, USA

9:10
Identifying Regions at Risk Using Time-series Analysis and Life-cycle Models
Keith Hayes, CSIRO Marine Research, Australia

9:30
Risk-based Decision Making in Ballast Water Policy Development
Jeremy Firestone, University of Delaware, College of Marine Studies, USA

9:50
From State Senator Sikkema to Congresswoman Miller: Shipping's Response to Ballast Water Initiatives in the Great Lakes
Georges H. Robichon, Fednav Limited, Canada

10:10
Break

10:40
Integrating Science in Ballast Water Management
Judith Pederson, MIT Sea Grant College Program, USA

11:00
Development of the Australian Port Monitoring Framework
Simon Barry, Australian Government Department of Agriculture, Fisheries and Forestry, Australia

11:20
Panel Discussion

12:00
Luncheon

Concurrent Session B

Industrial Biofouling

SESSION CHAIR:
Renata Claudi, RNT Consulting Inc.

8:30
The Recent and Rapid Spread of Zebra Mussels in England: Causes and Industrial Consequences
Paul Elliott, Cambridge University, England

8:50
Exotic Cooling Water Fouling Organisms in The Netherlands with Emphasis on Heat Treatment of the Japanese Oyster *Crassostera gigas*
Henk A. Jenner, NV KEMA, The Netherlands

9:10
Can Biology Control Brackish Mussel *(Mytilopsis leucophaeata)* Fouling in Industrial Cooling Water Systems?
Annick A. Verween, University of Gent, Belgium

9:30
Progress in the Biological Control of Zebra Mussels: Results of Laboratory and Power Plant Tests
Daniel P. Molloy, New York State Museum, USA

9:50
New Antifouling Technique by Combined Carbon Dioxide and Sodium Hypochlorite Dosing
Henk A. Jenner, NV KEMA, The Netherlands

10:10
Break

10:40
A Microencapsulated BioBullet for the Control of Biofouling Zebra Mussels
David Aldridge, Cambridge University, England

11:00
Development of an Efficient Low-cost Sparker Technology for Controlling Zebra Mussels
Raymond Schaefer, Phoenix Science and Technology, Inc., USA

11:20
Biofouling Control Strategies in ANAV Nuclear Power Plants
Oscar Nieto Garcia, Asociación Nuclear Ascó Vandellós, Dirección de Servicios Técnicos, Spain

12:00
Luncheon

Concurrent Session C

Invasion Impacts on Freshwater Ecosystems

SESSION CHAIR:
Darlene Smith, Fisheries and Oceans Canada

8:30
Assessing the First-order and Second-order Environmental Impact Effects of the Filter-feeding Asian Clam, *Corbicula fluminea*, and Omnivorous African Cichlid, *Oreochromis aureus,* Under Various Water Quality Conditions
Robert Brock, NOAA, National Marine Fisheries Service, USA

8:50
Differences in Composition of Macroinvertebrate and Fish Communities with Invasive and Native *Gammarus* spp. (Crustacea: Amphipoda)
David W. Kelly, Queen's University Belfast, Northern Ireland

9:10
The Influence of Eurasian Watermilfoil on Littoral Zone Structure and Function in an Oligotrophic Lake
Charles W. Boylen, Rensselaer Polytechnic Institute, USA

9:30
Golden Apple Snail, *Pomacea canaliculata* (Lamarck): An Alien Invasive Species, its Environmental and Economic Impact Assessment in Asia and Lessons Learned in the Philippines
Ravindra C. Joshi, Philippine Rice Research Institute, Philippines

9:50
Channeled Applesnail: Current US Distribution and Potential Threat to Coastal Ecosystems and Agriculture
Lyubov Burlakova, Stephen F. Austin State University, USA

10:10
Break

10:40
Ecosystem-level Impacts of Zebra Mussels in Lake Winnebago, Wisconsin
Alfred F. Cofrancesco, US Army Engineer Research & Development Center, USA

11:00
Effects of Zebra Mussels on Habitat Use and Foraging Success of Juvenile Lake Sturgeon (*Acipenser fluvescens*): Implications for Reintroduction Efforts
Declan McCabe, St. Michael's College, USA

11:20
The Impact of the Zebra Mussel Invasion on Phytoplankton, Zooplankton and Benthic Macroinvertebrate Communities in a Large Irish lake
Caitriona Maguire, Queen's University Belfast, Northern Ireland

11:40
Good, Bad, Ugly or Just the Latest Addition to the Fauna? Changes in the Fish Population of Lower Lough Erne, Ireland, Following Invasion and Effective Water Column De-trophication by Zebra Mussels
Robert Rosell, Department of Agriculture for Northern Ireland AFESD, Aquatic Systems Branch, Northern Ireland

12:00
Luncheon

Wednesday, September 22

Concurrent Session A

Monitoring and Detection

SESSION CHAIR:
Alan Craig, National Parks and Wildlife Service, Ireland

1:30
The Invasion of Eurasian Watermilfoil (*Myriophyllum spicatum*) and Curlyleaf Pondweed (*Potamogeton crispus*) in Lake Tahoe: The Risks of Benign Neglect
Lars W. J. Anderson, US Department of Agriculture, Agricultural Research Service, USA

1:50
Study on Invasive Alien Species in North Tipperary
Siobhán Geraghty, North Tipperary County Council, Ireland

2:10
Proactive Assessment of Invasion Potential in the United States for European Freshwater Aquaculture and Aquarium Trade Fishes
Kristina McNyset, The University of Kansas, Natural History Museum, USA

2:30
Using Predictive Habitat Modeling to Design Surveillance for Marine Pests
Graeme Inglis, National Institute of Water and Atmospheric Research, New Zealand

2:50
Current Use and Future Potential of Genetic Probes in Marine Invasion Science and Management
Nicholas Bax, CSIRO Marine Research, Australia

3:10
Adjourn

Concurrent Session B

Industrial Biofouling

SESSION CHAIR:
Henk Jenner, KEMA Nederland BV

1:30
Efficacy of a Starch-based Reagent as a Proactive Control for Mussels (*Dreissena* spp.) and Other Molluscs
Garry Smythe, Stantec Consultants Inc., USA

1:50
Water Treatment With Chlorine Dioxide as an Efficient Antifouling Technique
Matthias Rothe, ProMinent Dosiertichnik Gmbh, Germany

2:10
Zebra Mussel Distribution in the Riba-roja Reservoir (NE Spain) and First Results on Population Control Possibilities
Antoni Palau, Department of Environment and Sustainable Development, Spain

2:30
Zebra Mussel Control at Darlington Nuclear Generating Station
Wing Ng, Ontario Power Generation, Canada

2:50
The Response of Brazilian Utilities to the Invasion of *Limnoperna fortunei*
Maria Edith Rolla, Cia. Energética de Minas Getais, Brazil

3:10
Adjourn

Concurrent Session C

Invasion Impacts on Freshwater Ecosystems

SESSION CHAIR:
Helen Kay Austin, United States Section, International Joint Commission

1:30
Functional Changes in Freshwater Benthic Communities After *Dreissena polymorpha* (Pallas) Invasion
Lyubov Burlakova, Stephen F. Austin State University, USA

1:50
An Assessment of the Direct and Indirect Impacts of Aquatic Invasive Species on Lake Trout Restoration in the Great Lakes
John Fitzsimons, Fisheries & Oceans Canada, Bayfield Institute, Canada

2:10
An Evaluation of the Roach (*Rutilus rutilus*) Invasion in Ireland
Paul McLoone, Central Fisheries Board, Ireland

2:30
Invasive Plant Species in Irish Aquatic Habitats
John Lucey, Environmental Protection Agency, Ireland

2:50
Exotic and Endemic Flora on Reference and Non-reference sites from Iberian Fluvial Systems
Francisca Aguiar, Instituto Superior de Agronomia, Departmento de Engenharia Floresta, Portugal

3:10
Adjourn

Concurrent Session A

Invasion Impacts on Marine Ecosystems

SESSION CHAIR:
Judith Pederson, MIT Sea Grant

8:30
Blurring of Biogeographic Boundaries: A Multivariate Analysis of the Regional Patterns of Native and Nonindigenous Species Assemblages in Pacific Coast Estuaries
Henry Lee II, US Environmental Protection Agency, USA

8:50
Effects of Nonindigenous Species on the Taxonomic Diversity of Estuarine Assemblages
Deborah Reusser, US Geological Survey, USA

9:10
Is the Biological Integrity of the Baltic Sea Threatened by Invasive Non-native Species?
Erkki Leppäkoski, Åbo Akademi University, Finland

9:30
Invasive Blooms of the Green Alga *Caulerpa* in Southeastern Florida and the Bahamas Supported by Anthropogenic Nitrogen Enrichment
Brian Lapointe, Harbor Branch Oceanographic Institution, Inc., USA

9:50
The Ecology and Ecological Impact of a Highly Invasive, Marine Invertebrate on Hawaii's Coral Reef Communities
Samuel E. Kahng, University of Hawaii at Manoa, USA

10:10
Break

10:40
Introduction of the Polychaete *Marenzelleria viridis* and its Influence on Macrozoobenthos Long-term Trends in the Northern Baltic Sea
Ari Laine, Finnish Institute of Marine Research, Finland

11:00
Reproductive Potential and Predatory Pressure of the Gastropod *Rapana venosa* in a Locality of the Northern Adriatic Sea
Dario Savini, University of Pavia, Italy

11:20
Differences in Habitat Structure and Associated Macrofauna Between Native Kelp Beds (*Laminaria* spp.) and Meadows of the Invasive Green Alga (*Codium fragile* spp. tomentosoides) Along the Atlantic Coast of Nova Scotia
Allison L. Schmidt, Dalhousie University, Canada

11:40
Effects of Mussels on the Invasive Alga, *Codium fragile* spp. tomentosoides, on Artificial Structures in the Adriatic Sea (Northeast Mediterranean)
Fabio Bulleri, Università di Bologna, Centro Interdipartimentale de Ricerca per le Scienze Ambiantali di Ravenna, Italy

12:00
Luncheon

Concurrent Session B

Control Methods for Ecosystem Protection: Aquatic Plants

SESSION CHAIR:
John Lucey, Environmental Protection Agency, Ireland

8:30
The Reward Rapid Release™ Test: A Water Management Tool for Sensitive Use Sites Such as Reservoirs, Canals, and Lakes
James F. Petta, Syngenta Crop Protection, Inc., USA

8:50
Nutritional Status of *Hydrilla verticillata* and its Effect on Two Different Biological Control Agents
Judy Shearer, US Army Engineers, Research and Development Center, USA

9:10
Developing an Integrated Approach to the Management of Hydrilla
Michael J. Grodowitz, US Army Engineer Research and Development Center, USA

9:30
Invasion and Management of the Water Primrose (*Ludwigia* spp.) in France: A Panorama
Alain Dutartre, Cemagref, France

9:50
Biocontrol Potential for *Azolla filiculoides* and *Hydrocotyle ranunculoides* in the UK and Europe
Richard H. Shaw, CABI Bioscience, England

10:10
Break

10:40
Reward AccuGel™: A Precision Placement Formulation of Diquat for the Management of Invasive and Nuisance Plants in Both Static and Flowing Systems
James F. Petta, Syngenta Crop Protection, Inc., USA

11:00
Diquat Gel Formulation for Control of Aquatic Weeds
Kurt Getsinger, US Army Engineer Research and Development Center, USA

11:20
The Effects of *Spartina anglica* Eradication Treatments on Estuarine Benthic Macro-invertebrates
Mark Hammond, Department of the Environment, Environment and Heritage Service, Northern Ireland

11:40
The Integrated Management Approach to Control of Eurasian Watermilfoil: Cost Benefits and Long-term Effectiveness
Charles W. Boylen, Rensselaer Polytechnic Institute, USA

12:00
Luncheon

Concurrent Session C

Development and Use of Databases

SESSION CHAIR:
Gregory Ruiz, Smithsonian Environmental Research Center

8:30
NISbase: A Distributed Network for Invasive Species Information
Pam Fuller, US Geological Survey, USA

8:50
The Aquaculture Compendium and the Crop Protection Compendium: Global Knowledge Bases for Aquatic Invasive Species
Martin Parr, CAB International, Compendium Programme, England

9:10
A US-Canadian Aquatic Species Inventory and Invasive Species Warning System
Donna Turgeon, National Centers for Coastal Ocean Science, USA

9:30
SGNIS: Expanding the Knowledge Base Globally
Brian K. Miller, Illinois-Indiana Sea Grant, USA

9:50
The National Aquatic Nuisance Species Clearinghouse
Charles O'Neill, Jr., New York Sea Grant, USA

10:10
Break

10:40
Educators Respond to Invasive Species: Interactive Web-based Activities for Learning and Decision Making
Rosanne W. Fortner, Ohio Sea Grant Program, USA

11:00
Species Invasiveness and FishBase
Christine V. Casal, ICLARM, Philippines

11:20
Exploring the Concept of a World Atlas of Invasive Aquatic Species: Food for Thought
Graeme J. Inglis, National Institute of Water and Atmospheric Research, New Zealand

12:00
Luncheon

Concurrent Session A

Invasion Impacts on Marine Ecosystems

SESSION CHAIR:
Terry McMahon, Marine Institute, Ireland

1:30
Bioinvasion of the Pacific Oyster into the East Frisian Wadden Sea, Germany: Will *Mytilus*-beds be replaced by Oyster-reefs?
Andreas Schmidt, Senckenberg Institute, Germany

1:50
Invasive Macroalgae on Hawaii's Coral Reefs: Influence of Biodiversity on Invasion Success and Ultimate Consequences to Ecosystem Function
Jennifer E. Smith, University of Hawaii at Manoa, USA

2:10
Testing Intertidal Community Invasability: The Role of Nutrient Supply and Perturbations
Iñigo Sánchez, Uneversidad de Oviedo, Spain

2:30
Timing of Gamete Release in the Native Brown Seaweed *Cystoseira humilis* and the Invader Species *Sargassum muticum*
Aschwin Engelen, Universidad do Algarve, CCMAR, FCMA, Portugal

2:50
***Asterias amurensis* Management Strategy Evaluation Part 1: Integrating Population Biology and Oceanography to Determine the Limits of Natural Dispersal and Population Growth**
Piers Dunstan, CSIRO, Australia

3:10
Break

3:40
***Asterias amurensis* Management Strategy Evaluation Part 2: Defining and Testing the Effictiveness of Management Options**
Nicholas Bax, CSIRO, Australia

4:00
A Model for Forecasting the Propagation Potential of the Invasive Indo-Pacific Lionfish, *Pterois volitans/miles* in the Western Atlantic With Inferences on Ecosystem Effects
James Adiel Morris, National Oceanic and Atmospheric Administration, USA

4:20
Impact Analysis of the Red King Crab *Paralithodes camtschaticus* on Macrobenthos of the Barents Sea: The Maiden Estimates With Sea Urchin g. *Strongylocentrotus*
Elena Gudimova, Murmansk Marine Bioligical Institute, Russia

Concurrent Session B

Control Methods for Ecosystem Protection

SESSION CHAIR:
Marc Gaden, Great Lakes Fishery Commission

1:30
An Asian Carp Rapid Response Plan for the Chicago Sanitary and Ship Canal Dispersal Barrier
Philip B. Moy, Wisconsin Sea Grant, USA

1:50
The Potential for an Acoustic Based Barrier to Prevent Entry of Carp Species Into New Habitats
Edward Guida, Ultra Electronics Ocean Systems, USA

2:10
Eradicating the European Carp from Tasmania
Nicholas Bax, CSIRO Marine Research, Australia

2:30
Invasion of Ctenophore *Mnemiopsis leidyi* into the Caspian Sea and Measures to Control its Population Size
Tamara Shiganova, P.P. Shirshov Institute of Oceanology RAS, Russia

2:50
The Spread and Attempted Control of the Invasive Seaweed *Caulerpa taxifolia* in New South Wales, Australia
Tim Glasby, New South Wales Fisheries, Conservation Research, Australia

3:10
Break

3:40
Appearance of Zebra Mussels in a Reservoir of the Ebro Basin: Control Strategies
Concha Durán Lalaguna, Ministerio de Medio Ambiente, Spain

4:00
Vectors for Introduction of Alien Macroalgae in Europe: Oyster Transfers
Frédéric Mineur, Queen's University Belfast, Northern Ireland

4:20
Vector Management Tools for Invasive Marine Species: Reducing the Spread of Biofouling Pests with Aquaculture Transfers
Barrie Forrest, Cawthron Institute, New Zealand

4:40
Implementing A Sea Lamprey Control Program in the Laurentian Great Lakes
Marc Gaden, Great Lakes Fishery Commission, USA

4:40
Benefit-Cost Analysis of Water Hyacinth Control Methods in Lake Victoria, Kenya
Stephen K. Mailu, Kenyan Agricultural Research Institute, Lake Victoria Environmental Management Project, Kenya

Concurrent Session C

Biology, Physiology and Ecology of Invasive Bivalves

SESSION CHAIR:
Richard Thorn, Director, Institute of Technology, Sligo

1:30
Filtration Rates of the Invasive Pest Bivalve *Limnoperna fortunei* as a Function of Size and Temperature
Francisco Sylvester, Universidad de Buenos Aires, Argentina

1:50
Density of *Limnoperna fortunei* in Paraguay River, Brazil
Marcia Divina de Oliveira, EMBRAPA PANTHANAL, Brazil

2:10
A 10-Year Study of Population Dynamics of *Corbicula fluminea* Including Eventual Population Extinction in the Clear Fork of the Trinity River in North Central Texas
Robert F. McMahon, University of Texas at Arlington, USA

2:30
Genetic Identity and Invasion Dynamics of the Quagga Mussel *Dreissena rostriformis* (=*bugensis*) in the Volga River Basin and Great Lakes as Revealed by Microsatellite Analyses
Hugh J. MacIsaac, Great Lakes Institute, University of Windsor, Canada

2:50
Population Genetics of Zebra Mussel (*Dreissena polymorpha,* Pallas), an Exotic Bivalve Mollusc Recently Introduced in Ireland
Iulian Astanei, Galway-Mayo Institute of Technology, Ireland

3:10
Break

3:40
Oyster Invader Achieves Higher Densities in Marine Reserves.
Dianna K. Padilla, SUNY, Department of Ecology and Evolution, USA

4:00
Dominance of the Noxious Cyanobacterium *Microcystis aeruginosa* in Low-nutrient Lakes is Associated with Zebra Mussels
David Raikow, Kellogg Biological Station, USA

4:20
Distribution and Dynamics of *Dreissena polymorpha* Within and Among Lakes: 12 Years of Observations
Lyubov E. Burlakova, Stephen F. Austin State University, USA

4:40
Massive Invasion of an Estuarine Transition Zone Has No Detectable Effect on Zooplankton Community Structure
Ladd E. Johnson, Laval University, Canada

5:30
World Atlas of Invasive Aquatic Species – Concept Launch and Roundtable Discussion
The UNEP World Conservation Monitoring Network and GEF/UNDP/IMO-GloBallast Water Programme

Concurrent Session A

Invasion History

SESSION CHAIR:

Amy Benson, US Geological Survey

8:30
Global Distribution of the Alien Marine Amphipod *Caprella mutica*
Gail Ashton, Scottish Association for Marine Science, Scotland

8:50
Are Artificial Structures Facilitating the Spread of Invasive Species in Estuaries?
Tim Glasby, New South Wales Fisheries, Conservation Research, Australia

9:10
Tracking Progression of a Marine Invasion: Five Years of Observations of the Marine Gastropod *Rapana venosa* in the Chesapeake Bay, Virginia, USA
Roger Mann, College of William and Mary, USA

9:30
Taxonomic Distinctiveness Magnifies the Impact of Bioinvaders in Aquatic Ecosystems
Anthony Ricciardi, McGill University, Canada

9:50
New Invasive Phytoplankton Species Throughout the Suez Canal
Mohamed M. Dorgham, Alexandria University, Egypt

10:10
Break

10:40
Patterns of Spread of Introduced Pacific Oysters (*Crassostrea gigas*)
Susanne Diederich, Alfred Wegener Institute for Polar and Marine Research, Germany

11:00
Phylogeography: A Way to Track Gammarid Invasion Routes
Michal Grabowski, University of Lodz, Poland

11:20
Eradication of *Caulerpa taxifolia* in the US Five Years After Discovery: Are We There Yet?
Lars W. J. Anderson, US Department of Agriculture, Agricultural Research Service, USA

Concurrent Session B

Biology and Ecology of Dreissenids

SESSION CHAIR:

Sandra Nierzwicki-Bauer, Rensselaer Polytechnic Institute

8:30
Differential Excretion of Ammonia and Phosphate by Three Dreissenid Taxa
David A. Culver, Ohio State University, USA

8:50
The Impact of Dreissenid Ammonia and Phosphate Excretion on Lake Erie
David A. Culver, Ohio State University, USA

9:10
Dynamics of Zebra Mussel *(Dreissena polymorpha)* Populations in Lough Key, Ireland
Frances Lucy, Institute of Technology, Sligo, Ireland

9:30
Changing Distributional Trends for Dreissenid Mussels in the Upper St. Lawrence River, Lake Ontario, and Eastern Lake Erie
David Bruce Conn, Berry College, USA

9: 50
A Very Geographically-isolated Zebra Mussel – *Dreissena stankovici*: Comparison with Other *Dreissena* spp.
Daniel P. Molloy, New York State Museum, USA

10:10
Break

10:40
Preliminary Assessment of Protistan and Metazoan Symbionts of *Dreissena polymorpha* in the River Shannon, Ireland
Sarah Simpson, Berry College, USA

11:00
Current Distribution and Abundance and Future Colonization Potential of *Dreissena polymorpha* in the Hudson River Estuary
John Wimbush, Darrin Fresh Water Institute and Renssalaer Polytechnic Institute, USA

11:20
Distribution and Impacts of *Dreissena polymorpha* and *Corbicula fluminae*, Two Freshwater Exotic Suspension Feeders
Alexander Karatayev, Stephen F. Austin State University, USA

11:40
Patterns of *Dreissena* spp. Biomass in Relation to Physical Environmental Variables in the St. Lawrence River
Lisa A. Jones, McGill University, Canada

12:00
Human Waterborne Parasites in Zebra Mussels (*Dreissena polymorpha*) From the Shannon River Drainage, Ireland
Thaddeus K. Graczyk, Johns Hopkins University, USA

12:20
Effect of the Biotoxin Microcystin on the Feeding Behavior of the Zebra Mussel and Dynamics of the Toxins in the Mussel and in the Aquatic Environment
Guillaume Juhel, University College of Cork, Department of Zoology, Ecology and Plant Science, Ireland

Concurrent Session C

Vectors and Corridors for Introductions

SESSION CHAIR:

Charles W. Boylen, Rensselaer Polytechnic Institute

8:30
Alien Species in the Mediterranean Sea: Risks, Drivers and Vectors
Bella S. Galil, National Institute of Oceanography, Israel

8:50
The Sicily Channel: A Crossroad Between Atlantic and Indo-Pacific Worlds
Franco Andaloro, Central Institute of Research Applied to the Sea (ICRAM), Italy

9:10
Natural Dispersal Mechanisms and the Secondary Spread of Exotic Species
Dan Michin, Marine Organism Investigations, Ireland

9:30
Changes in Global Economy and Trade, and Potential Spread of Exotic Freshwater Bivalves
Alexander Karatayev, Stephen F. Austin State University, USA

9:50
Vectors of Local Dispersal of Marine and Estuarine Invasive Species in the Southern Gulf of St. Lawrence, Canada
Emily Darbyson, Dalhousie University, Canada

10:10
Break

SESSION CHAIR:

Charles L. Griffiths, University of Cape Town

10:40
Oyster Transports as a Vector for Exotic Species Introductions
Deniz Haydar, University of Groningen, Department of Marine Biology, The Netherlands

11:00
Invasion Corridors and Barriers to the Finnish Lake District, NE Baltic Sea
Marjo Pienimäki, Abo Akademi University, Finland

11:20
A GIS Analysis of Water Bodies Potentially at Risk for Zebra Mussel Invasion by Trailered Boat Transport in Western North America
David Britton, The University of Texas at Arlington, USA

11:40
Invasive Aquatic Species in Ontario: A Review and Analysis of Potential Pathways for Introductions
Steven Kerr, Ontario Ministry of Natural Resources, Canada

12:00
Invasive Freshwater Fish in the Iberian Peninsula: Introduction Pathways and Life-history Traits
Emili García-Berthou, Institute of Aquatic Ecology, University of Girona, Spain

12:20
Pilot Project on the Linkages Between Development Assistance and Invasive Alien Species in Freshwater Systems in Southeast Asia: A Report to the US Agency for International Development
Alexis T. Gutierrez, Smithsonian Institution, USA

12:40
Ships' Sea Chests – A Vector for the Dispersal of Aquatic Invasive Species
Martin H. Davis, Nuclear Department, HMS Sultan, England

1:00
Ballast Water as a Vector of Macroalgae: Experimental Studies in the Mediterranean Sea
Maria Monia Flagella, Stazione Zoologica 'A. Dohrn' – Benthic Ecology Laboratory, Italy

Review of Sound Studies for Deterring River Herring Species
Gregory Hunter, Ultra Electronics Ocean Systems, USA

Preliminary Study on the Diet of Two Invasive Gammarid Species *Dikerogammarus haemobaphes* (Eichwald 1841) and *Pontogammarus robustoides* (G.O. Sars 1894)
Karolina Bacela, University of Lodz, Poland

Alien Crustacea in Poland: A State of Art for the New Century
Michal Grabowski, University of Lodz, Poland

The Pacific Coast Estuarine Information System: Creating a Baseline for the Future
Deborah Reusser, US Geological Survey, USA

A Study on the Prevalence and Intensity of Parasitism in the Freshwater Mussel *Dreissena polymorpha* (Pallas, 1771) in Lough Derg, Ireland
Guillame Juhel, University College of Cork, Department of Zoology, Ecology and Plant Science, Ireland

Chemical Toxicity and Environmental Fate: An Evaluation of Aquatic Pesticide Use and Risk Assessment
James F. Petta, SYNGENTA, USA

Invasions of Ponto-Caspian Gobiidae in Poland
Joanna Kostrzewa, University of Lodz, Poland

Life History Traits of Ponto-Caspian Gobiids as Factors Promoting Their Expansion
Joanna Kostrzewa, University of Lodz, Poland

Harbor Water Quality - Origin and Settlement of Invasive Species
Jayaprada Chunduri, Tolani Maritime Institute, India

By Land and Water They Go: Aquatic Snails in the System. Are They Native, Exotic, Invasive or Just Great Bio-indicators?
Byron N. Karns, National Park Service, USA

US Coast Guard Ballast Water Management Program: Prevention of Ship-mediated Invasions
Richard Everett, US Coast Guard, USA

Range Limits of *Limnoperna fortunei* (Dunker, 1857) Due to pH Variation
Mônica Campos, CETEC/Setor de Recursos da Água, Brazil

Design and Testing of Incubator-emergence Traps (IETraps) for Use in Hatching Studies in Ballast Tanks
David F. Reid, NOAA, Great Lakes Environmental Research, USA

Elemental Fingerprinting of Zebra Mussel (*Dreissena polymorpha*) Shells Using Inductively Coupled Plasma Mass Spectrometry
Noel Casey, Institute of Technology, Sligo, Ireland

The National Aquatic Nuisance Species Clearinghouse and Searchable Electronic Database
Diane J. Oleson, National Aquatic Nuisance Species Clearinghouse, USA

Biological Invaders in the Taranto Seas (Mediterranean Sea)
Franco Mastrototaro, Università di Bari, Dipartimento di Zoologia, Italy

Effects of Natural and Artificial Filamentous Substrate on Settlement of Zebra Mussel Larvae
Nadine Folino-Rorem, Biology Department, Wheaton College, USA

Commercial Seaweed Farming of *Asparagopsis armata* at the West Coast of Ireland: Impact and Distribution
Robert Wilkes, National University of Ireland, Galway, Ireland

***Sargassum muticum* at the West and South Coast of Ireland: An Invasive Species on the Move?**
Stefan Kraan, National University of Ireland, Galway, Ireland

Impacts of the Zebra Mussel on Chlorophyll *a* and Nutrient Concentrations in Lough Erne, a Eutrophic Irish Lake
Bob Foy, Department of Agriculture and Rural Development, Ireland

Geographical Information System "INVADER" Online Version: Invasive Species of the Baltic Sea
Vadim E. Panov, Zoological Institute of the Russian Academy of Sciences, Russia

Nonindigenous Crustacean Species in the Coastal Zone of the Baltic Sea
Anna Szaniawska, Institute of Oceanography, University of Gdansk, Poland

Analysis of Shipping Traffic Into US Waters by Vessel Service
Elena Ryan, US Coast Guard, USA

Development of the Fluorescent *in situ* Assay (FISH) as a Species Specific Identifier of the Northern Pacific Seastar, *Asterias amurensis*
Barrie Forrest, Cawthron Institute, New Zealand

Ballast Water Exchange in Regional Seas
Tracy McCollin, Fisheries Research Services, Scotland

Enemy Escapee or Trojan Horse? Parasite Burden of the Invasive Asian Portunid Crab, *Charybdis japonica* and a Native New Zealand Protunid, *Ovalipes catharus*
Graeme Inglis, National Institute of Water and Atmoshperic Research, New Zealand

Modeling Saltative Spread of Established Marine Invaders and Their Management
Graeme Inglis, National Institute of Water and Atmoshperic Research, New Zealand

Use of Biocontrol Insects to Reduce the Use of Herbicides to Control Invasive Aquatic Plants
Charles E. Ashton, US Army Corps of Engineers, USA

The Present Status of the Asian Invasive Fish Species Topmouth Gudgeon, *Pseudorasbora parva*, (Schlegal, 1842) in Flanders, Belgium
Hugo Verreycken, Institute for Forestry and Game Management, Belgium

Developing a National Monitoring Program for the Early Detection of Coastal Aquatic Invasive Species
Michelle Harmon, NOAA, National Ocean Service, USA

The Louisiana State Aquatic Invasive Species Management Plan – Process and Product Update
Michael M. Stevenson, College of Sciences, University of New Orleans, USA

Synbranchid Eels in the United States: History of Introduction and Current Status
Leo G. Nico, US Geological Survey, FISC - Center for Aquatic Resources Studies, USA

Pulsed Low Power Laser Irradiation as a Ballast Water Treatment Technique: A Laboratory Study
Hideki Obika, National Institute of Advanced Industrial Science and Technology, Japan

Tools Assessing Risks: Ongoing Efforts to Evaluate Potential Harm of Introduced Aquatic Organisms
Amy J. Benson, US Geological Survey, USA

War Against *Crassula helmsii*
Debbie Wicks, Hampshire and Isle of Wight Wildlife Trust Ltd., England

Classroom Technology For Learning and Decision Making About Invasive Species
Rosanne Fortner, The Ohio State University, USA

Ships' Sea Chests – A Dispersal Mechanism for Nonindigenous Species
Martin H. Davis, Nuclear Department, HMS Sultan, England

Changes in the Gulf of Gdansk Biocenosis by Round Goby (*Neogobius melanostomus*) – An Invasive Ponto-Caspian Fish
Mariusz R. Sapota, University of Gdansk, Institute of Oceanography, Department of Marine Biology and Ecology, Poland

Invasive Molluscs in the Mediterranean: State of the Art
Gianfranco Scotti, Central Institute of Research Applied to the Sea (ICRAM), Italy

Vectors, Detectors and Inspectors

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Man has distributed aquatic species over millenia. For early species movements we have little or no evidence; and many will have spread before our general knowledge of biogeography. Consequently the assessment of species considered to be native may not be so. Most of these early arrivals will have been spread with trade, and ships' hull fouling. Over the last century many, new and more effective vectors have become active. Yet evidence apportioning the mode of arrival of a species is often unclear as there are many unexplained arrivals of species, or of unexplained events. Nevertheless, deductions based on species life-mode and nearby human activities have implicated some likely vectors and their pathways. These may involve a series of movements in relay arising from overlapping activities. Some vectors over time change in their power of transmission, or cease, and may be taken up by a different transferral process. One of the main changes is speed of transmission. For example, formerly over long journeys ships were the only means of carrying a species from Europe to Australasia taking some 10 or more weeks. During this time the carried species will have been subject to varying challenges thereby reducing their potency of establishment on arrival. To day, however, salmon eggs can be transported by plane in about a day. As we often have difficulty in apportioning a vector we have equal difficulty in calculating the size of a founder population and this is an important gap in our understanding. Further, the capability of natural vectors may not be so completely understood, rare or infrequent meteorological or earth crust events or changes in climate may be of import. Over the last three decades, leisure-time activities have expanded with the trade of plants and fishes for ornamental ponds (as well as their associated biota), sport fishing and aquaria and inadvertent transmissions and in the case of fouling on leisure craft. Such movements often involve small volumes of biota that can become widely distributed and may escape or become released. Many of these species are nurtured and so are provided special advantage. Management requires all of these complexities to be unravelled so that targeted action is both possible and practical and appropriate according to the expansion in the range of an impacting species. Some effective management options will only be possible soon after a species arrives, as in the case of eradication. Unless regular monitoring at specific sites is undertaken we will find invasions taking place without our knowledge until some impact is revealed. It is necessary to know the likely routes of invasion, the species involved and also monitor and inspect imported consignments. In addition it is helpful to undertake a shared responsibility with all stakeholders using recent knowledge. Such management would appear to be effective. However, legislation and its enforcement become important where there is non-compliance.

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N O T E S

Managing the Global Invasive Species Problem – Some Lessons from Experience With National, Regional and Global Programmes

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Invasive Alien Species (IAS) are a global and cross cutting issue affecting all countries but in various ways and extents. This paper will describe issues which affect how well the world is dealing with this threat to biosecurity based on the experience of a government agency officer working for national, regional and global IAS programmes. Some of the questions I will address include: what is the utility of national, regional and global programme(s), what are the threats to the success of IAS programmes, the "globalisation" issue, new initiatives which promise improved success, funding issues, how effective are conventions and what is the importance of law and regulation, and what is the responsibility of scientists and challenges for science and technology.

Finally, I will recommend future directions for dealing with the IAS issue.

NOTES

Invasive Aquatic Species and Ships Across the Sea – The IMO Response, Reflections and Directions

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In the last ten years or so, scientists, governments, the community and industry have come to increasingly recognise the harm that invasive species can cause to marine and aquatic environments. Today, invasive species are considered to be one of the major threats to marine biodiversity, as well as posing significant economic and public health problems.

Every major international conference on the environment in the last decade, including the United Nations Conference on Sustainable Development in 1992, the Conferences of Parties to the Convention on Biological Diversity, the World Summit on Sustainable Development in 2002 and the 5th World Congress on Protected Areas in 2003, have highlighted the issue of invasive species, and called upon governments and industry to act.

While shipping is by no means the only route through which harmful species may invade new areas, ballast water and hull fouling are both contributors to this global problem, and both the International Maritime Organization – IMO, and the shipping industry have taken concerted action to find ways to address the issue.

IMO has been working to address the ballast water vector for more than 10 years, developing two sets of guidelines and executing a major effort to assist developing countries through the Global Ballast Water Management Programme –GloBallast. In February this year, IMO's efforts were rewarded with adoption of the new International Convention on the Control and Management of Ships' Ballast Water and Sediments by a Diplomatic Conference convened by IMO at its Headquarters in London.

This act, providing a uniform and effective international instrument to regulate ballast transfers, is perhaps one of the most significant global environmental achievements in the early part of this Century. When one considers the enormous scientific and technological challenges, and the highly complex and multi-disciplinary nature of the problem - encompassing biology, chemistry, engineering, law, economics and ecology, not to mention ship design, construction and operation - achieving consensus on the convention must be seen as a major credit to the efforts of delegates from IMO member States and the staff of the IMO Secretariat.

The importance of international standards and a uniform global approach cannot be over-emphasised when dealing with a trans-boundary industry like shipping. The new ballast water management Convention will certainly have impacts on the industry; however these will be far less disruptive than the alternative, potentially disparate regional and unilateral responses, which would undoubtedly proliferate in the absence of the Convention.

The new Convention provides flexible options and builds on the complimentary roles of coastal, port and flag States in protecting the marine environment. It retains the current management measure of ballast water exchange at sea, for the foreseeable future, while providing for continuous improvement by setting standards to stimulate the development of alternative, more effective management measures over time.

Much work remains to be done however, to ensure that the ballast water management Convention enters-into-force as soon as possible, and that parties to the Convention implement it effectively through appropriate national legislation. There is also much work still to be done to develop technical guidelines under the Convention, including among others, guidelines for approval of ballast water management systems and prototype treatment technologies.

In developing regimes to regulate shipping, we must bear in mind the vital role this industry plays in our lives and the economy. Shipping is truly global and multi-national, carrying more than 90% of world trade. As such it underpins the continued economic development of human society, and is a vital force for the delivery of improved living conditions through trade and commerce. This highlights the need to balance environmental concerns with economic considerations of world trade, and importantly, safety of life on ships.

We must also bear in mind that shipping is by no means the only vector for the transfer of species to new environments. Aquatic species also invade new areas through canal developments, the movement of marine structures such as oil platforms, floating docks and barges, intentional and accidental introductions relating to aquaculture and fisheries and escapes and releases form aquaria, to name a few.

While the international community has moved to address the ballast water vector, through the development of a comprehensive regulatory regime, a major research and development effort and a global technical cooperation programme, similar global responses have not been mounted to the other vectors and pathways. Addressing one vector cannot be wholly effective if exotic species are able to continue to invade new environments through other vectors. While IMO has the international mandate to take the lead on addressing shipping issues, we urge other relevant international organizations, governments and industries to take urgent action to address the as yet unaddressed vectors for aquatic bio-invasions, through concerted, comprehensive and integrated global programmes.

NOTES

Two Nations, One Ecosystem, Working Together on Aquatic Invasive Species Management and Control

The Rt. Honorable Herb Gray, P.C., C.C., Q.C.
Chair, Canadian Section, International Joint Commission

Honorable Dennis Schornack
Chair, US Section, International Joint Commission

The International Joint Commission (IJC) prevents and resolves disputes between the United States and Canada under the 1909 Boundary Waters Treaty. With equal numbers of commissioners appointed by the leaders of their respective countries, the IJC pursues the common good of the US and Canada as an independent and objective. In particular, the IJC has the unique function of assisting the governments in the implementation of the Great Lakes Water Quality Agreement (GLWQA). First signed in 1972 and last revised in 1987, this visionary agreement commits the two countries "to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem." With respect to alien invasive species, the parties agreed to conduct "studies to determine if live fish or invertebrates in ballast water discharges constitute a threat to the System." (Annex 6) In this regard, both the US and Canadian Coast Guards report annually to the IJC on the status of their efforts.

In 1988, the IJC informed both governments that exotics species in ballast water did indeed constitute a threat to the Great Lakes and urged the Coast Guards "to make firm plans leading to the end of the ongoing introduction of exotic organisms to the Great Lakes via ballast water discharge." Since then, billions of dollars spent to control and remediate species already introduced in the system, from the sea lamprey to the zebra mussel, making binational action to prevent further introductions all the more critical.

Today, some scientists estimate that more than 170 nonindigenous fish, invertebrates, plants, algae, protozoa and parasites have entered the lakes and predict that one new alien species will be discovered about every eight months.

Now, following the signing of International Maritime Organization (IMO) standards for ballast water discharge, the IJC is recommending regional, binational action to stop further inflows of invaders before the convention is implemented and ratified. The convention recognizes the need for regional cooperation, stating that a party may individually, or jointly with other parties, impose additional measures to prevent, reduce or eliminate the transfer of harmful aquatic organisms and pathogens through ships' ballast water and sediment. A Great Lakes solution to invasive species must be a cooperative effort focused on regional concerns that includes a biologically protective standard for all the Great Lakes; requires technology certification to achieve the standard; requires enhanced measures of ballast management for ships carrying residual ballast water and sediment; promotes ongoing regional cooperation; and develops measures to ensure compliance.

Such regional cooperation will be facilitated by a recent Executive Order signed by the President of the United States creating a task force to improve interagency regional coordination among federal agencies having jurisdiction in the Great Lakes. Canada has expressed willingness to work with the task force and the IJC urges the two nations to pursue this initiative and harmonize national invasive species prevention plans, particularly with respect to ballast water management but also with respect to other invasion vectors. For example, the IJC is very concerned about the Asian carp, an invader introduced into aquaculture in the southern US that escaped and after traveling the Mississippi river system, now is within 40 miles of Lake Michigan. The carp are voracious filter feeders that could potentially disrupt the food chain in the Great Lakes and possibly devastate the $4.5 billion sport and commercial fishery in the lakes. The IJC has been a vocal and active proponent of an electric barrier in the manmade canal connecting the Mississippi basin to the Great Lakes.

The IJC believes that alien invasive species are among the top threats to biological integrity and biodiversity in the Great Lakes; however, in contrast to physical and chemical threats, present the most solvable problem confronting the world's largest source of freshwater. The key is binational cooperation.

Directions in Policy and Action on Aquatic Invasive Species in the United States

Timothy R.E. Keeney

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In the past, there has been a tendency to approach invasive species issues as individual problems rather than as generic problems, and this has affected the way in which we respond to them. Over the last decade, the United States government has moved in the direction of a more systematic approach to such issues. Of necessity, there also has been an effort to prioritize actions. Passage of legislation to address aquatic invasive species was a precursor to this trend. In 2000, the US government took a major step in addressing invasive species issues in a systematic, coordinated, and comprehensive manner when a National Invasive Species Management Plan was adopted. Since then, actions have been guided and influenced by the Plan.

One of the major foci since passage of the original legislation has been on ballast water. In the very near future, some of the issues associated with ballast water may be resolved. Whether through existing regulatory authority or through new legislation, ballast water management will be required for all ships entering US ports. We are also making substantial progress on technologies to serve as alternatives to ballast water exchange. Over the next five years, attention will be given to other pathways.

During the current Congress, the Nonindigenous Aquatic Nuisance Prevention and Control Act is due for reauthorization. The bills that have been introduced indicate that this will be a major rewrite of existing law. The proposed legislation addresses some existing gaps in legal authority such as rapid response to incipient invasions and a screening process for intentional introductions. In addition, additional emphasis is placed on monitoring activities and research. This will contribute to a comprehensive approach to invasive species problems.

Within the Executive branch of the government, much more emphasis is being placed on efficient and effective use of resources. No one agency has the capacity or resources – financial and human – to fully address invasive species, and in some instances, lack of cooperation and coordination has resulted in resources not being effectively utilized. Last year, in the spirit of the Management Plan, federal agencies put forward a limited crosscutting budget in which priority issues were addressed. Such cooperation and coordination will not only increase on the Federal level, but will also involve State and local partners.

NOTES

Integrating Science With Policy: The Canadian Experience

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Aquatic invasive species have been recognized as a problem in Canada for more than half a century. By the 1950s sea lamprey had decimated the valuable Great Lakes' recreational, aboriginal and commercial fisheries leading the Canadian and American governments to implement a control program that continues to this day at an annual cost of tens of millions of dollars. Sea lampreys were a very visible pest. Later invaders were not as obvious, becoming established as self reproducing populations and discovered by scientists long before they came to the attention of the media, general public and politicians. With the detection of the zebra mussel in the Great Lakes some 16 years ago and their subsequent rapid spread and millions spent to repair fouled infrastructure on both sides of the border, the media, public and politicians started becoming aware of aquatic invasive species and the environmental and economic damage they cause.

As often is the case there has been a lag between scientific discovery and mobilization of effort to effect preventative or remedial actions even as scientists identified more and more aquatic invaders. However, the media has now picked up this issue and is pursuing it vigorously. The public and non-government organizations have also shown increasing concern as lakes and rivers are clogged by invasive vegetation, molluscan aquaculture is threatened and fishing lines are fouled with spiny water fleas, and are looking to governments to take action.

This presentation will examine the social, political, economic and scientific factors that affect the transfer of scientific information into policy and how Canada is now responding to develop a National Action Plan to address the threat of aquatic invasive species.

NOTES

Invasive Species in Ireland

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International cooperation is fundamental in tackling invasive species problems, particularly where ecological and political sensitivities are evident. Northern Ireland (NI) and the Republic of Ireland (RoI) have domestic and international obligations to address invasive species issues. Recognising the need to manage invasive species impacts throughout Ireland, Environment and Heritage Service (NI) and National Parks and Wildlife Service (RoI) commissioned 'Quercus' to provide an all-Ireland review of invasive species. This culminated in recommendations to both Governments in March 2004. Intentional introductions in Ireland appear to be decreasing, whereas accidental introductions are increasing. In common with other regions, Ireland's shipping trade is a primary vector for potential invaders. The relatively recent invasion of Ireland by the zebra mussel, arising from changes in tax legislation with regard to recreational vessels, illustrates the nuances of invasion events. Many non-native species that have not become invasive are beneficial to Ireland (e.g., in forestry and aquaculture). Others have no detectable or recorded impacts. However, the most prominent negative impacts of invasives, in terms of numbers of studies, appear to be competition with and predation on natives, followed by habitat alteration and introductions of parasites and pathogens. Priority habitat types most under threat from invasives include mesotrophic lakes, native woodland and coastal saltmarsh. Priority native species of particular concern are freshwater crayfish (potential of invasive crayfish and associated disease) and red squirrel (competition and disease transmission from North American grey squirrel). A raft of international, EC and domestic legislation purports to protect Ireland from invaders, but provision for enforcement is often ineffective. Recording and monitoring of both invasives and natives requires streamlining between the two jurisdictions. We recommend a cross-border inter-departmental forum or agency for non-native species that takes primary responsibility for risk analysis and the formulation and operation of contingency plans.

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Introduced Aquatic Species in Europe — An Attempt at an Inventory

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Nonindigenous Species (NIS) introduced into major European Seas and adjacent waters show a similar pattern as in other parts of the world, with the exception of Lessepsian migrants, i.e., species migration through the Suez Canal. In total more than 800 NIS have been introduced in marine and brackish waters of Europe with the majority having been first recorded during the 1960s and 70s. The taxa being introduced ranges from unicellular algae to vertebrates with a clear dominance of zoobenthic organisms across all seas. The Mediterranean Sea is by far the major recipient of NIS. Outside the Mediterranean Sea the Baltic seems to be the most hospitable sea. However, for many NIS the establishment success remains unknown. It should further be noted that not all regions in Europe have carried out detailed inventories of NIS, i.e., the number of NIS in European seas as indicated above is clearly an underestimate. Migration through the Suez Canal and shipping appear to be the major vectors of introduction to be followed by introductions of target species and associated non-target species for aquaculture purposes. The introduction of NIS is a dynamic and ongoing process with new species being reported each year.

NOTES

Aquatic Invasive Species In South Africa – Environmental Impacts and Management Responses

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South African inland waters in have been heavily impacted by both deliberately and accidentally introduced aquatic species, as well as by introduced riparian plants, which impact river systems by transpiring enormous volumes of water, altering water chemistry and blocking both river flow itself and access to the banks.

Invasive alien aquatic plants are present in practically every freshwater ecosystem in the region, the species of most concern including *Eichhornia crassipes*, *Salvinia molesta*, *Pistia stratiotes Myriophyllum aquaticum* and *Azolla filiculoides*. Their impacts include blocking of channels, impeding water flow, decreasing light penetration and oxygen dissolution, increasing evaporation and interfering with recreational activities. Their presence can also lead to fundamental changes in biodiversity and community structure. Control mechanisms in use include mechanical clearing and spraying of herbicides, as well as the introduction of a number of successful biological control agents, of which examples will be presented.

The most significant introduced freshwater animals are fish. There are at least 41 species of alien fish naturalized in the region, while many others have been translocated within South Africa. The vast majority of these fish have been introduced deliberately, either for aquaculture, for sport angling, or to control mosquitoes or algae. The species with the greatest impact are trout and bass, which have had drastic effects on, and threaten the survival of, the populations of a number of small indigenous fish, many of which were already range-restricted. We are not aware of any measures that have been taken to date to eradicate alien fish populations, although there are proposals to poison bass and trout from short stretches of stream in the Southwestern Cape in an attempt to create sanctuaries for threatened native species.

There are far fewer marine than freshwater alien species in the region. To date approximately 20 invertebrates and one (very range-restricted) seaweed are recorded as introduced, mostly from the Western Cape region. Of these only three have significant ecological or economic impacts. The *ascidian Ciona intestinalis* is an important fouling organism, especially on mussel culture rafts. The European shore crab, *Carcinus maenas*, is currently restricted to the Cape Town region, but is a voracious predator that poses a significant threat to aquaculture operations and marine national parks should it spread further. The Mediterranean mussel *Mytilus galloprovincialis* has colonized over 1500 km of coastline and is now a dominant species along the entire west coast. Although it has a number of ecological impacts it is also commercially cultured and has the potential to be exploited by subsistence fishers. No attempts have been made to control or eradicate existing invasions, although efforts are underway to prevent additional introductions.

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Post-border Management of Non-native Marine Species in New Zealand

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New Zealand's response to the threat of non-native species is to focus on pre-border and border activities to prevent new species arriving — prevention rather than cure. However, no system can realistically achieve zero risk, consequently a strong post-border system also needs to be developed. An effective post-border system should be able to detect, respond and prevent the further spread of undesirable marine species should they arrive. The development of a comprehensive post-border regime will reduce the rate of dispersal of organisms from points of arrival to valued areas around the country. Valued areas requiring protection encompass the entire spectrum, from marine habitats with high biodiversity or rarity value, high production or commercial value to areas of cultural and recreational value.

This paper presents post border management initiatives being undertaken in New Zealand. The initiatives include developing an overall policy for management of an established pest, identifying and profiling the main vectors, mapping high value areas, developing codes of practice for vector operators and local government agencies and developing sanitisation treatments for the aquaculture industry to reduce the transfer of non-native species with the transfer of stock and equipment. Most of these initiatives have been developed primarily to combat the spread of *Undaria* and/or toxic micro-algae but will be effective in helping to reduce the spread of other non-native species in the future.

This paper also discusses guidelines being developed for hull cleaning. Biofouling of hulls is considered to be a major pathway for international and domestic transfer of marine organisms. In New Zealand recreational yachts and other vessels are encouraged, through educational material, to clean their hulls regularly so as to reduce the spread of undesirable species. However most cleaning processes result in biofouling organisms being washed back into the coastal area where they may establish unwanted populations. The guidelines being developed will minimise this risk through design and operation standards for vessel cleaning facilities and in-water cleaning. Facilities approved to the highest standard will be permitted to clean vessels that have recently arrived from overseas. Such vessels will not be permitted to clean other than in approved facilities or by in-water processes.

NOTES

The Aquatic Nuisance Species Task Force: A Mechanism to Coordinate Efforts to Combat Aquatic Nuisance Species in Order to Protect US Waters

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The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 established a Task Force to coordinate activities between Federal agencies, regional, State, tribal, and local organizations involved in carrying out the Act. The mission of the Aquatic Nuisance Species (ANS) Task Force is to develop and implement a program for waters of the United States, to: prevent introduction and dispersal of aquatic nuisance species; monitor, control, and study such species; and educate and inform the general public and program stakeholders about the prevention and control of these species. The ANS Task Force aims to reduce the threat of harmful aquatic species being introduced into US waters by: 1) facilitating the development and use of science based risk assessments to determine the level of risk associated with introductions of potentially invasive aquatic species; 2) identifying high risk pathways for the introduction of harmful aquatic species and coordinating specific actions to reduce the likelihood of introduction of harmful non-indigenous aquatic species; 3) increasing public awareness about the importance of ANS introductions and actions that can be taken to reduce the possibility of ANS becoming established; and 4) prioritizing and promoting research to reduce the threat of ANS introductions. The ANS Task Force aims to minimize the harmful effects of aquatic nuisance species already introduced into the waters of the United States by: 1) developing the capacity to respond rapidly to invasions; 2) facilitating survey and monitoring efforts to detect and control ANS; 3) facilitating the development of State and Interstate management plans to limit the spread of ANS; 4) coordinating development and implementation of ANS control plans; 5) encouraging education and outreach activities related to ANS, and 6) prioritizing and promoting research to evaluate the harmful effects of ANS. The ANS Task Force aims to cooperate in global efforts to reduce ANS harm by sharing information and expertise on ANS and coordinating international activities related to ANS among Task Force member agencies. Lastly, the ANSTF aims to maximize its organizational effectiveness by: 1) strengthening the its coordination capacity; 2) ensuring that adequate legal authorities are in place to implement the ANS Program; 3) coordinating Federal agency budgets to support Task Force priorities and establish a clear process that links local needs with the Federal budget process; and 4) instituting organizational improvements based on annual evaluation of ANS Program progress.

NOTES

European Cooperation in Research, Information Exchange and Management of Aquatic Invasive Species

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Incessant introductions of aquatic invasive species into coastal and inland waters are an increasingly serious threat to biodiversity and cause huge economic losses in Europe. The importance of international cooperation on the issue on both the regional (Pan-European) and sub-regional levels is well recognized by the European scientific community. Also, the European Strategy on Invasive Alien Species, adopted under the Bern Convention in December 2003, aims to promote the development and implementation of coordinated measures and cooperative efforts throughout Europe to prevent or minimize adverse impacts of invasive alien species, including regional and sub-regional cooperation in relevant research, exchange of information and management. Pan-European and sub-regional activities in these areas are undertaken in frameworks of relevant international working groups, networks, programmes and research projects.

European scientists are actively involved in several international and sub-regional working groups: ICES Working Group on Introductions and Transfers of Marine Organisms (WGITMO), ICES/IOC/IMO Working Group on Ballast and Other Ship Vectors (WGBOSV), the International Association of Theoretical and Applied Limnology (SIL) Working Group on Aquatic Invasive Species (WGAIS), Baltic Marine Biologists (BMB) Working Group on Non-indigenous Estuarine and Marine Organisms (WG NEMO), the Caspian Environment Programme (CEP) Regional Biodiversity and Invasive Species Advisory Group. Currently members of these working groups are involved in several international projects and initiatives regarding aquatic invasive species.

Ongoing sub-regional projects include: the three volumes of the "CIESM Atlas of Exotic Species in the Mediterranean" and the PORTAL initiative, Baltic Sea Alien Species Database and GIS "Invasive Species of the Baltic Sea" (both supported by the HELCOM and GEF Baltic Sea Regional Project), Caspian Sea Biodiversity Database and *Mnemiopsis* management project (supported by the GEF Caspian Environment Programme), Nordic/Baltic Invasive Species Informational Network (supported by the Nordic Council of Ministers).

Relevant Pan-European projects, supported by the European Commission, include: "Algal Introductions to European Shores" (ALIENS, 2002-2004), "On-board treatment of ballast water and application of low sulphur fuels" (MARTOB, 2001-2004), "Assessing Large-scale environmental Risks with tested Methods" (ALARM, 2004-2009), "Delivering Alien Invasive Species Inventories for Europe" (DAISIE, 2004-2007). European cooperation relevant to aquatic species invasions resulted in the establishment in 2001 of the European Research Network on Aquatic Invasive Species (ERNAIS), which currently includes more than 100 experts (scientists, managers and administrators) from 27 countries.

Facilitation of international cooperation in research, scientific information exchange and management of aquatic invasive species in Europe and worldwide is a main objective of ERNAIS. In the future ERNAIS may serve as an European part of the developing Global Invasive Species Information Network, and as a main European framework of on-line scientific information exchange, relevant to aquatic invasive species, providing essential information and expertise needed for management of aquatic invasive species on the European level.

A Global Perspective on Shipping as a Vector for New Species Introductions

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Species introductions are one of the top four anthropogenic threats of the worlds oceans. In average every nine weeks a new invader is found in coastal and adjacent waters worldwide. The major vector for unintentional species introductions in aquatic habitats is shipping. Historically hull fouling was the predominant introducing vector. However, ballast water in use since 1870s came more and more into focus. The global merchant fleet of more than 40 000 vessels discharges 3 to 12 billion tonnes of ballast water, being the key transport vector of species. In addition hull fouling contributes considerably to species movements being in some regions the dominant introducing vector. Estimations result in the assumption that more than 4000 species are in transit with ships at any one time. European studies on ballast water and tank sediments have shown that more than 1000 different taxa can be found in ballast tanks ranging from unicellular algae to fishes up to 15 cm in length. A worldwide comparison of results from various ballast water sampling studies (i.e., end-point sampling of un-managed ballast water) includes 429 zooplankton and 273 phytoplankton samples. Considerable variation exists in the concentrations of organisms arriving in unexchanged/untreated ballast water among vessels. The organism density median (half of the samples had concentrations above this value and the other half below this value) was 400 zooplankton individuals per cubic meter (range of concentrations was 0 - 172 000 individuals per cubic meter). The median of phytoplankton cell density was calculated as 13 300 cells per litre (the range of concentrations was 1 - 49 716 400 phytoplankton cells per litre). Some of this variation is explained by a) season, and b) voyage duration. Surprisingly, ballast kept onboard for longer than 100 days still contained a large number of organisms. It was further proven that certain species reproduce in ballast water during the ships voyage. As a result each single vessel carries an enormous number of organisms and therefore poses a high risk of introducing a new species. Each introduced species shows an impact on the receiving environment with a potential to negatively impact on economies, such as fishing, aquaculture and tourism. It is hoped that the recently signed Ballast Water Management Convention of the International Maritime Organization (IMO) will considerably reduce the number of organisms being discharged by ships in coastal waters.

N O T E S

Bioinvasions in North America's Great Lakes and the Shipping Vector

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The Laurentian Great Lakes have 176 established nonindigenous species (NIS) of which over 40% have been attributed to the ship vector. The invasion rate in these waters has increased to nearly six times the previous rate since the opening of the St. Lawrence Seaway in 1959. Interestingly, the invasion rate of ship-vectored faunal species has increased despite implementation of voluntary guidelines (1989) and mandatory legislation (1993) requiring open-ocean ballast water exchange. Such an increase in the face of current ballast water exchange policies may be related to the fact that 90% of transoceanic vessels entering the Great Lakes-St. Lawrence Seaway during the 1990s reported no ballast on board (NOBOB) and were therefore exempt from the legislation. NOBOB ships unload cargo at their first port of call, take on Great Lakes water (mainly from Lakes Ontario and Erie), which mixes with residual water and sediments present in the tanks of these vessels, and release this mixed ballast water prior to leaving the Great Lakes. Of all the Great Lakes, Lake Superior receives the most ballast water discharges from both ballasted and NOBOB ships but has sustained surprisingly few invasions since 1959, possibly owing to its relatively inhospitable physical environment. Recent studies have revealed that NOBOB vessels may carry viable resting eggs, and these vessels may pose an invasion risk to Great Lakes waters.

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Vectors for Introduction of Alien Macroalgae in Europe: Hull Fouling

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Shipping is recognized to have played an important role as a vector of transfer for marine species by the way of hull fouling throughout the past centuries. Nowadays, transport occurs principally through ballast water tanks. However, boat fouling could actually be underestimated as very few studies have been undertaken recently.

The present study has been carried out in the harbour of Sète (south coast of France) during 2003. A total of 23 ships with IMO registration have been surveyed for macroalgal fouling. Origins of the ships were Mediterranean Sea, Western Pacific, Indian Ocean, Atlantic coasts of Europe, Africa and South America. Lengths varied from 54 to 225 m. The last dry docking has been undertaken for all ships in the last 30 months. Except in one particular case, hulls were covered with tributyltin (TBT) based paintings.

More than 20 species of macroalgae have been found, mainly cosmopolitan species. When painted with non-toxic “antifouling”, a high macroalgal diversity has been observed, with species having a smaller range of native distribution.

The potential adverse effect of the future ban of TBT and consequences on macroalgal introductions will be discussed.

NOTES

Quantifying the Efficacy of Mid-ocean Ballast Water Exchange: An Experimental Approach

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It is widely recognized that invasions by nonindigenous species represent one of the most significant threats to global biodiversity. Within aquatic environments, ships' ballast water serves as a primary vector for the transfer of species, and many documented invasions are now attributed to ballast-mediated introductions. Mid-ocean Ballast Water Exchange (BWE) has been advanced as one method to reduce the transfer and subsequent establishment of coastal organisms by ships. BWE involves the replacement of coastal ballast water with open ocean water. Through BWE, many coastal organisms are released into the open ocean, where conditions are usually not appropriate for their survival. Conversely, coastal environments do not favor most oceanic organisms that become entrained during BWE. This method is currently being promoted worldwide, and is immediately available on many ships to reduce the risk of invasions, but few data are available to evaluate its efficacy.

In this study, we quantitatively measured the efficacy of BWE in reducing concentrations of coastal macrozooplankton (biological tracers) and Rhodamine dye (physical tracer), using controlled experiments on eight replicate voyages. The experiments occurred aboard oil tankers, traveling along western North America to Alaska in 1998 and 1999, with voyage durations between 2 to 8 days. On each voyage, we sampled at least one 'experimental' tank, which was subjected to BWE by either of two methods: (i) 100 % Empty-Refill (ER) exchange, (ii) Flow-Through (FT) exchange, including 100% FT and 300% FT. We also sampled one 'control' tank, which was not subject to any form of BWE, on each voyage. Within each tank (experimental and control), replicate samples were collected at least before and after exchange.

To estimate the effect of BWE on the initial water mass, a known concentration of Rhodamine dye was placed into all tanks before the commencement of the voyage, and changes in concentration were estimated using whole water samples taken with a Niskin bottle from multiple depths. To estimate the effect of BWE on zooplankton, samples were collected using bottom to surface net (80 µm) tows within ballast tanks. Replicate net tows were taken at a minimum of two locations in each tank on multiple occasions during the voyage, allowing comparisons of temporal changes and spatial (within tanks) heterogeneity in zooplankton abundances.

Zooplankton analyses were restricted to organisms that occurred in the coastal zone, to remove possible confounding effects of entrainment during exchange in open ocean. Seventeen coastal zooplankton taxa were chosen as 'target taxa', allowing us to compare changes between treatments (control and experimental tanks) and to estimate the effect of BWE.

Survivorship of zooplankton within non-exchanged (control) tanks showed considerable temporal and spatial variability, and BWE resulted in significant reductions in zooplankton density. The 100% ER treatment consistently showed greater reductions in density than did 100% or 300% FT treatments. Relative to control tanks, BWE by the ER method resulted in reductions of zooplankton densities by an average of ~99%, compared to ~60% for 100% FT and 75% for 300% FT. Measurements of BWE efficacy using Rhodamine dye revealed similar results.

Our data suggest that BWE is highly effective at removing coastal zooplankton from ballast tanks. These results differ from some previous reports, which suggest that the efficacy of BWE can sometimes be relatively low. We suggest that this difference may result largely from methodology, whereby earlier studies did not control for initial starting concentrations (which can be highly variable) but instead compared densities on ships that undertook BWE to those that did not. In general, our data suggest that BWE is a useful management tool to reduce organism transfers and should result in reduced likelihood of invasions.

Ballast Water Management: Toward Understanding Treatment Efficacy

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Ships have been an important mechanism for the transfer and establishment of non-native species in coastal ecosystems throughout the world. In US waters, for example, ships have historically been responsible for most known invasions, and ship-mediated invasions have exhibited an exponential increase over the past two centuries. A similar pattern has emerged in many different global regions, increasing both scientific and public concerns. Over the past few years, a growing number of policies and management efforts have emerged to reduce the likelihood of transfers by ships' ballast water.

There remain many fundamental gaps in knowledge about the efficacy of management strategies to reduce new coastal invasions. These can be divided into three general categories. First, the relative importance of various transfer mechanisms (vectors) to observed invasions is still often not clear, due to the existence of multiple plausible vectors for invasion events. Second, efforts to measure effects of treatment options to reduce species transfers, especially across a wide spectrum of organism types, are still at an early stage. There is a great deal not yet known about treatment effects on both quantity and quality of organisms across the wide spectrum of taxa, life stages, and environmental conditions involved in transfers. Third, and perhaps most importantly, the quantitative relationship between the number of propagules (organisms) delivered and the likelihood of colonization, or the "dose-response" relationship, is poorly resolved.

In the first category, it is clear that the relative importance of vectors varies in space and time and that shipping continues to be an important vector. In North America, for example, most marine invasions are attributed to shipping as either a sole source or one of multiple possible sources. However, within the "shipping vector", it remains a challenge to clearly distinguish the relative importance of ballast water versus hull fouling, because many organisms have life stages that can occupy either ship habitat. In addition, unlike surveys of biota in ballast tanks, there are few contemporary analyses of hull fouling communities on modern ocean-going vessels.

As for the effect of treatments to reduce species transfers, a proximate measure of efficacy, much of the current efforts have focused on Ballast Water Exchange (BWE). BWE is intended to flush out ballast tanks at sea, reducing the concentration of coastal organisms that can become established at subsequent ports of call. Further, it is believed coastal organisms discharged at sea, or oceanic organisms discharged in nearshore (port) environments, pose little risk of establishment.

We have quantified the efficacy of BWE to reduce the transfer of organisms on > 24 different voyages, using controlled exchange experiments. The experiments were conducted on multiple vessel types, including U.S. Navy vessels, commercial oil tankers, container ships, and bulk carriers. On each voyage, we measured changes in rhodamine dye and zooplankton concentrations in identical fashion for paired exchanged (experimental) and unexchanged (control) tanks at multiple time points: Before BWE, after 100% BWE, and sometimes after 200% BWE..

Results across these studies show strong concordance, indicating BWE is highly effective at removing the original water mass (rhodamine dye) and waterborne organisms, excluding benthic or biofilm communities (which were not examined). This contrasts with a review of previous studies, for which efficacy measures show a wide range. We suggest that this difference results largely from methodology, whereby some earlier studies did not control for variation due to ship, ballast tank, or time (see also abstract by Verling).

We are aware of several other studies underway to examine the effects of BWE, as well as a variety of other treatment methods, on entrained organisms. We anticipate rapidly increasing knowledge about the capacity of various treatments (including BWE) to reduce organism transfers by ships' ballast water. Despite the current efforts to advance technologies for ballast water treatment, these efforts are still in the development and testing stage, and full-scale implementation is clearly many years away. For the near future, BWE should be encouraged to the full extent possible, as a treatment method that is readily available and that is able to significantly reduce transfers of coastal biota.

Finally, although progress is evident in measuring the efficacy of treatments to reduce organism transfers, insufficient attention is given to understanding dose-response relationships. The efficacy of treatments to reduce invasions, the ultimate measure of efficacy, is only coarsely understood. Several lines of evidence indicate reduction in organism transfers should reduce invasion success. Yet, the likelihood of invasion associated with various levels of transfer, and how this varies spatially and temporally (and taxonomically), is largely unexplored in marine ecosystems. It is this very relationship that is key to understanding invasion risk and developing science-based “standards” for ballast water treatment. Thus, a quantitative understanding of the dose-response relationship is a high priority for invasion biology and management.

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Modeling of Ballast Water Flow Dynamics to Understand Ballast Water Exchange

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A Ballast Water Modeling Program was initiated to address the problem of aquatic invasive species (AIS) entering United States waters from ballast water. The objective of the program is to develop an experimentally-validated computational fluid dynamics (CFD) model of flow in a bulk carrier ballast tank that can be used to study fluid flow dynamics during ballast water exchange. Development and validation of a computational flow and mixing model will provide interested parties (researchers, naval architects, ship owners, masters, port authorities, lawmakers) a tool to better understand the fluid dynamics occurring in ballast tanks, predict the efficacy of ballast exchange as an AIS management and treatment practice, assist with the design and implementation of treatment technologies, track and minimize the accumulation of sediments, and to identify deadspots (i.e., areas where water does not mix, exchange, or flush during ballast exchange) and other flow phenomena in these tanks.

Mid-ocean ballast water exchange (BWE) is presently the primary management practice with widespread acceptance for reducing or preventing the spread of nonindigenous aquatic species via ballast water. While ballast exchange by itself may not be a viable long-term solution, it likely will continue to be used for the foreseeable future and may ultimately be combined with some other technologies and management approaches. Therefore, it is essential to fully understand the ballast exchange process and what occurs inside a ballast tank during exchange. Attempts to determine the efficacy or effectiveness of BWE have produced inconsistent and generally unsatisfying results most likely due to the complex structure and inaccessible location of typical ballast tanks, such as double bottom tanks and lower wing or hopper side tanks. These difficulties have limited experimental design and resolution of sampling to determine the effectiveness of ballast water exchange. The development of a computer-based model of the flow dynamics in ballast tanks makes should provide several advantages over the experimental approaches to date.

This paper describes the use of a small-scale physical model to conduct experiments that are the first steps in a staged progression of research to provide data to validate the CFD models and their interrelation. The scope of the present study only included dilution and mixing experiments that yield the fluid fraction of the original fluid within the ballast tank during exchange. Fluid fraction of the original ballast tank fluid was measured using laser-induced fluorescence (LIF). The original fluid is "tagged" by premixing a small concentration of rhodamine into the tank fluid before the experiment. Selected two-dimensional planes inside the tank were illuminated by a laser light sheet from a pulsed Nd:YAG laser and recorded using a digital camera with a resolution of 2048 x 2048 pixels. Through calibration using normalization from a "reference" image, this technique not only yielded useful visualization of the mixing phenomena within the tank but provided an accurate quantitative measurement of the fluid fraction of the original fluid. Once normalized, the fluorescence recorded by each image pixel in the illuminated plane is directly proportional to the fluid fraction of the original fluid.

Transfer of Nonindigenous Species to the Laurentian Great Lakes in Residual Ballast Water from No-Ballast-On-Board (NOBOB) Vessels

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The majority (>90%) of vessels entering the Laurentian Great Lakes are laden with cargo and declare no-ballast-on-board (NOBOB) status. Current ballast exchange regulations do not apply to NOBOBs despite the presence of tonnes of residual salt-, brackish- or fresh-water, sediments, and the species contained in these ballast tanks. Residuals may eventually be released into the Great Lakes after ballast unloading events are conducted within the system, thus potentially transferring nonindigenous species (NIS). During 2001 and 2002, we sampled residual ballast water from 66 tanks on 30 ships at their first port-of-call in the Great Lakes, and recorded 7 rotifer and 37 microcrustacean species, predominantly cyclopoid and harpacticoid copepods, as well as 8 species of cladocerans. We detected three non-indigenous cyclopoid species (*Acanthocyclops venustus*, *Eucyclops serrulatus*, *Cyclops abyssorum*), and three nonindigenous cladoceran species (*Daphnia magna, D. cristata, D. atkinsoni*) currently not found in the Great Lakes. Total invertebrate abundance was not related to ballast water salinity, although total invertebrate species diversity was significantly higher in high salinity water.

N O T E S

Modeling the Risk of Invasion by Diapausing Eggs in Residual Ballast Sediments

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Ballast water has been recognized as the primary vector for the introduction of aquatic nonindigenous species (NIS) to the Great Lakes. As a result, ballast water exchange regulations were enacted that effectively require inbound ships to exchange fresh or brackish ballast water with open-ocean saltwater if that water is to be discharged in the Great Lakes. However, the rate of discovery of new NIS in the Great Lakes is now three times that of pre-regulation. This may be a result of the increased importance of alternate vectors, such as residual ballast sediment. In this study, we model the risk associated with invertebrate diapausing eggs in residual ballast sediments as a possible vector of NIS to the Great Lakes. We used both biological (egg density, viability and species richness) and physical (sediment volume) parameters to estimate the number of viable propagules carried by the 'average' NOBOB vessel. An additional parameter, describing the potential for introduction based on *in situ* hatching experiments, was added to estimate invasion risk. Both hatch rate and species diversity was higher in laboratory trials than in the in-situ hatching trials, indicating that although NOBOB vessels can carry a large number of propagules (2.3×10^6 eggs per vessel), the introduction potential of NIS via diapausing eggs in residual sediments is low, as compared to the traditional ballast water vector. Both temperature and sediment depth were found to be important variables affecting introduction potential. Lastly, we attempted to predict the rare occurrence of 'high-risk' sediments by comparing our laboratory results with physical ship characteristics and ballast history information.

N O T E S

Viability of Invertebrate Diapausing Eggs Exposed to Saltwater: Implications for Great Lakes' Ship Ballast Management

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International shipping has been the dominant vector of nonindigenous species introductions to the Laurentian Great Lakes over the past century. Apparent ballast-mediated invasions have been recorded in recent years, despite the implementation of voluntary ballast water exchange regulations in 1989. Since unregulated "No-Ballast-On-Board" vessels currently dominate inbound traffic to the Great Lakes, it has been proposed that live or dormant organisms contained in residual ballast of these vessels may be partially responsible for recent invasions. Alternatively, euryhaline species may pose a significant invasion threat because they can potentially survive ballast exchange. In this study, we explored whether exposure to open-ocean water (32%) reduced the viability of invertebrate diapausing eggs in ballast sediments. Sediments collected from three transoceanic ships and from three freshwater habitats were exposed to open-ocean seawater. Egg viability, assessed as the abundance of taxa hatched between exposed and unexposed sediments, was not affected by saltwater exposure in any experiment. Species richness of hatched diapausing eggs was reduced by saltwater exposure in only one of seven trials. Our results indicate that oligostenohaline zooplankton potentially pose an invasion risk because their diapausing eggs are largely resistant to exposure to open-ocean saltwater.

NOTES

The Spread of Dace – An Invasive Fish Species in Ireland

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The dace (*Leuciscus leuciscus* (L.)) was first introduced from Britain to the Munster Blackwater in 1889. Until the early 1990s dace were restricted to this catchment. They have since been recorded in the lower reaches of the River Shannon, in Doon Lake (Co. Clare) and in the Rivers Barrow and Nore. In the River Barrow, where dace were first reported in 1994, they rapidly spread upstream and large populations now occupy the river from below St. Mullins to Athy, a channel length of 69 km. Dace now represents an important angling species in the river, with angling catches regularly in excess of 20kg. This paper describes the rapid spread of dace within the River Barrow and compares the growth rates of dace from the River Blackwater, a stable population, with the invasive population in the River Barrow. While all the populations studied exhibited similar growth patterns, the growth rate for the invasive population in the River Barrow was significantly different, in each year class, from that recorded in the stable population. The likely impacts of the invasion on fish communities and on angling in Ireland are discussed.

N O T E S

Preliminary Results on the Movements and Microhabitat Use of Introduced Pumpkinseed (*Lepomis gibbosus*) in Small English Streams

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Little is known of the movements and habitat use of pumpkinseed (*Lepomis gibbosus*) populations, especially in their introduced European range. During summer 2004, pumpkinseed were coded-wire (CW) and passive integrated transponder (PIT) tagged in the River Ouse catchment (Sussex, England) to assess, respectively, the dispersal of pumpkinseed from lakes to connecting streams (CWT) and the medium-to-long term dispersion (PIT) of pumpkinseed within the streams. In six lakes and ponds, movements of CWT pumpkinseed (n = 2467) were recaptured up to 220 m from initial capture point within a few days, with CWT fish also captured in the receiving stream. Of PIT-tagged stream pumpkinseed, 49 % were recaptured within a few months of release, with the maximum movements downstream and per day being 1 550 m and 300 m, respectively. Introduced pumpkinseed microhabitat use was assessed and pumpkinseed (especially larger specimens) were frequently found to co-occur with native brown trout *Salmo trutta*; the two species appearing to share broadly similar habitats: deeper pools with sheltering roots and overhanging bushes. Implications and further seasonal issues of resource use are considered.

NOTES

Risk Assessment of Introduced Black Carp in the United States: Potential Geographic Range and Ecological Impacts

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The Black Carp *Mylopharyngodon piceus*, native to eastern Asia, is one of several commercially important carps often referred to as the Chinese or Asian carps. It is a large fish, reported to attain lengths of over 1.5 m and weigh more than 70 kg, that inhabits big rivers and associated backwaters. Unlike most other cyprinids, adult Black Carp feed almost exclusively on mollusks (mussels and snails). It is morphologically adapted for such a specialized diet, being armed with large, crushing teeth mounted on large and well-muscled pharyngeal jaws. The presence of Black Carp was not generally known outside aquaculture circles until the early 1990s. This is when concern began to be expressed over potential escape and establishment of Black Carp in open waters of the United States. This concern was based primarily on fear of its potential to feed on native snails and mussels, the most highly endangered group of aquatic organisms in the United States. Recent events have kept the Black Carp issue a subject of concern and contention. In early 2003 a commercial fisher netted a single Black Carp (triploid) from a backwater of the Mississippi River in southern Illinois. During 2004 additional Black Carp have been taken in the middle and lower Mississippi Basin. To gain a better understanding of its potential range and the types of environments Black Carp might successfully invade, in this paper we identify and assess factors important to the survival and persistence of Black Carp populations in the wild. Of particular importance are environmental tolerances and spawning and habitat requirements. We also discuss possible ecological impacts that may result from presence of this large mollusk-eating fish.

N O T E S

Invasive Freshwater Fish and Water Clarity Decline in New Zealand, North Island Lakes

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Summer secchi disc transparency in small lakes (surface area < 2 km^2, max. depth < 20 m) was related to both lake depth and the presence/absence of communities of exotic fish (i.e. one or more of rudd, tench, goldfish, perch, koi carp, catfish). The presence of such exotic fish was associated with a general decline in water clarity irrespective of lake depth. A limited comparison of before-and-after data on water clarity indicated that historic introductions of these fish have initiated the decline in water clarity. However, increased eutrophication related to concurrent land use changes in the catchment confounds this relationship in many lakes. These exotic fish are often found in very large numbers in New Zealand lakes because of a lack of natural predators. Preliminary modelling of the trophic role(s) of these fish in New Zealand lakes predicts that they would accelerate the process of eutrophication, particularly in lakes where natural aquatic predators are lacking, and where avian predation is reduced.

NOTES

Aquatic Invasive Species Impacts Upon the Lake Erie Sport Fishery

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Lake Erie is the warmest, most fertile, and most biologically productive of North America's Laurentian Great Lakes. This high level of productivity, combined with a large human population in the surrounding Great Lakes Basin led to the development of a multi-species sport fishery estimated by various models to be valued at several hundred million US dollars per year.

The arrival of several ballast water-introduced species in the late 1980s induced unprecedented changes in Lake Erie's ecosystem and fishery. Dreissenid mussels, first discovered in Lake Erie in 1988, brought the greatest transition in the fishery. Filtration of algae and other particulates transferred energy and nutrients from pelagic waters to the benthic region, effectively restructuring complex food webs. As zooplankton decreased in average density, benthic invertebrates such as gammarids experienced marked increases – although native *Gammarus* currently are being replaced by introduced *Echinogammarus* in some habitats. Burrowing mayflies (*Hexagenia*), declined severely in the 1950s due to eutrophication and anoxic sediments, but recovered in the 1990s as lower algal densities reduced biological oxygen demand in bottom sediments. Mayfly densities in some western Lake Erie areas currently reach or exceed densities of 200 nymphs/m^2. Emerging mayflies are widely considered to be a nuisance, although the nymphs have become an important food source for many fish species. Water transparency increased by two to three-fold in the early 1990s, attributed to zebra mussel filtration. Increased light penetration stimulated the emergence of extensive aquatic macrophyte beds in Lake Erie's littoral zone, diversifying the habitat types available to the fish community.

Round gobies (*Neogobius melanostomus*) were documented in Lake Erie by 1993 and recently have been recorded in densities ≥30 individuals/m^2. Round gobies compete with other benthic foraging fishes for food but have raised particular alarm in the Lake Erie sport fishery as egg predators impacting spawning smallmouth bass (*Micropterus dolomieu*). Recent research documented smallmouth bass egg predation by round gobies, coinciding with increased observations by fishers of diminished numbers of juvenile smallmouth in traditional fishing areas. A second related species, tubenose goby (*Proterohinus marmoratus*), has failed to achieve abundance in Lake Erie.

Important impacts upon the sport fishery include behavioral modification of Lake Erie's most valuable sport fish species, walleye (*Sander vitreus*), caused by increased light penetration. Walleye are found less frequently in large, suspended pelagic schools that characterized the fishery in the 1980s and more frequently in smaller, bottom-oriented schools found in proximity to benthic food sources. Feeding activity has shifted from diurnal to crepuscular behavior. Lake Erie's sport fishers have not fully adapted practices to these changes, contributing to the 74 % decline in walleye fishing participation measured since 1989, a decline corresponding to decreased economic activity. The State of Ohio preemptively imposed a spring closed season on smallmouth bass beginning 2004 to reduce round goby predation in smallmouth nests that results when parent fish are removed by angling. Angling opportunities have increased for littoral vegetation dwelling fish species but have received little attention from the angling public.

N O T E S

Complex Interactions Between Native and Invasive Fish: The Simultaneous Effects of Multiple Negative Interactions

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The effects of invasive species on native species can be complex and involve a combination of multiple interactions. We suggest that the coexistence of native species with invasive species depends on the number of simultaneous negative interactions, and that body size must be considered when predicting the ultimate outcome (extinction or coexistence). We found evidence for five types of negative interactions (predation and competition) between the adults and juveniles of invasive species and native juveniles where both species have similar body sizes. Although native species can trade-off various components of fitness and continue to persist if confronted by a single negative interaction (i.e. trading decreased growth for increased survivorship when confronted by predation), we propose that multiple interactions can constrain the ability of native species to trade fitness components causing a spiral to extinction.

We illustrate the effects of multiple simultaneous interactions between species of similar body size with research conducted on native least chub (*Lotichthys phlegethontis*) and introduced western mosquitofish (*Gambusia affinis*). Least chub juveniles are figuratively caught in a vice between predation and competition from mosquitofish. Rapid growth by least chub and a larger juvenile body size could reduce the risk of predation from mosquitofish, but this requires energy that is not available because of the simultaneous effects of interference and exploitation competition. Instead, competition reduced least chub growth and prolonged the period when juveniles were vulnerable to mosquitofish predation. A spatial or temporal refuge would allow the time needed to increase the survival of native species. However, when native and invasive species are similar in body size and thus, view the world on the same spatial and temporal scales, then refugia are often not available, and without human intervention native species will spiral to extinction when confronted by multiple simultaneous negative interactions.

N O T E S

Occurrence of an Introduced Freshwater Fish, the Rio Grande Cichlid (*Cichlasoma cyanoguttatum*), in Estuarine Habitats of Southeastern Louisiana, USA: Can We Assume That Estuaries Are Effective Barriers to Expansion?

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The Rio Grande cichlid, *Cichlasoma cyanoguttatum*, is native to northeast Mexico and extends into the United States in the Rio Grande drainage. Accidental or intentional introduction has allowed for populations to become established in central Texas and peninsular Florida, USA. Recently, *C. cyanoguttatum* has been collected in the canals and bayous of the Greater New Orleans Metropolitan Area (GNOMA). These aquatic habitats are part of the Lake Pontchartrain drainage, an oligohaline estuary in southeastern Louisiana, USA.

Since the first collection of *C. cyanoguttatum* in 1996, the species has been found at numerous sites throughout the region. Successful reproduction has been verified and some populations of *C. cyanoguttatum* are established within the drainage. I developed a diffusion model to describe the initial stages of expansion of *C. cyanoguttatum* in the GNOMA. Diffusion models are regularly used to explain natural and artificial invasions of organisms into new habitats. Results from the model provided insights about the temporal dynamics of this invasion. In particular, the model supported the possibility that advection via both anthropogenic (canal pump stations) and natural (wind and tidal currents) sources has promoted the rapid expansion of cichlids along the southern shore of Lake Pontchartrain.

To test these model results, I conducted monthly trapping along the highly modified southern shore to determine if these estuarine habitats were being used by this introduced freshwater fish as corridors for expansion. Both adult and juvenile *C. cyanoguttatum* were collected in salinities ranging from 0 to 5 ppt, including a single gravid female that was collected while moving from Lake Pontchartrain into a freshwater canal. In addition to these occurrences, *C. cyanoguttatum* has been photographed in other Lake Pontchartrain estuarine habitats and a single specimen was reported from a trawl sample taken 6.5 km from shore. Combined, this evidence suggests that *C. cyanoguttatum* may not only survive movement through estuarine conditions, but may also be capable of becoming established in these habitats. Preliminary accounts of two other introduced freshwater fishes, the silver carp (*Hypophthalmichthys molitrix*) in Louisiana and the Nile tilapia (*Oreochromis niloticus*) in southern Mississippi, suggest similar scenarios. Implications from this information include that: a) no assumptions should be made about the effectiveness of estuaries as barriers to the expansion of introduced freshwater fishes; and b) valuable estuarine fisheries may not be immune to negative impacts associated with such species.

NOTES

Early Life Interactions Between Native Cyprinids and Invasive Sunbleak *Leucaspius deliniatus* in a Three-lake System

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The introduction and translocation of exotic species are a problem of increasing concern to scientists, environmental managers, conservationists, policy makers and naturalists throughout the world. The sunbleak *Leucaspius delineatus*, a small cyprinid of Ponto-Caspian origin, was introduced to British waters in the 1980s via the aquaculture trade and is now well established in the canal system of Somerset as well as in a few locations in the counties of Dorset and Hampshire, including Stoneham lakes, a system of three connected lakes. The aim of the present study was to investigate the interactions between the larvae of sunbleak and those of native fish species. Intensive point abundance sampling was carried out between May and July 2002 and May and October 2003. Niche overlap during early life history stages was examined and the potential social and environmental implications for native species are discussed.

N O T E S

Heterosporis sp. (Microspora): A New Parasite From Yellow Perch (*Perca flavescens*) and Walleye (*Stizostedion vitreum*) in Minnesota, Wisconsin and Lake Ontario, North America

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Heterosporis sp. is a newly reported intracellular parasite in skeletal muscle cells of yellow perch from the Eagle River chain of lakes in Vilas Co., Wisconsin, Leech Lake in Cass Co., Minnesota and Bay of Quinte in northern Lake Ontario. The parasite has also been confirmed in perch from eight other lakes in Minnesota, walleye from Minnesota and Wisconsin, northern pike (*Esox lucius*) from Minnesota and burbot (*Lota lota*), mottled sculpin (*Cottus bairdi*) and pumpkinseed (*Lepomis gibbosus*) from Wisconsin. *Heterosporis* has previously been reported from cultured eels (*Anguilla japonica*) in Japan and Taiwan and from several ornamental fish species in France (*Pterophyllum scalare*), Germany (*Pseudocrenilabrus multicolor*, *Ancistrus cirrhosus*) and Thailand (*Betta splendens*). The North American source of the parasite is unknown. Prevalence is usually less than 15-30% in inland lakes and approximately 5% in the Bay of Quinte. The presence of this parasite in Great Lakes perch forces commercial fishers to fillet the fish thereby ensuring that infected fillets are not sent to market; such additional handling is significant for a commercial fishery that is already depressed by declining perch stocks. Infected fillets are opaque and milky white in color, and 90% of the fillet may contain parasites. Examination with LM and TEM shows infected muscle cells filled with sporophorocysts containing numerous intact sporophorous vesicles, each containing 8 or 16 mature spores. A Polymerase Chain Reaction diagnostic assay has been developed and made available to any interested diagnostic facilities. Laboratory exposures indicate that eurasian perch (*P. fluviatilis*), carp (*Cyprinus carpio*), goldfish (*Carassius auratus*), rainbow trout (*Oncorhynchus mykiss*), brook trout (*Salvelinus fontinalis*), lake trout (*S. namaycush*), brown trout (*Salmo trutta*), channel catfish (*Ictalurus punctatus*) and fathead minnows (*Pimephales promelas*) are extremely susceptible to infection, while bluegill (*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*), coho salmon (*Oncorhynchus kisutch*) and white suckers (*Catostomus commersoni*) are much less susceptible to infection. Golden shiners (*Notemigonus crysoleucas*) and smallmouth bass (*M. dolomieui*) appear to be refractive to infection. Therefore, *Heterosporis* exhibits an extremely wide host specificity. The appearance of *Heterosporis* in North America has serious implications for culture operations that harvest wild fish as bait fish or as forage for production fish. (Supported by a grant from the Great Lakes Fishery Commission.)

Guilty Until Proven Innocent or Innocent Until Proven Guilty? The Further Development of Criteria for Assigning Introduced Versus Endemic Status

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Introductions and establishment of nonindigenous species can have dramatic impacts on invaded ecosystems. The successful establishment of nonindigenous species beyond their historical range is currently recognised as one of the major driving forces in ecological change. To avoid or mitigate potential biological and economic costs of incursions, many countries are developing biosecurity procedures that attempt to safe guard their territory. While significant effort is put forward in pre-border biosecurity management, the "battle-ground" is typically post-border where monitoring, detection and rapid response become powerful management tools necessary for biosecurity success.

An important component of post-border control is detecting and determining 'new' incursions and reacting rapidly to eradicate or control such incursions. To act effectively, scientists and managers must be sure that they are indeed dealing with a "new" species to their region; such assignments to native or introduced status are reliant upon accurate taxonomic identification, most often to the species level. It is at this point where the dilemma of deciding if a species is native, cryptogenic or introduced occurs. In many marine regions of the world taxonomic knowledge is limited or confounded by differing expert opinion. In such instances we have often been faced with the question "how do we know if a species is introduced, when it could be endemic?"

Endemic species fall into two categories: paleo-endemic (species that were widely distributed in the past but now have very restricted distributions) and neo-endemic (species that have 'recently' evolved yet to spread and have resulted from a speciation event). Introduced species are species that have established outside of their historical range by human mediated transport. Typically, endemic species are not considered to be successful invaders, in fact invasives and endemics are considered to be at opposite ends of the spectrum. So, how does this confusion occur and how do we solve it?

Chapman and Carlton (1990) identified 10 criteria to aid in the classification of introduced species. These criteria have generally been accepted, and applied in a variety of contexts, yet problems still exist. The criteria however, are not definitive, with several criteria that potentially result in identical outcomes for both introduced and endemic species. In this paper we use the example of *Halophila johnsoni*, a rare "endemic" seagrass in Florida that is listed for protection, which may be introduced, to examine the intricacies of determining if a species is endemic or introduced.

N O T E S

Guilty Until Proven Innocent or Innocent Until Proven Guilty? The Practical Biosecurity Management of Cryptogenic Species

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Biological introductions have the potential to cause significant, irreversible impacts. In light of this, many management agencies have developed legislation and regulatory frameworks that include the use of rapid response plans to aid decision making and prevent new incursions from spreading and causing damage. With respect to biosecurity, these plans presuppose that the identification of a species and assignation to native or non-native status can be achieved instantly/rapidly. However, this is rarely the case as we continually find that we know little about our biodiversity. Identification of species requires specialist taxonomic knowledge, frequently not readily available, and regional experts are less likely to be familiar with overseas (and therefore non-native) fauna or flora resulting in an increased likelihood of designating an organism as native when it is in fact introduced.

Species whose origin cannot be readily determined are called cryptogenic. Cryptogenic species are of two types: those widespread species that may have been transported through human activities in the past; and those species for which we have limited knowledge. This second group creates a domain for which management actions and response are problematic. On the one hand, a cautious biosecurity manager might classify all cryptogenic species as non-native until proven otherwise, that is, 'guilty until proven innocent'. The implications would be to undertake a much stronger response in the face of uncertainty. While this would lead to a more rapid and unequivocal approach to biosecurity management, it would undoubtedly be more expensive and possibly result in the eradication of small populations of previously unnoticed or unrecognised rare (and possibly threatened) species. On the other hand, the manager might employ an 'innocent until proven guilty' approach whereby cryptogenic species are assumed to be native (with respect to management action) until evidence is gained to the contrary. Such an approach does not benefit from the advantages that might be gained from a rapid response. In this presentation, we discuss the practical implications of this dilemma in the New Zealand marine biosecurity context, and provide examples of both rationale and processes to account for cryptogenic species in biosecurity management.

N O T E S

Italian Project on Aquatic Invasive Species in Italian Seas

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The Central Institute of Research Applied to the Sea (ICRAM) has realized a research program in order to meet the commitments taken upon the Ministry of the Environment and of the Protection of the Sea with the ratification of Article 13 of the ASPIM Convention in Barcelona.

The Project, funded by the Ministry and named "Identification and Distribution in Italian Seas of nonindigenous species" encompasses investigations on eight different taxa (Macroalgae and Angiosperms, Annelids, Cartilaginous and Bony fish, Ascidiaceans, Molluscs, Bryozoans, Polychaetes and Cnidarians). These taxa were taken into consideration because they contain species that entered the Mediterranean Sea from the Gibraltar Strait as well as from the Suez Canal. The groups were studied and monitored with the support of 30 experts. Besides the species that entered "*motu proprio*", the Ministry also wanted to include problematic aquaculture, aquariology and ballast water in the Program.

The primary objectives of the Program are the following:

- to define the present state of knowledge of the immigration phenomenon;
- the acquisition and analysis of existing literature for the realization of diagnostic cards of nonindigenous species;
- the realization of a network involving the Mediterranean area researchers to define a system capable of registering new sightings.
- the realization of a databank with the purpose of allowing for an exchange of information in real time among experts of different research institutes in Italy as well as in the Mediterranean, which will allow them to follow the evolution of the immigration and biomass growth phenomenon in time and space
- the realization of an updated thematic bibliography, composed of all existing articles and publications, to allow the experts to have a point of reference for all known species;
- the realization of a tissue bank aimed at developing an archive of nonindigenous species;
- the realization of an updateable geo-referenced cartography (GIS) on the expansion of invasive species;
- the analysis of reference literature, of the protocol used for the collection, analysis and filing of data related to the aquariology and aquaculture species, the allochtonous species, hybrids and GMOs;
- a bibliographic search for ongoing international initiatives on ballast water and the development of protocols for the analysis of the planktonic communities present in ballast water, in addition to the consultation of the international organizations operating on this issue (IMO, RAC-SPA, etc.).
- the elaboration of recommendations to be used when the introduction of allochtonous species occurs;
- the definition of criteria for evaluating the damages caused by the introduction of non-allochtonous species.

NOTES

The Proposed Australian System for the Prevention and Management of Marine Pests Incursions

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The Australian approach for a National System for the Prevention and Management of Marine Pest Incursions is being developed to provide a nationally coordinated, holistic, effective and cost efficient approach to marine pest management. The System is being designed to provide strategies to combat marine pests at each stage of their introduction through three management elements: prevention of introductions to and translocations within Australia; *emergency preparedness and response* to deal with new incursions; and *ongoing management and control* to contain established populations. To adequately address the issue, collaboration and coordination between the Australian Government and the Australian States and Northern Territory, industry representatives and other stakeholders is required. Accordingly, the National System is currently being developed through a formal collaborative process agreed by all Australian governments. Governments have agreed to a time frame of three years for the implementation of the System, with voluntary based arrangements possibly in place during 2005 and a full System operating by October 2006.

The *prevention* element has two main aspects: international or incursion risks to Australia and domestic or translocation risks within Australia waters. Management of these risks requires assessing as appropriate the ballast water and biofouling risks for all potential vectors, including commercial shipping, recreational and fishing vessels, marine aquaculture operations, the aquarium trade and port, harbour and marina facilities. Vector management is crucial to the successful implementation of the prevention element and management actions will include a range of regulatory measures and voluntary guidelines. The *emergency preparedness and response* element aims to contain and/or eradicate any new marine pest incursions to Australia. These efforts are coordinated by a consultative committee, which comprises representatives from all Australian Governments. The development of the *ongoing management and control* element of the National System aims to contain and control any introduced marine pests that have established viable populations within Australia. Control measures will be outlined in national control and local management plans, based on the potential extent of any impacts.

The National System also includes components to provide legislative authority to the statutory framework and the funding arrangements. Industry and governments have agreed to fund the operation of the System based on the level of private and public contribution to and benefit from the System.

The development of all System elements and associated management measures will be informed by a range of research and development (R&D) activities which are outlined in a national R&D strategy. These research needs apply to all three System elements, and can be broadly grouped into the following categories: governance systems; vector management; species and ecological information for management; information, communication and education; and evaluation and review. Development within these areas is critical to the successful implementation of the National System: clear and transparent governance systems are required to integrate sectors and jurisdictions for the National System to function; understanding the way vectors function and their role in marine pest movement is critical to vector management; understanding biological and ecological characteristics of introduced marine pests is fundamental to the risk management approach of the System; and effective implementation of the National System requires accessible and current information, and periodic review to ensure objectives are being met.

N O T E S

Status, Environmental Threats, and Policy Considerations for Invasive Seaweeds for the Pacific Coast of North America

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Nonindigenous species (NIS) of seaweeds are probably the least well documented and understood of introduced marine macro-organisms. Seaweeds are often difficult to identify, skilled seaweed taxonomists are few in number, and seaweed flora are often poorly known, making it difficult to recognize new introductions or to accurately tally the number of previous introductions. Hence, uncertainty exists concerning the actual number of NIS now part of a flora.

Only 25 NIS of seaweeds are listed for the Baja California to Bering Sea (B2B) corridor. However, it is likely that many more undocumented NIS occur in the region. Moreover, three seaweed invasions (*Caulerpa taxifolia*, *Undaria pinnatifida* and *Caulacanthus ustulatus*) have occurred in the last five years in California alone, suggesting that seaweed introductions may be increasing in frequency.

Early detection and rapid management response are of paramount importance if eradication efforts are to be successful. Once a marine NIS becomes established and begins to spread, eradication may not be possible. The combination of early detection and rapid management response was seen in the apparently successful eradication of *Caulerpa taxifolia* in southern California. This effort, which stands as an excellent example of multiple agency cooperation, was advantaged by early detection resulting from the presence of an active, field study program, and the rapid response of managers. Unfortunately, coastal field monitoring programs are generally limited to selected sites and are difficult to sustain with funds over the periods required to be effective in detecting marine NIS. Moreover, little tri-national or even interstate coordination exists between those monitoring programs that exist. Perhaps the last management option is to attempt to control (or manage) the spread or damage of an invader. For decades, efforts have been made to control unwanted NIS in terrestrial and freshwater ecosystems; control of marine invasions, however, is in its infancy and there are very few examples of successful control efforts.

Policy considerations should emphasize preventing the introduction of seaweeds and other marine NIS. For NIS of seaweeds and most other marine NIS, emphasis should be placed on four main vectors: 1) ballast water, 2) hull fouling, 3) aquaculture activities, and 4) aquarium trade release.

NOTES

Developing Technologies for Aquatic Invasive Species Risk Assessment for the US Army Corps of Engineers Projects

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Risk Assessment technologies are being developed for a wide range of environmental areas. The need to utilize these technologies to assess the potential threats that aquatic invasive species pose is becoming greater every day as our ability to transfer them across wide expanses rapidly increases. The Corps of Engineers is beginning a process to assess the risk aquatic invasive species pose to our current and future water resource operations. The ultimate goal is to produce predictive risk assessment tools for Corps of Engineer facilities. By assessing potential risks, our limited funding resources can be focused on the areas/species that pose the highest risk.

NOTES

Life-history Variation and the Spread of Aquatic Nonindigenous Species Across Ontario Lakes

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Spatially-explicit predictions of range expansion of aquatic nonindigenous species is an important undertaking as often it is easier to prevent novel invasions than to mitigate the impacts once a lake has become invaded. Lakes are well suited to serve in models of spread as lakes consist of well-defined habitat and vectors of spread are readily identified and quantified. Transport models, such as production-attraction constrained gravity models, require information on both vector traffic inflows and outflows from lakes and offer the most spatially-explicit predictions of spread. In this study, we compare the patterns and mechanisms of spread of the spiny waterflea, *Bythotrephes longimanus*, and the zebra mussel, *Dreissena polymorpha* among inland Ontario lakes. We surveyed recreationalists regarding the movement of trailered boats and other risky activities to model vector traffic from invaded lakes to non-invaded or other invaded lakes. Since both species may be transported overland by similar mechanisms associated with recreational boating, differences in patterns and rates of spread may be influenced by life-history traits. For example, resistant resting eggs produced by the spiny waterflea may be transported over greater distances compared to zebra mussel adults or larvae, potentially leading to greater rates of spread.

NOTES

Emerging Threats: Potential Geographic Distributions of Temperate Aquatic Invasive Species

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Present approaches to species invasions are reactive in nature, resulting in management that perpetually lags behind the most recent invasion and makes control much more difficult. In contrast, spatially explicit ecological niche modeling provides an effective solution to predicting where a species might spread following introduction to a new area, allowing management and regulatory agencies to include proactive approaches towards invasive species. To identify regions where temperate aquatic ecosystems may be vulnerable to emerging invasive species, I used the Genetic Algorithm for Rule-set Prediction (GARP, a machine-learning algorithm) to model the ecological niches of invasive species having relatively limited distributions outside of their native ranges (e.g., golden mussel *Limnoperna fortunei*, rusty crayfish *Orconectes rusticus*). I then projected these models globally to determine the potential geographic distributions of these taxa. The spatially explicit nature of these predictions can help decision makers and environmental managers to make better, and more timely decisions regarding the detection and control of invasive species.

N O T E S

Watershed Characteristics and Nonindigenous Fish in Mid-Atlantic Streams

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The establishment of nonindigenous species in freshwater systems in the United States seems to be rising sharply. An EPA (EMAP) data set, collected from 1993 - 1995 for Mid-Atlantic small order streams, was analyzed using multiple regression to learn more about the role that watershed condition plays in invasion biology and whether watershed characteristics can be used as a predictive tool. Sixty percent of Mid-Atlantic streams contain nonindigenous fish species and, on average, there were about seven times more native fish species in the sampled streams than nonindigenous fish. The number of nonindigenous fish species is related positively to the number of native fish species and both natives and non-natives are positively correlated to the size of the watershed. The more disturbed the watershed, the more exotic species are likely to occur in the sampled stream. Distance to the ocean, population density and the number of point source dischargers did not correlate with the number of nonindigenous species. Native species are impacted by point source dischargers; the more dischargers, the fewer natives. The number of nonindigenous species increased in the sampled streams and, by extrapolation, the entire Mid-Atlantic region. This study is the first to document for the Mid-Atlantic region a statistically significant increase in nonindigenous species within just a three-year period. Although the ability to predict invasivness is elusive, this study does offer some potential for using watershed characteristics to predict the invasion of small order streams by nonindigenous fish species.

N O T E S

US Coast Guard Shipboard Technology Evaluation Program

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The Shipboard Technology Evaluation Program (STEP) is a voluntary program available to all vessels subject to the Coast Guard's Ballast Water Management (BWM) regulations, 33 CFR § 151 Subparts C and D. The STEP is intended to facilitate the development of effective BW treatment technologies, thus creating more options for vessel owners/operators seeking alternatives to ballast water exchange. An increasing number of alternative ballast water treatment (BWT) technologies capable of significantly reducing the probability of introducing foreign organisms via ballast water discharges are being developed and tested as small to mid-scale prototypes. However, complete evaluations and refinement of the capabilities of such systems require ship-scale installations that are tested for longer periods of time under a wide range of conditions. As on-board installation and testing costs are likely to be significant, vessel owners/operators are understandably reluctant to participate in onboard testing projects. To encourage ship owners/operators to participate in projects designed to test the effectiveness of prototype treatment systems under real world, operational conditions, the Coast Guard is implementing the STEP.

This program is intended to facilitate shipboard testing of prototype treatment systems aboard a limited number of vessels for research and development purposes. Vessels accepted into the STEP may be granted a conditional equivalency to future ballast water discharge standard regulations, for up to the life of the vessel or the system, while the prototype system operates satisfactorily. The length of the period of equivalency is dependent upon the date on which the vessel applies to the experimental program. However, in the event that subsequent information on the experimental system indicates the potential for an adverse affect to the environment, risk to the vessel or human health, acceptance in the STEP will be withdrawn. In addition, participation in the STEP may be discontinued if a system no longer performs satisfactorily. Lessons learned in this effort will help resolve the technical challenges associated with employing these BWT systems on operational vessels, and will also facilitate development of the formal procedures for general approval of BWT systems.

The Coast Guard will accept or reject applications to the STEP on the basis of reviews by Coast Guard staff and the recommendations of an independent review panel with expertise in experimental investigations of biota associated with ballast water, water treatment technology, naval architecture, and marine engineering. The purpose of the independent review is to ensure that vessels accepted into the STEP are conducting rigorous and scientifically supportable test programs. To make the reviews as uniform as possible, the process will adhere to an explicit protocol, including standard review questions addressing specific issues. These protocols are described in the application package available from the Coast Guard. Specific conditional requirements will be identified for each vessel accepted into the program, based on the details of the vessel's design, operation, and study plan. With the exception of the equivalencies provided by the STEP, discharged ballast water must meet all other federal, state, local, and tribal environmental regulations.

NOTES

The US Ballast Water Technology Demonstration Program: Progress Report

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The Ballast Water Technology Demonstration Program was authorized by the National Invasive Species Act of 1996 and has been administered by the US Fish and Wildlife Service and the National Oceanic and Atmospheric Administration, since it was first funded in 1998. In 2002, the US Maritime Administration became a third federal partner in the program. The objective of the Ballast Water Technology Demonstration Program is to demonstrate effective ballast water treatment technologies that are practicable for use on commercial ships in American waters. The Ballast Water Technology Demonstration Program has, thus far, been administered through a system of competitive grants. From 1998 to 2002 the FWS and NOAA spent $5.803 million to fund 30 ballast water technology demonstration projects. The ballast water technologies that have been studied and/or demonstrated as part of the Program include: oxidizing biocides (peracetic acid, ozone, chlorine); non-oxidizing biocides (juglone, menadione, gluteraldehyde); separation (filtration, hydrocyclone, centrifugation); energy (ultraviolet, acoustic, thermal); Depressurization; Deoxygenation; Exchange; Onshore Treatment; Redesign of Ships or Tanks. In addition, the Program has funded basic research into microorganisms transported in ballast water and potential invasive species transfer from No-Ballast-On-Board (NOBOB) ships.

NOTES

Evaluation of Filtration Components for Ballast Water Treatment

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Considerable efforts throughout academia and industry are currently focused on technologies to reduce or eliminate the translocation of organisms in ships ballast water. In support of these technologies, a pilot-scale facility to test candidate technologies has been constructed. The intention of the pilot scale facility is to supply a means to test shipboard equipment as close to full-scale as possible with increased control of the various parameters affecting performance, which are typically unknown or uncontrolled in the ship's environment. For example, input water properties are controlled by the surface waters which the ship typically operates in, whereas the waters utilized at the test facility may be supplemented to adjust organism densities, salinity and suspended solids. In the past year, this facility has been conducting experimentation to evaluate the test facility and also ballast water treatment equipment.

A variety of filtration technologies exist on the market today which may be viable candidates for the removal of biological organism from ships ballast water. In the present document, the results of testing at the pilot scale facility are reported. These systems included a disc, a screen and a media filtration system. Additionally, combinations of these units were evaluated. These filters were evaluated for the relative ability to reduce particulate concentrations and biological organisms of ambient water drawn from the Gulf of Mexico. Where appropriate or necessary, the test waters were supplemented with concentrations of Arizona Test Dust to alter the total suspended solids and overall turbidity. Particle counting was used on the input and output of each filtration systems to evaluate filter removability. Direct enumeration of organisms in the feed water and filtrate were utilized to evaluate effectiveness in the removal of organism. Discussion of the performance of each system and their combinations over the size ranges 10-30, 50-80 and 100-200 microns are reported.

N O T E S

Evaluation of a New Method for Control of Aquatic Invasive Species: Effects of Carbon Dioxide and Stack Gas Supersaturation on LT_{50}

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Release of ballast water from ships is a major transport mechanism for nonindigenous aquatic organisms as recognized by the 1996 National Invasive Species Control Act. Approximately 40 000 major cargo ships operating worldwide pump ballast water on board to ensure stability and balance. Ship surveys have demonstrated that ballast water is in general a non-selective transfer mechanism — many taxa representing planktonic and nektonic organisms capable of passing through coarse ballast water intake screens are common. These include zebra mussels, Asian clams, bloom forming dinoflagellates, fish and crustaceans. Current control methods rely on ballast water exchange at sea but this is only partially effective and can result in excessive structural loading of the ship's hull. There is a pressing need for new economical and safe control strategies. Aquatic species, in general, are intolerant to increases in dissolved carbon dioxide concentrations given its effect on water, blood and hemolymph pH. These species are also sensitive to elevated total dissolved gas pressures. The gas bubble disease that develops following exposure can, as with carbon dioxide exposure, cause mortality. We are exploiting this sensitivity by developing a control method based on manipulation of dissolved gas concentrations — supersaturation of blood and tissues with gas followed by an induced (short-term) pressure release. Specific hypotheses being tested, are 1) supersaturation of water with carbon dioxide, power plant exhaust (CO_2, 14%; O_2, 4.5%; N_2, 81.2%; SO^2, 0.3%) or a combination of these gases will cause mortality of target species; and 2) control method efficiency is dependent on dissolved gas concentrations, treatment duration, target species and life stage.

Tests to date have been completed using replicate bench scale hyperbaric chambers that provide temperature and dissolved gas pressure control. Results indicate carbon dioxide and power plant exhaust are effective at controlling a wide range of target species, including mollusks, crustaceans and fish. Required exposure periods (LT_{50}) are relatively short and decrease with increasing gas supersaturation levels. Gas recovery and reuse methods developed have reduced gas requirements by up to 85% making the method attractive in ballast tank applications as well as water conduits susceptible to fouling with exotics such as the Zebra Mussel. Further refinement of the method is required prior to application by industry. Specific needs currently being addressed include 1) modeling the effect of ballast tank geometry on gas transfer and mixing 2) evaluating the potential for use of diesel engine exhaust gases; and 3) demonstrating method effectiveness in water conduit applications.

NOTES

Rapid Deoxygenation of Ballast Water: Effectiveness and Applicability of a Bio-reactive Process

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Laboratory experiments in 200-liter tanks were conducted to determine the effectiveness of a bio-reactive process to induce rapid oxygen depletion in ballast tanks in order to reduce the risk of transferring invasive aquatic organisms. Results showed that dissolved oxygen levels dropped below 0.2 mg/L in 1 to 5 days after the beginning of the treatment. The rate of oxygen depletion in water was inversely related to temperature ranging between 4 and 25°C. The performance of the process is similar in both fresh and salt water and was unaltered by the level of mixing of the medium. Hypoxic conditions (<0.2 mg/L) were maintained up to 12 days after inoculation. During treatment, levels of nitrates dropped to zero, while levels of ammonia increased. Levels of dissolved organic carbon declined and particulate carbon and particulate nitrogen both increased over time. Production of hydrogen sulfide was noted but levels were low and tended to increase with experimental temperature. Toxicity testing using Microtox bioassay showed no evidence of environmental toxicity of the treated waters once discarded. The above results suggest that this technology seems environmentally-safe and that its application as a ballast water treatment method on board ships should be considered. A cost-benefit analysis of this method relative to other treatment methods is presented.

NOTES

Treatment of Ships' Ballast Water Using the Strong Dielectric Barrier Discharge

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Until now, no effective method is used in the treatment of ship's ballast water on board. A physics method is studied that the electrons are accelerated and then the gas molecules are aroused using a strong dielectric barrier discharge. With this method, the strong electric field ($E_d \geq 400$Td, 1Td=10^{-17}Vcm^2) is formed with the thinner α-Al_2O_3 dielectric layer in the micro- gap at a high pressure ($P \geq 0.1$Mpa or n=2.6x10^{-19}/cm^3). The electrons achieve the average energy of above 12eV. As a result, O_2 in air and H_2O in seawater are ionized and dissociated into a number of activated particles such as OH, O_2^+, O(^{1}D), HO_2 radicals, and then dissolved into a part of seawater to form the dissolved hydroxyl radicals. The ratio concentration of OH is 23.4mg/L in 20t/h pilot-scale system and injected into the main pipeline of ballast water discharge. The experimental results are as following:

1) OH radicals are dominantly produced from the positive ions O_2^+ reacting with H_2O to form the water cluster ions.
2) The concentration of killing organisms in ship's ballast water is only 0.63m/L.
3) The duration to kill mono-cell algae, bacteria and protozoan are very fast only 2.67s.
4) The hydroxyl radicals have much stronger oxidized and decomposed actions to the photosynthesis pigments of phytoplankton. The contents of chl-a, chl-b, chl-c and carotenoid are decreased to 35%-64% within 8.0s further to the lowest limit of test after 5 minutes.
5) The lipid peroxide degree of cell is increased three times. The basic life substances, monose, amylose, protein, DNA and RNA of cell, are greatly destroyed. Also CAT, POD and SOD of antioxidant enzyme system are obviously destroyed. Biochemistry processes is the main reasons of organism cell death.
6) The quality of ballast water is greatly improved. With the duration of 2.67s, the decrease rates of COD, nitrite and ammonium salt are 100%, 98.3% and 99.5% respectively, and the turbidity is decreased to 50%. DO is increased 77% due to the decomposition of residual OH.
7) The equipment of hydroxyl solution has some advantages such as small volume, simple operation and low running cost, which is only 1/30 cost in comparison with the open-ocean- exchange of ship's ballast water.

In a word, the treatment of ships' ballast water using OH radicals is a kind of advanced oxidation method, which realizes Atom Economy, Zero Emission and Zero Pollution in the process of the production of OH radicals and the killing of organisms in ships' ballast water. Invasive marine species can be killed in ship in the process of the discharge or inputting ballast water.

NOTES

Development, Verification and Installation of Electro-ionization Technology for Ballast Water Treatment on a Cruise Ship

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Ballast water discharge, which is causing severe worldwide economic, ecological and health concerns, has been the focus of intensive research and development by Marine Environmental Partners, Inc. (MEP) and has led to the introduction of the MariSan™ ballast water treatment system. Incorporated into its multi-step sanitation process is electro-ionization. MEP tested its capabilities in a system built and operated in the laboratory at Nova Southeastern University Oceanographic Center (NSU) and onboard Carnival Cruise Lines' MS Elation.

The complete MariSan™ Ballast Water System includes:

1) Solids removal module,

2) Seawater electrolysis module,

3) Ambient air ionization (IONZTM) module, and

4) Static mixing module.

MEP subsequently sold and installed a full-scale system on Carnival's Elation, and built a 1/20th scale model research unit housed at NSU for parameter experimentation.

Onboard and lab tests thus far show 95% or greater elimination of biota and system modifications produce no chlorine or bromine residuals. Chlorine and bromine are not added; biota inactivation is accomplished through the introduction of traces of bromine/chlorine that have been produced from the sea water through electro-chemistry. Ionized gases that have been produced from ambient air enhance sanitation and aid in the neutralization of the bromine/chlorine produced in the process.

Comprehensive independent toxicological tests on the ballast water effluent were performed using water treated by electro-ionization. Acute exposure test results indicated no surrogate organism (Mysid shrimp) death. Chronic static exposure (seven days) test results indicated no impact to growth or their ability to reproduce. A critical element of the MariSan™ ballast water system is its lack of environmental impact upon discharge.

Additional testing for the State of California Lands Commission and the United States Coast Guard will be conducted on various other life forms including:

- *Haliotus rufescens* - red abalone (invert. mollusc)
- *Crassostrea gigas* - oyster (invert. bivalve mollusc)
- *Mytilus* spp. - mussel (invert. bivalve mollusc)
- *Macrocystis pyrifera* - giant sea kelp (alga)

Testing for miscellaneous compounds possibly formed during the process also were conducted. This included testing for carcinogens, THMs, etc. Formal testing for California Lands Commission commenced in February 2004 and the results of all of this testing formed the basis of this presentation.

MEP specifically designed the MariSan™ ballast water system to meet the International Maritime Organization's (IMO) mandate for a system:

- Safe to ship and crew
- Environmentally acceptable
- Practical
- Cost efficient
- Biologically effective

With MariSan™ technology the hazards associated with open sea exchange are eliminated; testing has shown the effluent to have no affect on the natural ecology; the system has a small footprint enabling adaptation to confined space configurations; it is fully automated; and it is cost efficient to operate and maintain.

NOTES

Engineered Biomimetic Surfaces To Reduce *Ulva* Zoospore Settlement

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There is a significant need for coatings and substrates with the ability to tailor settlement and adhesion of biological organisms and cells. The cascade of events involved in biological adhesion to a synthetic surface is complex. Surface chemistry, topography, and bulk properties of the substrate all affect the strength of biological adhesion. The ability to tailor a surface to control bioadhesion would have implications in applications as diverse as ultrafiltration, coatings, and biomaterials. Coatings are specifically needed for the prevention of marine biofouling on surfaces such as the hulls of ships and water treatment facilities. The formation of marine biofouling is an intricate hierarchical process, involving the sequential settlement, adhesion, and growth of progressively larger and more complex organisms.

The marine alga, *Ulva*, is the most common macroalga that fouls ships and submarines. Fouling occurs by the settlement of motile spores, which subsequently adhere by the secretion of a glycoprotein adhesive that anchors the spore to the surface. Previous studies have shown that the swimming spores are able to sense the energetically most favourable location to settle on a given substrate, via settlement cues including phototaxis, chemotaxis and thigmotaxis.

Our research group has engineered surface topographies that significantly reduce marine fouling by optimizing mechanical and energetic effects. It has long been known that surface roughness affects wettability. Wenzel and Cassie have previously described the geometric relationships between surface topographies and both advancing and receding contact angles of liquids on solid surfaces. Kendall has described the influence of the bulk modulus and surface energy of a solid surface on adhesion strength of elastomers. Our group has combined these two concepts into engineered surfaces that mimic biologic surfaces that exhibit antifouling properties in the marine environment.

We will report on the effect of micropatterned surfaces for control of biological settlement and adhesion with respect to zoospores of the macrofouling alga, *Ulva* as well as large macrofoulers such as bryozoans and barnacles. The topographical features studied included ridges, diameter pillars, and a biomimetic engineered surface topography that resembles shark skin. The dimensions range from a sub-micron nano features to large features on the order of millimeters. Surfaces with dimensions greater than ca. 2 micron topographies, e.g., 2 µm wide x 2 µm deep, enhance settlement of the zoospores. Our first successful biomimetic engineered surface embossed on a polydimethylsiloxane elastomer has reduced settlement of the zoospores by 86%. This is compared directly with a control surface of the PDMSe that is topographically smooth to the nanometer scale. We will report on the physical and mechanical properties of the elastomers and the bioassays used to characterize both biosettlement and biorelease. These results are the first definitive example that minimally fouling substrates can be produced using microtopographies. Future studies will examine the limits of the models to predict the anti-fouling and foul-release behavior of engineered surfaces.

N O T E S

Acute Toxicity of SeaKleen (Menadione) to Zooplankton Diapausing Eggs

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Of the vectors for nonindigenous species introduction into the US Great Lakes, transoceanic vessels are especially well known and problematic. Efforts to reduce the risk of nonindigenous species introduction from these ships have concentrated on preventing the release of ballast water collected at foreign freshwater ports. But ballast tanks devoid of water remain a threat due to the presence of residual sediment, which is known to harbor the resting stages (diapausing eggs or cysts) of invertebrates. Treatment of ballast residuals with biocides has been proposed as a possible control method, but the response of target organisms in the resting stage to biocides is not well understood. If biocides are to be used as a control method, vulnerability of resting egg stages to biocides must be assessed directly. We will report on the acute toxicity of SeaKleen, a commercial product consisting of Menadione, on rotifer, copepod, cladoceran, and brine shrimp resting eggs obtained from commercial sources, laboratory cultures, and lake sediments. New methods for the use of resting eggs in bioassays will be described. Additionally, the establishment of Artemia resting eggs as a standard test organism for toxicity studies examining aquatic invertebrate resting life stages will be advocated.

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Development of Full-Scale Ballast Water Treatment Systems for the Control of Aquatic Nuisance Species

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The paper will describe the Baltimore Harbor Ballast Water Treatment Program (the largest program of its kind in the US), which examines a variety of technologies designed to eliminate nuisance species from ships' ballast. The current program involves the testing of full-scale systems both in Baltimore Harbor and aboard commercial vessels. We will discuss the development of UV, biocide and physical filtration/separation systems during laboratory/mesocosms studies in our laboratory over a period of more than ten years and will report on their efficacy under shipboard conditions. We will also describe progress in deployment and testing of full-scale commercial trials of some of these systems developed as a result of this program. Finally, a soon to be conducted test aboard an operating cruise ship, fitted with a BWT system employing solids filtration and UV light irradiation will be discussed.

NOTES

Design Optimization and Test of an Onboard Treatment of Ballast Water (TREBAWA) – Combination of Hydrocyclone and UV

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The harmful environmental effects on the ocean environment as a result of translocation of foreign or unwanted aquatic bodies via ballast water are well documented. The TREBAWA group is a European consortium that addresses this issue by focusing on the development of a new technically and economically competitive ballast water treatment system to be employed onboard ship. The proposed system consists of a primary (hydrocyclone) pre-treatment phase together with a secondary integrated UV system to prevent microorganisms' transport by disinfection of the ballast water.

The paper will present research methodology applied in the project, the results of system design optimisation with computational fluid dynamics (CFD) simulation, system set up and operation, results of field tests, conclusions and recommendation to further work.

NOTES

Shipboard Demonstration of Chlorine Dioxide as an Effective Ballast Water Treatment on the M/V Atlantic Compass

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Chlorine dioxide has been used safely and economically for over 50 years in industrial and municipal applications to control microorganism. Chlorine dioxide is unique in effectiveness against all organisms. It does not form unwanted chlorinated by-products even in heavily contaminated water and after treatment it is environmentally acceptable. Chlorine dioxide can also be generated on site safely and economically.

Chlorine dioxide has been used successfully in brine applications from deep oil well applications to a disinfectant in contact lens solutions. However, the effectiveness of chlorine dioxide as an effective treatment for the control of invasive species was not determined until breakthrough research was conducted at the University of Rhode Island Graduate School of Oceanography in 2001.

Through the work conducted at the University of Rhode Island, it was found that a low dosage (5.0 mg/l) of chlorine dioxide is sufficient to kill 99% of zooplankton, phytoplankton, bacteria and viruses in seawater. The chlorine dioxide residual was depleted in less than 24 hours after treatment and there was no re-growth of any organisms. Chlorine dioxide can be safely manufactured on board ship and the treatment dosage will not affect the ship's base metals or coatings. The ability to neutralize invasive species at a low dosage and then be environmentally acceptable makes chlorine dioxide an excellent candidate for treating ballast water.

Ecochlor Inc. has installed its patented Ecopod™ System on board the M/V Atlantic Compass owned and operated by Atlantic Container Lines. The Atlantic Compass is a Swedish flagged, RORO / Containership that was built in 1984. The vessel has a length of 292 meters (958 feet), a breath of 32.26 meters and at max draft, a tonnage of 51,648 DWT. The Compass has two ballast water pumps that are each rated at 900 m^3 per hour.

The Ecopod™ System is a self contained system that was installed during normal ship operations as the vessel traveled from Antwerp, Belgium to Gothenburg, Sweden in May of 2004. Additional electrical installation for the system was done as the ship sailed from Liverpool, England to Newark, New Jersey. The Ecopod™ System installed on this vessel is designed to treat in excess of 2,500 m^3 per hour.

Chlorine dioxide has been produced by the Ecopod™ System during the initial stages of the demonstration. Ballast water was treated in Newark, New Jersey, Baltimore, Maryland and Portsmouth, Virginia. Chlorine dioxide demand testing was performed as well as residual decay in the treated ballast water. Chlorine dioxide residuals were verified to be less than detectable levels prior to discharge.

This paper will discuss the preliminary results of the collaborative study between Atlantic Container Lines and Ecochlor, Inc. and the future plans for independent verification of this technology.

NOTES

An Economical Ballast Water System – Combined Effects of Hypoxia (De-oxygenation), Hypercapnia and a Low pH by Inert Gas Infusion

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This paper describes the ship-board design of a ballast water treatment (BWT) system, which infuses inert gas into the ballast water. The tests and analyses show that the system effectiveness meets or exceeds the standards for ballast water treatment, as stated in the pending legislation in the United States or in the proposed rules of the International Maritime Organization (IMO). The infusion of the inert gas, has been laboratory tested at the Scripps Institution of Oceanography and results of the tests are presented.

Treatment methods and options to "kill" Aquatic Nuisance Species (ANS) introduced by ballast water, in the most cost effective and pragmatic approach, are discussed in this paper. The ballast water treatment method focuses on bubbling inert gas via a row of pipes located at the bottom of the ballast tanks. The infusion of the inert gas, a tri-mixture of about 2% oxygen, 12% to 14% carbon dioxide, and the rest nitrogen achieves de-oxygenation (resulting in hypoxia), elevated level of CO_2 (resulting in hypercapnia) and acidic pH. The very promising combined effects of hypoxia, hypercapnia and acidic pH on marine organism are discussed in this paper.

Research methods are described here-in. Several different marine invertebrates, plankton and a representative bacterium, *Vibrio cholerae*, were incubated in experiments to determine their survival. The parallel incubations were gassed with nitrogen (anaerobic control) or "Trimix" (2% oxygen, 12% carbon dioxide, balance nitrogen). Aerobic controls, which were gassed with air, were done in parallel for each incubation. The test results show that the treatment objectives are met. All organisms tested died within few hours after incubation by the "tri-mixed" inert gas. The survival rate appears to be significantly shorter than in anaerobic incubation. All invertebrates showed no mortality in aerobic incubations. *V. cholerae* was non viable (>99%) after an incubation period of 24 hours. Special consideration is given to the development of methods to determine unequivocally the time of death of plankton, microorganisms, and macroalgae.

Shipboard Installation: Analyses and a shipboard design of the treatment system are presented in this paper. Installing a cost effective, practical and viable ballast water treatment system on-board a ship is challenging because of the huge amounts of ballast that must be treated. There are at least half a dozen systems, which may be effective in "killing" ANS, but are impractical on board a ship, costly to operate, dangerous or grossly inadequate to treat large amount of ballast water in a given time frame. The ballast water system described and analyzed in this paper is based on a 300 000 dwt tanker, which carries about 128,000 tons of ballast. A cost estimate for the installation of the system on a 70 000 dwt tanker is also performed.

Shipboard System Description: Each ballast tank has rows of pipes at the tank floor with downward pointing nozzles. The pressurized inert gas is jetted downward out of the piping. The bubbles rise through the ballast water to the space above the surface, which has been (optional) previously underpressurized to – 2 psi. Details of the design study are presented as well as the economic analysis. Based on the 300 000 dwt tanker design, which carries 128,000 tons of ballast, the system described can effectively treat that ballast in approximately 48 hours. The pacing events in the establishing of the lethality in ballast water are the times required to elevate the concentrations of CO_2 and its ionic forms and the decrease of the oxygen level.

Economic Analysis: The economic analysis shows, for a 300 000 ton tanker utilizing its own inert gas generator, that installation cost of the ballast water system described here-in is approximately $2.7 million and the operating cost of treating per ton of ballast water is 3.8 cents. Similarly, for a 70 000 ton tanker the installation cost is approximately $1.5 million and the operating cost is 3.5 cents per ton.

Relationship Between Body Length and Egg Volume in a Mass Invader *Chelicorophium curvispinum* (Sars, 1895) (Crustacea: Amphipoda)

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Chelicorophium curvispinum is a small tubiculous amphipod originating from the brackish (below 6% salinity) and freshwater of the Ponto-Caspian area of Eastern Europe. Several races exist of this species, of which forma *devium* is adapted to fresh water. Even though large numbers of euryoecious and exotic species have invaded the River Rhine, *C. curvispinum* appears to be more successful than any other invader. *C. curvispinum* has also been reported to have had an enormous impact on the River Rhine ecosystem by changing food webs and energy fluxes.

Seasonal patterns of egg production have been recorded for many amphipod species. In most amphipods, eggs produced in winter tend to be larger than eggs produced in summer. The effects of harsh environmental conditions on juvenile survival have been attributed for the changes in egg volume of amphipods and more recently, for an adaptive response to the brood sex ratio. We have studied egg volume, clutch size (number of eggs per brood) and overall brood volume (egg volume x clutch size) in females from field populations of *C. curvispinum* collected from different locations for a two year period in the Lower Rhine. We found distinct seasonal changes in egg volume, clutch size and overall brood volume which decreased over the breeding season. Possible causes for such a variation include food limitation and temperature variation.

NOTES

Colonization by Alien Amphipods on Stone Substrata Hung in the River Rhine

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Connectivity between rivers and extensive shipping expose ecosystems to invasive stress. The River Rhine is a good example of a heavily invaded river. Since the opening of the Main-Danube canal in 1992, the number of Ponto-Caspian invaders in the River Rhine strongly increased. A number of alien amphipods colonized this river successfully and are currently the most dominant macroinvertebrates, viz. the North American *Gammarus tigrinus* since 1984, the Ponto-Caspian species *Chelicorophium curvispinum* (1987), *Echinogammarus ischnus* (1989), and *Dikerogammarus villosus*, a stone dwelling amphipod that inhabits the Rhine since 1995.

Drifting amphipods can colonize free substrata in the Rhine. Therefore, nets with stones were hung in the head-stream of the river to study colonization by drifting alien species and their population development in those artificial habitats. Colonization depended on dial and seasonal variation as well as timing and duration of exposure (varying from 8 hours to 2 months).

N O T E S

Mud Fixation by the Ponto-Caspian Amphipod *Chelicorophium curvispinum* (Sars, 1895)

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Chelicorophium curvispinum (Sars, 1895) is the most successful amphipod in the river Rhine until now. All hard substrates are colonized by these invasive mud shrimps and their muddy tubes are covering the surface areas. Mud material including macroinvertebrates were brushed off from stones monthly. The fluctuations in the dry weight including macroinvertebrates (38-1044 g m^{-2}) and the ash-free dry weight (7-138 g m^{-2}) of mud material on the stones are highly correlated with the varying densities of *C. curvispinum*. The increase and decrease in densities as well as amounts of mud material were observed in July and August respectively. When the densities of *C. curvispinum* dropped, the mud material eroded more slowly than expected from the population decrease.

NOTES

Population Dynamics and Development of the Invasive Caprellid Amphipod *Caprella mutica*

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The caprellid amphipod, *Caprella mutica* was discovered on artificial structures associated with mariculture activities and marinas on the west coast of Scotland in 2002. *C. mutica* is indigenous to the sub-boreal coastal waters of North-East Asia, but has a record of accidental introductions worldwide. In the 1970s and 1980s, the species was introduced to various locations along the Pacific coast of North America. More recently, it has been found in Norway, the Netherlands, the west coast of Scotland, and the south coast of England. The date and mode of introduction to Scotland, and the impact of this non-native species on native sub-littoral marine communities is unknown.

This paper presents results from field and laboratory studies to investigate population dynamics and developmental rates of *C. mutica* in Scotland. Seasonal population dynamics were studied on artificial polypropylene line (length, 1 m) deployed at a depth of 10 m at two sites for 14 months. The stations were located at distances of 10 m (Fish Farm) and 500 m (Reference site) from caged mariculture activity. The abundance and biomass of *C. mutica* on lines at each site was recorded bi-monthly. For each line sampled, the body length and sex (excluding immature animals) of 25 randomly selected individuals was measured. Developmental rates were investigated in the laboratory. Newly hatched juveniles were maintained in aerated aquaria in a temperature controlled room (14 ±1°C). The caprellids were provided with *Fucus versiculosus* as a substrate to cling to and fed daily with the diatom *Cylindrotheca fusiformi*. Body length and instar were recorded every 2 to 3 days. Individuals were separated into pairs upon determination of their sex. The number of juveniles produced by each female was recorded.

Population abundance and biomass increased significantly ($p < 0.05$) at the fish farm site in early spring (May). *C. mutica* attained extremely high densities (10 000+ individuals m^{-2}) in the summer months (May to July) at the fish farm compared with the reference site. At both sites, the winter population of *C. mutica* consisted predominately of females and the abundance of males in the population increased in the summer months. In the laboratory, instar duration increased with developmental stage. After instar VII, instar duration was longer in females relative to males, and males displayed a greater increase in length with each instar. Development to instar X took 69 and 77 days for males and females, respectively. High mortality rates occurred during instar III. The number of offspring produced increased with female body length. The maximum number of offspring produced in one brood was 179.

The results suggest that *C. mutica* is a highly successful invasive species in the UK with populations in Scotland displaying the following characteristics: rapid population expansion, efficient utilization of enriched food supplies, over-wintering populations consisting predominantly of females, and rapid population increase under favorable conditions in spring.

N O T E S

The Nonindigenous Cladoceran *Cercopagis pengoi* in the Northern Baltic Sea: Some Remarks on its Distribution and Energetic Significance

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The predatory cladoceran *Cercopagis pengoi*, a recent Ponto-Caspian invader, was first recorded in the Baltic Sea in 1992 in Pärnu Bay and Gulf of Riga and now appears to be in the process of extending its geographical range in the region.

According to the earlier results and our own experiments in 2001, the salinity range in the upper water layers in the Baltic Sea today does not limit the expansion of *C. pengoi.* The species can reach high local densities up to 1800 ind. m^{-3} in the eastern parts of the Gulf of Finland, and foul fishing nets. The abundance of *Cercopagis pengoi* varies considerably. Mass occurrences in the northern Baltic Sea usually start in the second half of July and continue until late September. It seems to be clear that the preceding temperature development influences greatly the extent and abundance of the appearance of *C. pengoi*.

In addition to the regular monitoring program, intensive studies on the abundance, distribution, temperature and salinity tolerance of *C. pengoi* have been annually carried out since 1999 in late summer over the wide sea areas in the Northern Baltic and Baltic proper. In 2003 ecophysiological studies were completed by the measurements of respiration and ammonium excretion, which also will be discussed.

NOTES

If They Can't Meet You, They Can't Eat You: Simulation Grid Experiment to Investigate Body-size Related Habitat Choice in the Freshwater Amphipod *Dikerogammarus villosus* Sowinsky (Crustacea) and its Introduction Into a Freshwater Lake in the Netherlands

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Substrate dwelling organisms, like some amphipod crustaceans, will avoid being preyed upon by choosing the smallest possible refuge that still provides enough freedom of movement, sufficient food availability and favourable hydrodynamics. Habitat structure can favour or limit invaders range extensions. We tested body-size related habitat choice of a freshwater amphipod *Dikerogammarus villosus* with a simulation grid, a fibreglass plate with randomly distributed holes of different sizes. We found an almost perfect match of hole size choice and body size. The smallest animals having the biggest choice of hole size were nevertheless found in the smallest holes only, even when larger size classes were absent. This strongly suggests a genetic basis for this important survival mechanism. The introduction process of *D. villosus* in a freshwater lake in the Netherlands and the impact on the native amphipod species is presented with emphasis on the role of habitat structure.

NOTES

Invasive Gammarids in Poland – Migration in Progress

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The area of Poland belongs almost entirely to drainage systems of the largest Baltic rivers: the Vistula and the Oder. Through the constructions of canals starting in the XVIII-th century, these river basins became interconnected with the North Sea and the Black Sea drainages creating the so called “central corridor” – one of the three main corridors for migration of aquatic organisms in Europe. Through these canals, by intentional introductions and by migration along the sea coast, the Vistula and Oder basins witnessed a number of successful gammarid invasions. A current list of alien invasive gammarids penetrating Polish waters includes six species, Ponto-Caspian: *Dikerogammarus haemobaphes*, *D. villosus*, *Pontogammarus robustoides*, *Obesogammarus crassus*, *Chaetogammarus ischnus* and North American *Gammarus tigrinus*. The oldest invader is *C. ischnus*, found in the Vistula River already in the 1920s, whereas five other species entered Polish waters only since the late 1980s.

Our extensive monitoring of alien gammarid distribution in Poland revealed a fast colonisation process in the case of some species. Most recently, *G. tigrinus* has moved far upstream the Oder River to its upper reach near the city of Opole, whereas in the Vistula high upstream invasion has been recorded for *D. haemobaphes*, reaching the city of Cracov. The latter species has penetrated also upstream the Narew River and through its tributary – into the Great Masurian Lakes. *P. robustoides* was found recently in the lowest section of the Bug river, i.e., Zegrzyńskie Lake, where it migrated from the Vistula. The most impressive is the quite recent invasion of *D. villosus*; the species first entered the Oder river from the west, probably through the canal connecting the Oder river with the Elbe basin. Soon after it has been found in eastern Poland in the Vistula system, namely in the Bug river downstream of the Bug-Pripet canal connecting Baltic Sea and Black Sea basins. This shows clearly that the invasion of this species goes two ways simultaneously: 1) through the southern (Danube-Main-Rhine) corridor and then back to the east through the western part of the central corridor (Mittelland canal-Elbe-Oder); 2) through the central invasion corridor (Dnieper-Pripet-Bug) from east to the west.

N O T E S

Invasive Amphipods as a Food Resource for Local Fishes in the Vistula River

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It is commonly known that amphipod crustaceans form an important part of the diet of many fishes. Unfortunately, most analyses of fish gut content group all amphipods together as one food category or, often erroneously, various gammarid species are labeled simply as *Gammarus* sp. That makes it unclear what is the real contribution of particular (especially alien) species to a diet of various fishes. To elucidate this problem we analysed gut contents of a number of fish species occurring in the littoral zone of the Wloclawski Dam Reservoir located in the middle section of the Vistula River.

The Vistula River is a crucial part of the so-called central invasion corridor for the freshwater fauna in Europe. Until now, there are three species of invasive Amphipoda known to occur in the purely freshwater sections of the river: *Pontogammarus robustoides*, *Dikerogammarus haemobaphes* and *Chelicorophium curvispinum*. Also the above species are there are the only amphipods occurring on the studied site. Our study concerned five littoral fish species: perch (*Perca fluviatilis*), ruffe (*Gymnocephalus cernua*), ide (*Leuciscus idus*), chub (*Leuciscus cephalus*), roach (*Rutilus rutilus*) and weatherfish (*Misgurnus fossilis*) native to the Polish waters, as well as two Ponto-Caspian invaders: goad goby (*Neogobius gymnotrachelus*) and monkey goby (*Neogobius fluviatilis*).

All the species were found to feed on the invasive amphipods, which appeared to be quite an important element of their diet. In some species the contribution of the amphipods reached 100% of the total stomach content, also the frequency of occurrence in fish stomachs was high, often exceeding 50%. A detailed analysis of the fish gut content encountering contribution of each amphipod species will be presented and discussed.

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Biological Invasions in European Inland Waters: A Case Study of the Red Swamp Crayfish, *Procambarus clarkii*

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Since 1973, the red swamp crayfish, *Procambarus clarkii*, from Louisiana has been successfully introduced into many European aquatic systems, where its ecological plasticity has favored the presence of many reproductive populations. Here we present results from studies conducted by our lab through six years of research.

Main points of discussion will be:

a) Dynamics of this species' invasion throughout Europe (using molecular techniques and radio-telemetry,

b) Biological traits as prerequisites of its invasive potential (e.g. life history patterns, resistance to extreme environments, feeding ecology,

c) Its impact on the invaded habitats, including native species and communities, and

d) Hypotheses on its control and management.

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NOTES

The Invasion and Spread of the Chinese Mitten Crab in Europe from a Multidisciplinary Perspective

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Owing to its catadromous lifestyle, the Chinese mitten crab, *Eriocheir sinensis*, allows comparisons between the invasive spread of the same species in coastal and inland habitats. Analysis of detailed historic data from the first recorded outbreak in Europe revealed that there were two separate invasions, one in Northern Europe and the other in Southern France. Analysis of migration, size-class distribution and catch data allowed the prediction of a lifecycle for this species. The distribution of mitten crabs in the United Kingdom indicated that its range has expanded since the species arrival in 1973. The spread has been most marked along the North Sea coast, northwards to the River Tyne, and on the South coast westwards to the River Teign. The rate of spread values are comparable with the historic outbreak in Continental Europe.

A spatially explicit simulation model of the spread of the Chinese mitten crab in the River Elbe over the first 20 years of invasion was developed. The key input parameters influencing the rate of spread were upstream and growth survival, upstream migration rate and the carrying capacity. The model was validated by comparing model predictions with the observed cumulative spread of mitten crabs in the Elbe. Cross correlation analysis determined that the model underestimated the establishment phase by 5 years, whereas the exponential phase is well predicted.

In this study, six microsatellite loci were used in order to determine the invasive pathway of mitten crab populations in six different European locations. An isolation by distance effect was observed, indicating distance related structure in Europe. Further analysis found the genetic similarities pointed towards ballast water transport and not larval drift as the main distribution vector.

N O T E S

Passing Successful Invasive Plant Legislation in the State of Maine: Making a Difference on the Local, State and National Level in an Age of Political Cynicism with Grassroots Activism…One Vote Counts

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In 2000, four citizens in the State of Maine got together to formulate an anti-invasive aquatic plant piece of legislation that galvanized grass roots support, became a top media story and in 2001 came into law by one vote. Subsequently the legislation has been held up as national model and as a result of a presentation made to the North American Lake Management Society's annual conference regarding the legislation, Ship Bright was appointed to the Federal Invasive Species Advisory Committee by the Bush Administration.

The state of Maine is only one of three states in the lower 48 states that does not have Eurasian Milfoil – yet! In a hard fought battle the Maine legislature passed the nation's most comprehensive anti-invasive aquatic plant prevention legislation in April of 2001. Passing preventative legislation on any issue is difficult despite the wisdom that a "stitch in time saves nine". By one vote "An Act to Prevent the Infestation of Invasive Aquatic Plants and Other Species" was passed and signed into law despite an initially indifferent Executive branch and hostile political interests over its dedicated funding mechanism.

The final legislation included a dedicated revenue source [boat sticker program], quarantine provisions, temporary boat ramp closure authority, fines, public education, boat inspections, and the creation of an invasive species task force. The final bill which passed was constructed around a bill that Save Maine's Lakes [a Maine Political Action Committee] researched and introduced in the Maine Legislature. We'll talk about the challenges and the opportunities of raising awareness at the political and decision-making levels. This is a story of grassroots activism that fought against indifference, ridicule and hostility to the measure. It shows that with credible data, the ability to craft a message designed for "the people", and perseverance in a system that is purposely designed to make the passage of new laws difficult one can prevail. This presentation is about empowerment of the individual to make a difference on a large scale for the common good. While good science is necessary for good public policy it is most often not sufficient.

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Cooperative Federalism: Regional Aquatic Nuisance Species Panels in the United States

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Since the creation of the first Regional Aquatic Nuisance Species (ANS) Panel in 1990, pursuant to the Nonindigenous Aquatic Nuisance Prevention and Control Act (NANCPA), efforts to foster a regional approach to ANS prevention, control, and management have increased considerably. Initial efforts focused primarily on state and regional ANS management plans with narrowly prescribed objectives and priorities. Regional ANS Panels represent much broader geographic regions although they have only an advisory role. In efforts to implement such a federal approach, a policy of "cooperative federalism" has been used in which overlapping responsibilities are being addressed in a cooperative fashion by both the state and federal governments. Such regional organizations, coordinated across broad geographical areas, are often necessary as a means to bring government agencies and interested parties together, in a common forum to prepare and implement regional development plans.

Six Regional ANS Panels have been established in the United States: Great Lakes, Western, Gulf, Northeast, Mississippi, and most recently the Mid-Atlantic. The Panels have been created by two mechanisms: legislative mandates and ANS Task Force (ANSTF)-mediation. The Great Lakes Panel was mandated by §1203 of the NANCPA and the Western Panel was mandated by §1203 of National Invasive Species Act (NISA). However, the US Congress made it clear in NISA that, while additional Regional ANS Panels were necessary, the responsibility for the creation of such panels would be delegated to the ANSTF. The Gulf of Mexico, Northeast, Mississippi, and Mid-Atlantic Regional Panels were created subsequently – not by legislative mandate, but through the efforts of the ANSTF in cooperation with existing regional organizations.

The purpose of this presentation is to examine the origins, structure, and functions of Regional ANS Panels which have emerged as the primary mechanism in managing the complex regional issues relating to the prevention, control, and management of ANS and in implementing the milieu of related state, federal, and municipal policies.

N O T E S

Developing Essential Resources for Rapid Response to Aquatic Invaders in the Northeastern US and Atlantic Canada

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The Northeast Aquatic Nuisance Species Panel (the NEANS Panel) was formed in the summer of 2001 to coordinate aquatic invasive species (AIS) management activities in the Northeastern US and Atlantic Canada. Since then, the NEANS Panel has begun to address a variety of regional invasive species issues including ballast water management, monitoring and tracking of aquatic invaders, and educating key industries on threats from AIS. Among its management priorities, the NEANS Panel has identified the need to assist states and provinces in developing early detection and eradication protocols. Managers throughout the Northeast have recognized that a successful eradication campaign requires careful planning prior to an invasion to address risk assessment, permitting, response strategies, and a variety of other considerations related to both the invading species and the invaded resource. Through a regional planning workshop held in the spring of 2003, the NEANS Panel has identified the fundamental components of a comprehensive rapid response planning effort, as well as some of the resources necessary to initiate a successful response to new aquatic invaders. This presentation provides an overview of the NEANS Panel's rapid response planning activities, as well as a suite of web-based resources being developed to aid local managers in quickly responding to new biological invasions.

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Aquatic Invasive Species in the Pacific Northwest

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In 1999, the Bonneville Power Administration (BPA), recognizing the potential impact to its operations, began funding the Pacific States Marine Fisheries Commission (PSMFC) and Portland State University to conduct an aquatic nuisance species (ANS) prevention program for the Columbia River Basin (CRB). Further funding has come from the US Fish and Wildlife Service and NOAA Fisheries.

Authorized by Congress in 1947, the Pacific States Marine Fisheries Commission (PSMFC) is dedicated to resolving fishery issues. Representing California, Oregon, Washington, Idaho, and Alaska, the PSMFC works closely with the Center for Lakes and Reservoirs (CLR) at Portland State University on aquatic nuisance species (ANS) management.

The objective of the PSMFC ANS Program is to prevent harm from ANS species to important commercial and recreational fisheries and the ecosystems upon which these fish depend. Program emphasis is on outreach and education to appropriate user groups, assisting states in the region develop ANS management plans, and funding and coordinating monitoring of species of concern.

Currently, the PSMFC program funds are directed at four species: Zebra mussel (*Dreissena polymorpha*), Atlantic salmon (*Salmo salar*), European green crab (*Carcinus maenas*) and Mitten crab (*Eriocheir spp*).

The Bicentennial Commemoration of the Lewis and Clark expedition in 2003-2006 will result in many thousands of large and small boats, canoes, and other watercraft being paddled, motored, and trailered along Lewis and Clark's route. This anticipated mass movement of watercraft represents a significant threat to move zebra mussels and other invasive aquatic organisms from the Midwest to the West Coast of the US The PSMFC with state and federal partners is focusing resources on educating the public, especially bicentennial participants, about the zebra mussel hazard.

With funds secured by the PSMFC in 2003, the Washington Department of Fish and Wildlife (WDFW) began assessing the presence or absence of Atlantic salmon in selected freshwater streams using primarily snorkel surveys.

The CLR program includes research on these species and on freshwater aquatic weeds, ANS surveys, management planning for spartina in Oregon estuaries, research on ballast water introductions of ANS, and implementation of the Oregon Aquatic Nuisance Species Management Plan.

Discharge of ships' ballast water offshore and at ports may be a significant pathway for ANS introduction (e.g., zebra mussels) to the West Coast of the United States. With differing coastal state and British Columbia port regulations for ballast water management, there is a clear need for enhanced coordination on the West Coast. The PSMFC assists in regional coordination of West Coast ballast issues with the Pacific Ballast Water Group. The Pacific Ballast Water Group was formed following a series of informal meetings of state [OR, WA, CA, AK] and federal agencies, shipping industry, and Canadian representatives concerned about the introduction of aquatic nuisance species through ballast water discharge.

NOTES

Novel Application of a Novel Tool: Using a US Endangered Species Act Safe Harbor Agreement to Reduce the Use of Mosquitofish

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The Arizona Game and Fish Department (AGFD), in cooperation with the US Fish and Wildlife Service (the Service), has developed a Safe Harbor Agreement (Agreement) for the Gila topminnow (*Poeciliopsis occidentalis*), Yaqui topminnow (*Poeciliopsis sonoriensis*), desert pupfish (*Cyprinodon macularius*), and Quitobaquito pupfish (*Cyprinodon eremus*). Safe Harbor Agreements are a tool allowed for by the US Endangered Species Act that are available to non-federal landowners. The AGFD Safe Harbor for topminnow and pupfish is a proactive tool that will promote the conservation and recovery of these endangered species.

The Agreement has several conservation goals:

- Provide additional suitable aquatic habitats that have been largely unavailable for re-establishment of topminnow and pupfish populations. Reestablishing additional populations will promote species recovery;
- Increase public awareness of conservation needs for native fishes;
- Provide native fish for mosquito control while reducing or eliminating the use of the non-native mosquitofish; and
- Develop new partnerships between federal, state, private, and other non-federal landowners to create a new era of trust and improved conservation efforts for threatened and endangered species.

The topminnow and pupfish were listed as endangered in 1967 and 1986 respectively. Since then, many conservation efforts have been attempted, but the status of all four species is only marginally better than when the species were listed. Additional conservation measures on many fronts are needed to improve the status of these species.

Safe Harbor Agreements are voluntary arrangements between the Service or National Marine Fisheries Service and non-federal landowners. The main purpose of these Agreements is to promote voluntary habitat management that may benefit listed species on non-federal lands, and give assurances to participating landowners that no additional regulatory restrictions will be imposed.

Besides the continual loss of habitat, conservation and recovery of the topminnow and pupfish are seriously threatened by the western mosquitofish (*Gambusia affinis*). There are documented instances where Gila topminnow populations have been lost in less than five years after mosquitofish were found. Mosquitofish continue to be stocked in Arizona and continue to spread and impact native fish populations.

The arrival of West Nile Virus in Arizona in 2003 may actually be beneficial to topminnow and pupfish recovery. Since both topminnow and pupfish are known to prey on mosquito larvae as effectively as mosquitofish, a tremendous marketing opportunity has presented itself. Making these native fish available for release in suitable habitats to assist with mosquito control will allow us to meet all our goals for the Safe Harbor. There will be tremendous interest in using all mosquito control tools available.

Though the agreement is not finalized yet, it is expected to be signed in 2004. Implementation is expected to begin immediately, and we expect this new Endangered Species Act tool to assist in the fight against *Gambusia.*

County Heritage Plans as a Tool for Raising Public Awareness

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Public understanding and cooperation are important elements in the control and limitation in the further spread of invasive alien species. Professionals working with communities at a local level can help to promote this. County Councils throughout Ireland have recently adopted their first five-year heritage action plan. Many are now preparing county biodiversity assessments, part of the overall plan. This process has been facilitated at a local level by the installation of heritage officers, employed by local authorities with the support of the national Heritage Council. Their role is to manage the heritage function within a county in a strategic and co-ordinated manner. Local Heritage Plans are prepared in cooperation with a local heritage forum after extensive public consultation. The heritage forum composition varies slightly from county to county, but in all cases there is representation from broad sectoral interests, including elected representatives, staff of the local authority, community representatives, heritage professionals, heritage NGOs, business, tourism, farming and forestry interests.

The aim of the process is to identify and prioritise heritage objectives in the county. In all cases, raising awareness of important issues, providing education and advice, have emerged as important aspects of the plan. Collecting raw data, collating existing records, and identifying and filling gaps in knowledge are also important themes.

Heritage Plan and Biodiversity Plans are proving useful tools for raising awareness of issues and for promoting best practice on a local level. Individual County-based projects are also helping to fill out the national picture on issues related to the problems of invasive aquatic alien species such as zebra mussels and ornamental plants. Heritage officers are an important link in communicating issues such as exotic species management measures to the public who otherwise will be often unaware of such matters.

NOTES

Effective Strategies that Work to Prevent the Spread of Aquatic Invasive Species by Recreational Boaters

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Effective public education is the key to prevent and slow the accidental spread of aquatic invasive species (AIS). While many human-mediated pathways exist for overland dispersal of AIS, recreational boaters are recognized as a primary pathway. Results of a Sea Grant-sponsored mail survey administered in Minnesota, Ohio, Vermont, Kansas, and California shows that AIS education can significantly change boater behavior to reduce their risk for spreading AIS. Minnesota and Vermont have invested more in AIS public education programming and used a greater variety of effective methods than the other states surveyed. Minnesota and Vermont boaters were most aware of AIS issues and reported taking action (90% and 82%, respectively) at water accesses to prevent their spread. Ohio boater awareness was also relatively high, however, less than half (45%) took actions to prevent AIS spread. Although AIS boater awareness was generally lower than other states surveyed, California and Kansas boaters regularly took appropriate actions at water accesses (40% and 30%, respectively) to prevent the spread of AIS. Another sign that AIS education works is that the percentage of Minnesota boaters who took action has increased by over 20%, compared to a similar Sea Grant survey in 1994 (when 70% took action).

Results indicate that boaters are willing to take action if they know what to do. Most often, boaters' motivations for taking action were to keep AIS "out of my lake" or because "it is my personal responsibility." Effective public education taps these motivations, stresses why preventing the spread of AIS is important, and delivers concise, consistent messages. Miscommunication like, "it's only a matter of time" or "it only takes one mistake to cause an infestation," confuses the message, undermines successes in behavioral change, and fuels public apathy.

Making AIS a priority through a comprehensive program of public education, monitoring, watercraft inspection, and enforcement is effective. (In particular, enforcement of state laws prohibiting transport of any aquatic plants, injurious species, and contaminated boats and water has successfully interrupted the pathways for AIS spread.) Using education as the 'carrot' and enforcement as the 'stick' is an approach that works.

Funding for this project was provided by a grant from the US National Oceanic and Atmospheric Administration to the National Sea Grant College Program through an appropriation by Congress based on the National Invasive Species Act of 1996.

NOTES

Integrating an Aquatic Invasive Species Unit Into School Curricula

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A long-term approach to aquatic invasive species is education, beginning with 6-12. A project-oriented approach addresses a host of educational standards across the disciplines and teaches environmental literacy. Focusing on a relevant environmental topic is also a way to hook and motivate prospective teachers.

This presentation will introduce participants to creative and diverse ways to integrate an aquatic invasive species unit into the curriculum — using costumes, puppets, and other innovative props. It is not enough that students do science, they need to share their discoveries. The Maine Lakes Conservancy Institute has created an award-winning Students' Portal website at www.mlci.org that allows students to investigate their lakes and then post the material, including a map of what the spread of an invasive species would look like and mean for their community's lake.

NOTES

Employing a Volunteer Network to Help Control Purple Loosestrife: Implementation and Impact

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The curriculum, *Biological Control of Purple Loosestrife,* was created for youth interested in learning how to reduce negative impacts of purple loosestrife infestations in the United States. It uses informal educational techniques to teach youth about wetlands, invasive species, and how to raise and release Galerucella beetles to help control purple loosestrife. The curriculum development, pilot testing, and dissemination plans were presented at the 11th International Conference on Aquatic Invasive Species (Feb. 2002, http://sgnis.org/publicat/sicmb112.htm). This presentation will report on the implementation, evaluation, and impact of the Biological Control of Purple Loosestrife informal youth curriculum.

The curriculum consists of activities for high school students and a teacher guide, which are available in hard copy from Purdue University and online at http://sgnis.org/publicat/portrat1.htm and http://sgnis.org/publicat/portrat2.htm. It is appropriate for use by community groups, school, 4-H, and scout clubs, by individuals, and by teachers who do not have enough class time to use formal classroom curriculum. The website, http://www.four-h.purdue.edu/purple/, gives suggestions, links to other programs, and additional information. The *Biological Control of Purple Loosestrife* curriculum was evaluated using both the inquiry assessment model (Tafoya, et al., 1980) and the Project 2061 criteria of the American Association for the Advancement of Science. The inquiry assessment showed that two activities are at the confirmation level, five activities are at the structured inquiry level, three are at the guided inquiry level, and one is at the open inquiry level of difficulty. The Project 2061 evaluation showed the following general results:

- All the activities teach skills in management of resources and working in groups
- Most of the activities incorporate the following skills: acquiring, analyzing, and using information; and observation skills
- 30-40% of the activities teach Problem solving & decision making, predicting, and questioning skills

The *Biological Control of Purple Loosestrife* curriculum was also jury reviewed by informal education specialists and accepted into the National 4-H curriculum collection. These reviewers made the following comments about the curriculum:

- "The variety of learning modalities is excellent. The content includes biological sciences, ecology, math, community development, and communication skills. The entire project is focused on a real, current, societal issue."
- "The purpose of this project is extremely clear, and all activities lead directly toward its achievement."

The project has generated a lot of media attention and enthusiastic youth who find the project to be a great learning experience and a rewarding community service project. This curriculum has been used by 4-H youth and their volunteer leaders, parents, community groups, and individuals interested in helping to address a local problem. Youth have learned more about wetlands, invasive species, and community service. This project addresses a local problem, teaches youth (and, therefore, their parents) about invasive species, biological control, and community service.

NOTES

Overcoming Obstacles in the Control of Water Chestnuts in an Urban Setting

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The City of Holyoke, Massachusetts, United States is the site of a major infestation of water chestnuts, *Trapa natans*. This infestation has provided lessons in the importance of partnering, education, outreach, cooperation, and solving logistical problems in the control of aquatic invasive species in an urban setting.

The City of Holyoke, Massachusetts, known as the Paper City of the World, is one of the first industrial planned communities in the United States. Located on the Connecticut River, a significant number of its downtown buildings are tied into the Holyoke Canal System and the Holyoke Dam, which is used to generate electricity. Once a thriving economic area, the City now struggles with low median incomes, poor standardized test scores, and a high percentage of persons living below the poverty level. These socio-economic challenges have often diminished the value of the preservation and protection of environmental resources in the city.

The water chestnut infestation was first noted in 1997 at Log Pond Cove - the site of the city dump in the late 1800's and early 1900's. Located on the Connecticut River, just above the famous Holyoke Dam, the Cove was initially used to hold logs sent downstream from timber operations in Vermont and New Hampshire. The north opening of the Cove gradually filled in, leaving only a small opening from the main Cove to the river and a finger-like backwater cove. These slow moving protected areas presented ideal habitat for an invasive species to flourish.

By the time control operations began in summer of 1998, water chestnuts completely covered the sixteen acre surface of Log Pond Cove and the five acre surface of the finger cove. First attempts at control included the use of garden wheelbarrows and a small mechanical harvester borrowed from another community. Of course, early attempts at harvesting with wheelbarrows seem thoroughly foolish and naïve in hindsight. Each year of control work since 1998 has developed new insight and better management. Issues like access to the Cove for on-shore handling over an active railroad line; safety and security of the harvesting operations in light of a vagrant camp in the Cove floodplain; project abutter complaints of odor and noise; mechanical harvesting versus herbicide treatment; project financing; final disposal locations; permitting; scheduling; education and outreach efforts to prevent additional infestations; and partnering with other municipal, state, federal, non-profit organizations and private individuals have been fully developed to produce a now-successful control and management program at the Cove.

Local officials and others have recognized the water chestnut control project at Log Pond Cove as an exemplary example of how well government can work when difficult questions are approached creatively and cooperatively. Now, even those with no previous environmental experience are touting the importance of invasive species control.

NOTES

Outreach and Communications: Vital Components of the Asian Carp Rapid Response Plan

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Bighead (*Hypophthalmichthys nobilis*) and silver carp (*Hypophthalmichthys molitrix*) are two of several Asian carp that have been introduced into North America. Both species have established large populations and impacted native aquatic communities in the Mississippi and Illinois Rivers. They are now moving to more inland waterways and north toward Lake Michigan — systems in which they could have tremendous negative impacts.

To prevent the bighead and silver carp from entering Lake Michigan via the Chicago Sanitary and Ship Canal (CSSC), a committee of representatives from federal, state and local agencies was formed to develop a rapid response plan in the event that these fishes made their way into CSSC. Although an electric barrier was installed in CSSC to impede the migration of fishes between Lake Michigan and Illinois' inland waterways, there was concern that this barrier would not be able to deter juvenile Asian carp.

To ensure success of the Asian Carp Rapid Response Plan, the rapid response committee determined that the Plan must contain a comprehensive outreach component. Therefore, an outreach subcommittee of communicators, public relations professionals, educators and scientists was formed. This subcommittee devised the communications component of the Plan using various tools including informational open houses, press releases, direct media contact, personal meetings with elected officials, and phone calls to environmental organizations and user groups. Our communications plan can be used by others when developing their own state or species-specific rapid response plans.

NOTES

Habitattitude! A National Campaign to Prevent the Introduction of Aquatic Invasive Species by Aquarium and Water Garden Owners

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Scientists have identified the release of aquatic organisms by aquarium and water garden owners as a vector for introduction and spread of potential invasive species into lakes, rivers, wetlands, estuaries, and coast waters of the United States. While environmental and economic consequences for most species are unknown, impacts of others have resulted in millions of dollars to support control and management activities. This is concerning, especially with the projected growth of the aquarium hobby. Home aquaria have become tremendously popular with an estimated 12 million households participating, while another 2 million households enjoy outdoor ponds. This popularity suggests that the risk for release of potentially invasive aquarium plants and animals by uninformed owners will also grow.

To address these concerns, the US Fish and Wildlife Service (FWS), state fish and wildlife agencies, the Great Lakes Sea Grant Network, and the US Pet Industry Joint Advisory Council (PIJAC) and its member organizations have formed a collaborative partnership. This unique alliance has pooled its resources, creativity and expertise to design *Habitattitude*, a nationally branded public awareness and partnership campaign that promotes awareness and preventive action focusing on the accidental release of fish, snails, crayfish, and aquatic plants by aquarium hobbyists and water garden owners.

Following the successful *Stop Aquatic Hitchhikers!* campaign, this new effort translates a complex issue into simple, relevant prevention message to promote the importance of not releasing aquarium plants and fish and provides alternatives to release. Designed as a multi-level strategic campaign, *Habitattitude* is founded on social marketing principles and is designed to raise awareness, provide ownership for the issue and empower people to take preventive actions. This campaign is unique in that it brings many diverse partners together and focuses their collective efforts by combining proven strategic communications, marketing, branding, and evaluation processes with the intent of fostering sustainable behavioral change. With over 90% of the US. aquarium fish supply annual market represented in this partnership, campaign partners have produced various educational materials that are being distributed through the industry's chain of commerce. This support and promotion of the campaign by the industry is another aspect that makes *Habitattitude* so unique. By using the retail-consumer relationship as an educational intervention point, and following it up with proactive outreach, campaign partners expect *Habitattitude* to become a household concept with aquarium hobbyists and water garden enthusiasts. *Habitattitude* is a campaign that seeks to unify the conservation community with the aquarium industry and allow us to speak with one voice regarding aquatic invasive species. Project partners invite your participation in this campaign to promote aquatic resource conservation.

Presented on behalf of the US Fish & Wildlife Service, Pet Industry Joint Advisory Council, Great Lakes Sea Grant Network and State Fish & Wildlife Agency Partnership.

NOTES

The GEF/UNDP/IMO Global Ballast Water Management Programme: Reflections, Achievements, Progress and Plans

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The Global Ballast Water Management Programme (GloBallast) is an international technical cooperation programme executed by the International Maritime Organization (IMO), with funding provided by the Global Environment Facility (GEF), through the United Nations Development Programme (UNDP), and with support from individual countries and the shipping industry. GloBallast activities commenced in March 2000 and are scheduled to run until September 2004.

The programme's Development Objectives are to assist developing countries to:

- reduce the transfer of harmful aquatic organisms and pathogens in ships' ballast water,
- implement existing IMO ballast water management Guidelines, and
- prepare for the implementation of a new international ballast water Convention.

The programme is working to achieve these objectives through six initial Demonstration Sites, located in the six main developing regions of the world, followed by regional replication and cooperation. At the global level the Programme has established information clearing-house mechanisms, including internet-based networks, directories and databases, has catalysed a more globally coordinated and cooperative research and development effort, is developing modular training packages and is implementing highly successful communication and awareness activities. Activities being carried out at the Demonstration Sites include:

- Establishment of national and regional institutional structures.
- Communication and awareness activities.
- Hazard analysis and risk assessments (developing standard methodologies).
- Invasive aquatic species surveys and monitoring and ballast water sampling (developing standard methodologies).
- Support for R&D of treatment technologies.
- Assistance with national ballast water policies, strategies, legislation and regulations.
- Training and technical assistance with implementation of the ballast water guidelines, compliance monitoring and enforcement.
- Assistance with developing self-financing and resourcing mechanisms.
- Regional replication of the successes at the initial Demonstration Sites and development of cooperative, multi-lateral regional action plans.

The GloBallast Programme is making a major contribution to addressing one of the greatest threats to the world's oceans, adopting a multi-disciplinary, inter-sectoral approach, embracing partnerships between governments and industry and for the benefit of both developed and developing countries. This paper will review progress to date, lessons learned and plans for the future.

NOTES

US Coast Guard Ballast Water Management Program: Battling Aquatic Invasions Through Regulations

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The Coast Guard is the US Federal agency authorized by Congress to develop a national regulatory program to prevent the introduction and spread of nonindigenous aquatic organisms into US waters via the operations of vessels. By direction of two Federal laws, the Nonindigenous Aquatic Nuisance Prevention and Control Act (NANPCA) of 1990 and the National Invasive Species Act (NISA) of 1996, the Coast Guard has promulgated regulations and established ballast water management programs for the US.

Following the invasion of the Great Lakes by zebra mussels, the Coast Guard developed regulations in 1993, for vessels entering the Great Lakes with mandatory ballast water management practices, and extended these requirements to the Hudson River in 1994. Subsequent high profile invasions, particularly along the Pacific coast, prompted Congress to amend NANPCA with NISA in 1996. Under NISA, national voluntary guidelines on ballast water management (BWM) practices were developed for most vessels entering all other regions of the US after operating outside of the EEZ. One mandatory requirement common to all vessels regardless of entering the Great Lakes are any US port is the submission of a report detailing their BWM practices.

The Coast Guard submitted a report to Congress in June 2002, assessing compliance with the national guidelines and establishing the rate of compliance during the first two years of the voluntary program. The report concluded that compliance was so low that the data could not be used to extrapolate conclusions about industry activities as a whole. Therefore, the Coast Guard is promulgating regulations to address these issues.

The Coast Guard proposed a rulemaking in 2003, to establish penalty provisions for vessels bound to US ports that fail to submit a ballast water reporting form and for vessels bound for the Great Lakes or portions of the Hudson River who violate the mandatory BWM requirements. This regulation was promulgated in 2004. The Coast Guard also proposed another rulemaking in 2003, converting the national voluntary guidelines into a mandatory national BWM program. NISA requires that this mandatory regime be based on the previously established voluntary guidelines and that exemptions for safety concerns be included. This regulation was established in 2004. With the establishment of these two regulations, we have put together an enforcement and compliance program to ensure that vessels comply with these and future regulations.

Since early 2001, the Coast Guard has been working on a regulatory standard for the discharge of ballast water. We have begun the process with an analysis of the environmental impacts of several alternative ballast water discharge standards as required by the National Environmental Policy Act.

These regulations address very complex issues, so to assist the Coast Guard in their development, we are working in conjunction with several other Federal agencies to assist us with the analysis of environmental and economic effects of the regulations themselves as well as to address any endangered species issues that may arise from the development of these regulations.

It is clear that the continued introduction of nonindigenous aquatic organisms by ships poses a serious threat to the environment, economies and health of all nations. We have made great strides with our regulatory efforts this past year and are optimistic that they and future regulations will bear success.

Identifying Regions at Risk Using Time-series Analysis and Life-cycle Models

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Simple time-series models of the water temperature in locations across Australia (based largely on National Tidal Facility SeaFrame Data) have been developed as part of the on-going improvement of the Australian Ballast Water Decision Support System. The forecast time series is used to simulate the daily temperature stress on an organism introduced into each of these locations. When coupled with species-specific life-cycle models incorporating temperature tolerance information, these models allow a biologically "realistic" estimate of the probability that the species is able to complete its lifecycle (i.e., survive) in the new location. An invading organism must negotiate a number of abiotic (e.g., temperature, salinity, habitat) and biotic (e.g., predation, competition, disease) barriers in order to complete its life-cycle in a new environment. The probability that its temperature and/or salinity tolerances will not be exceeded is only one of a number of factors that reduce its chances in the new environment, and hence these models represent the maximum probability that the organism will complete its life cycle in the new locality. Nonetheless this approach provides demonstrable risk reductions over previous simpler approaches to this problem, and form an important new component of the ballast-water risk assessment recently implemented for domestic (i.e., regional) vessel traffic in Australian coastal waters. The models are able to account for and delineate variability and model uncertainty. Furthermore, regression analysis of the probability of survival and latitude highlights a number of interesting regional relationships and allows the probability of survival to be assessed for physically similar locations without specific data.

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Risk-based Decision-making and Optimization in Ballast Water Policy Development

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Invasive species continue to threaten coastal and inland waterways in many global regions, motivating policy action at the international, national, and local level. Ballast water introductions are a major focus of these policy efforts. Many different policies have been proposed with the current policies relying on ballast water exchange as the status quo action for ballast water treatment. At the international level, the recently adopted IMO Ballast Water Convention, when in force, will, in large part, require the attainment of ballast water concentration-based discharge performance standards between 2009 and 2021. The current research will direct significant attention toward examining which trade routes and vessel types present the greatest risk of introducing non-indigenous species; which suite of technologies will need to be employed on a particular vessel type that follows a specific route to reduce the concentration of organisms prior to discharge to a level that is below the specified discharge standard; the least cost solution for that vessel to come into compliance with the standard; and the cost-effectiveness of meeting the present standard and/or alternative standard(s).

The use of linear (and nonlinear) programming to explore tradeoffs between cost and benefits of new technology and to derive optima has a long history of use in energy-related sectors. More recently, Winebrake, Corbett and their collaborators have used it to derive optimal air pollution reductions from Passenger Ferries. We propose the use of a mixed integer, nonlinear programming model to evaluate the potential for technology-policy alternatives to mitigate introductions of organisms. In particular, the model will permit explicit evaluation of potential reductions, costs, and cost-effectiveness of different combinations of technologies and policy approaches to identify a set of candidate technology policies that may achieve environmental policy goals at least cost. Policies that could be evaluated include: no regulation, ballast water exchange, IMO convention concentration limits, more stringent concentration limits, quantity limits, and market-based mechanisms.

At present, we have begun to evaluate cost minimization and the risk of introduction based on several factors, including vessel type, voyage duration, port type/ecosystem (salinity, temperature), treatment-method effectiveness, treatment costs (capital and O&M), tank size, and volume of ballast water discharged. The presentation will include a formal presentation of the nonlinear programming model.

NOTES

From State Senator Sikkema to Congresswoman Miller: Shipping's Response to Ballast Water Initiatives in the Great Lakes

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Fednav is the major ocean carrier trading into the Great Lakes, representing some 50% of the tolls paid by ocean vessels transiting the St. Lawrence Seaway. As such, it has both acknowledged the ANS problem, and been at the forefront of efforts aimed at finding workable solutions.

Fednav's position has been and remains that the relationship between ballast water and aquatic nuisance species can only be dealt with effectively by national, indeed international, regulation; and local initiatives, such as what we are witnessing in the Great Lakes, while laudable, only distract the key players from what should be their focus.

At the 11th International Conference, I addressed how the ocean shipping industry in the Great Lakes had responded to Senator Sikkema's initiative in Michigan, which culminated in the passage into law of *Michigan Public Act 114 of 2001.*

That Act resulted in three significant developments:

(a) the incorporation into Michigan law, and, as a practical matter, throughout the Great Lakes, of The Shipping Federation of Canada's ballast water management practices for ocean vessels transiting the Seaway;

(b) the adoption by the two Seaway corporations of the requirement that ocean vessels transiting the Seaway confirm their adherence to these management practices; and

(c) Fednav installed on its vessel, the *M. V. Federal Yukon*, two biocide treatment systems, which were tested by the Michigan Department of Environmental Quality, and the results reviewed by the Michigan Environmental Science Board with inconclusive results.

Following the adoption of the Michigan law, but unrelated to that law, has been the examination of ballast tanks in a number of NOBOB vessels entering the Great Lakes. A NOBOB vessel is one with no ballast on board and, hence, exempted from the requirement of having the salinity level of its ballast verified to ensure that the vessel has conducted a deep sea ballast exchange prior to entering the Seaway.

Senator Sikkema's initiative gave rise to similar legislative initiatives in other Great Lakes states, none of which has, so far, advanced to become law other than in New York State where the New York State Invasive Species Task Force was established.

In addition to state initiatives, the International Joint Commission, a binational body established in 1909 pursuant to the Boundary Waters Treaty between Canada and the United States, is actively lobbying for a reference from both countries to examine the relationship between aquatic nuisance species and ballast water in the Great Lakes.

Evidence that the relationship between ballast water and ANS is poorly understood among certain politicians can be found in Congresswoman Candice Miller's (R.MI.) Bill H. R. 3122 introduced in the fall of 2003, an amended version of which she took aggressive, albeit ultimately unsuccessful, efforts to have tacked on to the US Coast Guard appropriation bill in November, 2003.

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Integrating Science in Ballast Water Management

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Ballast water exchange at sea is used to reduce and minimize introductions into coastal areas. In many regions, coastal traffic is exempt from ballast exchange and may be responsible for dispersing non-native organisms from local regions of invasion throughout the coast. In northeastern North America, coastal vessels travel between Cape Hatteras and northern reaches of Atlantic Canada creating complicated compliance issues that may or may not provide optimal protection.

A regional effort is underway to work with industry, regulators, policy makers, and scientists to promote ballast water exchange by coastwise vessels. A workshop was held to provide information on physical and biological oceanographic data, vessel traffic, industry practices for ballast exchange, and current policies and regulations. Using criteria developed by the workshop participants, data from oceanographic studies have identified areas where ballast water exchange is less likely to result in onshore currents thus, minimizing the potential for introductions. Three regions, the Gulf of Maine, the Laurentian Channel, and the productive Georges Bank areas have unique political, industry limitations, and oceanographic issues that will require further exploration of how best to proceed. Recommendations for proposed exchange areas and practices have been reviewed by industry, regulators and policy makers based on the available scientific data. A proposal that includes proposed best management practices for industry and a regional policy has been drafted, however, a new deep water invasion has modified the recommendations.

Within a few months of the initial draft of the recommendations, a highly invasive ascidian, *Didemnum* cf. *lahillei*, has been found in the productive fishing area of Georges Bank. This is one of the first documented invasions in an area near the continental shelf and has implications for the proposed ballast water exchange policies and management practices. This presentation will review the findings of the workshop participants and the recommendations of the proposed ballast water exchange areas for coastal traffic.

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Development of the Australian Port Monitoring Framework

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Australia has performed a series of baseline surveys in recent years to assess the spread and impact of introduced marine pests on Australian ports. While these surveys provided critical information used in the development of the policy response, the cost of these surveys meant that it was not possible to repeat them with the frequency required for ongoing management.

This presentation will describe the ongoing monitoring system that is being implemented and the scientific basis behind it. It will discuss the different information needs for biodiversity data, early warning of incursions, the monitoring of pest establishment and the management of translocations. It will then discuss the system that is being implemented.

NOTES

The Recent and Rapid Spread of Zebra Mussels in England: Causes and Industrial Consequences

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Although zebra mussels have been present in England since the 1820s, we provide evidence that the distribution and abundance of the species has increased remarkably in the last five years. Seven out of 23 major water companies in England have reported increases in their regions, as have the Environment agency, regional river authorities, angling clubs and boatyards. This paper reviews the possible causes of this rapid spread, highlighting similarities to the current spread of zebra mussels in Ireland.

The spread has been accompanied by many new reports of industrial biofouling. Questionnaires and manual surveys have revealed that 24 water-treatment works in England have experienced increasing problems with zebra mussels during the last 5 years. Hundreds of tonnes of mussels are being removed each year from raw water intakes, pipelines and reservoirs. Problems have been exacerbated by the cessation of intake pre-chlorination during the early 1990s following strict trihalomethane limitations imposed in the 1989 Water Act. We present a number of industrial case studies and review the control strategies that are being considered in current and future English water supply schemes.

NOTES

Exotic Cooling Water Fouling Organisms in The Netherlands with Emphasis on Heat Treatment of the Japanese Oyster *Crassostera gigas*

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In recent years, many exotic species have successfully invaded the Dutch coastal water, brackish water and freshwater. Origin is two-fold: first the un-intentional routing by ships (hulls and ballast water), new routes (canals) in Europe, holiday traveling and secondly the intentional route by releases from aquaria, breeders and nurseries.

The exotic species specifically important for cooling water systems of The Netherlands as fouling organisms are: the Mediterranean mussel *Mytilus galloprovincialis*; the oyster *Crassostera gigas*; the barnacles *Elminius modestus* and *Balanus improvisus*; the brackish water mussel *Mytilopsis leucophaeata*; the Asiatic clam's *Corbicula fluminea* and *C. fluminalis*; the tubeworm *Ficopomatus enigmaticus*; the Chinese mitten crab *Eriocheir sinensis*. All listed species will be shortly introduced and discussed directed to their fouling problem contribution.

The main emphasis is on the Japanese oyster, which is causing serious problems in power stations using thermal treatment for regular cleaning of the intake systems from mussels. The common target temperature is 40°C for at least 30 minutes. The water authorities do not allow higher temperatures beyond 40°C. However, *C. gigas* can withstand this temperature – time combination without any problem. The results of the present experiments for *C. gigas* will be presented within the scope of the now existing heat treatment data for different oyster species and other fouling organisms.

NOTES

Can Biology Control Brackish Mussel (*Mytilopsis leucophaeata*) Fouling in Industrial Cooling Water Systems?

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Mytilopsis leucophaeata, the Brackish Water Mussel, is a typical estuarine species, and thus resistant to a wide range of intermediate salinities although the species can't survive in full sea water. In 1835, it was first detected in Europe, in the harbour of Antwerp, in the dock used to repair ships. At that time it was presumed that the dispersal occurred through these vessels. The species originates from the Atlantic coast of North America from Hudson Bay, Canada to Tampico, Mexico. After a period where no observation of *M. leucophaeata* in Europe occurred, currently, the species is found along the coast of the North Sea from Germany into France and recently in Great-Britain. Again, ballast water was assumed to be the dispersal force, as ballast water discharges from ships have been identified as a major vector in the transfer of nuisance aquatic species from one area of the world to another. The fact that the species was not detected in Belgian waters over more than 50 years does not mean that *M. leucophaeata* abandoned the European coast. Because of the resemblance with the closely related *Dreissena polymorpha*, the zebra mussel, species-confusion aroused. When *M. leucophaeata* became an economic problem in the 1990s, attention was brought back to this relative unknown species.

Cooling water plants of large industrial sites use huge amounts of water to cool the electric power stations. Such volumes are unable to realize with pre-treated water, so often water from nearby seas and streams is used. Any surface exposed to untreated water provides an opportunity for the settlement and subsequent growth of organisms: bio-fouling. Worldwide, mussels cause serious problems in cooling water conduits. Because of the great economical damage, caused by these fouling-organisms, the search for efficient control measures has been going on for a long time.

The biology and possible control methods of the famous fouling species zebra mussel *D. polymorpha* are well examined throughout the years. Brackish water species, on the other hand, are far more resistant to environmental changes, which makes them particularly robust fouling species. These qualities and the characteristics of the water itself diminish the use of anti-fouling treatments, which limits the number of possible solutions. The most effective and less costly control measure is still the use of chlorine-holding biocides. To use these detrimental chemicals properly, knowledge of the lifecycle of these organisms is indispensable and monitoring is necessary.

Using the Scheldt water as cooling water, a lot of companies in the harbour of Antwerp have problems with *M. leucophaeata*. The problems and possible solutions are examined at the site of BASF, Antwerp.

A model, integrating all results of the study, will allow to 1) considerately dose biocides, dependent on the expected recruitment success; and 2) if possible, reduce the recruitment success of *M. leucophaeata* by manipulation of the relevant environmental factors of the incoming cooling water.

NOTES

Progress in the Biological Control of Zebra Mussels: Results of Laboratory and Power Plant Tests

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Strain CL0145A is a North American isolate of *Pseudomonas fluorescens* – a ubiquitous, soil-water, Gram-negative rhizobacterium. A patent for the use of this naturally occurring strain for *Dreissena* control has been issued. Zebra mussels (both *D. polymorpha* and *D. bugensis*) do not die as a result of infection, but rather from intoxication due to a natural product present within the cells. Nontarget safety data have indicated that the bacterium is a highly selective control agent. The laboratory and power plant tests reported herein further demonstrate the promise of this bacterium as a potentially useful zebra mussel control agent.

Laboratory tests were conducted to determine the most effective method of treating zebra mussels with a defined mass of inoculum under warm (ca. 23°C) and cold (ca. 13°C) water conditions. The specific question addressed at each temperature was whether higher mortality could be achieved by exposing mussels to lower concentrations of inoculum over a longer period of time *versus* higher concentrations over a shorter time period. The results of the warm water tests suggested that as long as the total quantity of bacteria applied during the entire treatment period was the same, similar mussel mortality would be achieved in treatments lasting 1.5 hr to 12.0 hr. It was noteworthy that 1.5-hr treatments in the warm water tests consistently achieved >90% mussel kill as no other zebra mussel control method has been reported that can achieve such high kill following such a single, short treatment period. The results of the cold water tests suggested that when treating with a defined mass of bacteria, higher mortality will most likely be achieved by treating for 3 to 12 hr (*versus* 1.5 hr). These warm and cold water tests also indicated that the total percentage of mussel mortality achieved in future power plant trials should be the same at 13°C and 23°C. Thus, in contrast to some currently used commercialized chemical molluscicides such as chlorine, this bacterial control agent is unusual in that it does not lose its effectiveness when waters decline to 13°C. This is significant because the development of a zebra mussel control method that is equally efficacious in such a wide range of temperatures broadens its usefulness as a potential commercial product.

Once-through, 6-hr treatments conducted within a power plant in artificial acrylic pipes (5.7 cm diameter) demonstrated that high mussel kill could be achieved along the entire pipe length. Two tests (each with 3 replicate pipes) were carried out during the summer of 2003. The initial test was conducted at ca. 141 ppm using 26°C service water in pipes of 8.6 m length and achieved a mean (±SD) kill of 96.0 (±1.7)% and 95.7 (±2.5)%, respectively, at the beginning and end of the pipes (upstream control mortality = 6.7 (±3.2)%). The second test was conducted at ca. 116 ppm using 23°C service water in pipes of 17.1 m length and achieved a mean (±SD) kill of 97.0 (±1.0)% and 97.0 (±2.7)%, respectively, at the beginning and end of the pipes (upstream control mortality = 3.7 (±0.6)%). The significance of these encouraging pipe test results in relation to the overall goal of the commercialization of strain CL0145A of *P. fluorescens* as a zebra mussel control agent will be discussed.

NOTES

New Antifouling Technique by Combined Carbon Dioxide and Sodium Hypochlorite Dosing

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At present, more than 90% of the Dutch industries are using sodium hypochlorite as anti-fouling agent to combat macrofouling in cooling water systems. However, water authorities are imposing the industry to look for alternatives and/or to reduce the application of chlorine to a minimum in order to reduce the environmental impact.

This project is a follow up of recent studies carried out for the Dutch E-sector. The main goal is to reduce the amount of chlorine in combination with carbon dioxide to achieve optimal antifouling results. Main conclusions of all different studies are:

- A carbon dioxide dosing highly increases the effect of chlorination due to primary muscle relaxation followed secondary muscle stiffening which is caused by the carbon dioxide only and not by induced pH change.
- From the large-scale field experiments in 2003 at Maasvlakte power station, it can be concluded that a continuous carbon dioxide dosing (pH 5.3) and low-level sodium hypochlorite (0.5 mg Cl_2/L TRO) results in 100% mortality of *Mytilus edulis* within six days of exposure. This result was also confirmed by the laboratory studies carried out at the University of Nijmegen. *Mytilus edulis* subjected to only 0.5 mg Cl_2/L TRO at laboratory took 63 days for the 100% mortality. This implies a reduction in hypochlorite by 90% compared to the 63 days, which are necessary for 100% mortality of *Mytilus edulis* with chlorination alone.
- The proposed, although preliminary dosing regime is as follows: 1) start with 4 hours CO_2 dosing at a pH of about 5.3 in front of the condenser to open the mussel shells; 2) followed by a combined continuous 24 hours CO_2 (pH 5.3) and chlorine dosing (TRO 0.5 mg Cl_2/L); 3) a continuous chlorine dosing (TRO 0.5 mg Cl_2/L) for another 5 days to prevent the recovery of already affected mussels.

In 2004 further experiments and studies are planned like testing full scale at a 500Mw unit at Maasvlakte power station, a cost-effectiveness study for the use of purified flue gasses versus commercial available carbon dioxide, health risks for employees, the risk for corrosion and environmental effects in the outlet area.

NOTES

A Microencapsulated BioBullet for the Control of Biofouling Zebra Mussels

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Since the arrival of the zebra mussel to North America in the 1980s, numerous attempts have been made to develop an effective control strategy. However, chlorination remains the only widespread licensed technique. Chlorination is disadvantageous because zebra mussels can 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 toxic THMs and pollutes recipient water bodies.

We have developed a novel, environmentally friendly and highly effective method for controlling zebra mussels: the BioBullet. Our method uses the encapsulation of an active ingredient with a material edible to mussels. Mussels then filter and concentrate our BioBullets without detecting the presence of a toxin. We can engineer our bullets to break-up and lose toxicity within one hour of entering a pipeline, thus eliminating the risk of polluting the wider ecosystem.

Our bullets are cheap to produce and field trials have produced remarkable results. We are confident that our product has utility in controlling zebra mussels and other pest species on a commercial scale.

NOTES

Development of an Efficient Low-cost Sparker Technology for Controlling Zebra Mussels

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Sparkers generate strong pressure pulses using electric discharges between electrodes in water. The pressure pulse can control zebra mussels by preventing the attachment and growth of veligers and by causing detachment of adult mussels to escape the inhospitable environment created by sparker pulses. The use of pressure pulses to control zebra mussels (and for antibiofouling in general) is attractive because it both replaces the use of chemicals and is effective over several hundreds of feet of pipe.

This paper presents recent sparker system developments and field test demonstrations showing that the sparker is a non-toxic, practical and cost effective solution for controlling zebra mussels. The new prototype sparker system employs a parabolic reflector, efficient electrical driver and new electrodes that increase effectiveness and reduce cost. In field tests, a sparker in a wet-well prevented growth of zebra mussels in a water intake pipe on Lake Champlain in New York, USA.

Measurements of the pressure inside the water intake pipe show that the levels are approximately fifty times higher than that of a previous sparker. Also, the field tests provided measurements of the pressure levels needed to prevent growth and for mortality of adult mussels. The paper also will include cost estimates of a commercial sparker for controlling zebra mussels and address application to ballast water control. The work in this paper was funded by the United States Environmental Protection Agency in a Small Business Innovative Research program.

N O T E S

Biofouling Control Strategies in ANAV Nuclear Power Plants

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Since 1987, the Central Nuclear Vandellós, located on the Mediterranean Coast in Catalonia (Spain) has been trying different alternatives for the purpose of controlling the colonization of the refrigeration structures in contact with sea-water. During the last fifteen years, chemical control methods using oxidizing agents have been tested, obtaining results with different efficacy. In 2002, we decided to use two different anti-scaling surface coatings.

The Central Nuclear Ascó has been threatened since 2001 by the presence of the zebra mussel in the River Ebro. The fragile ecosystem in the river has conditioned the adoption of a non-chemical control method. Some thermal shock treatments have been performed in 2003 in the refrigeration water system. The results have been fully satisfying when considering the control of the zebra mussel colonization. Additionally, during 2003, the company has started the monitoring of the presence of larvae in the Intake Bay water column.

The experience of Asociación Nuclear Ascó-Vandellós with different control methods against the colonization of mollusks, autochthons or invasive species, would by useful for thirds.

NOTES

Assessing the First-Order and Second-Order Environmental Impact Effects of the Filter-Feeding Asian Clam, *Corbicula fluminea,* and Omnivorous African Cichlid, *Oreochromis aureus*, Under Various Water Quality Conditions

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The filter-feeding Asian clam, *Corbicula fluminea*, and omnivorous African cichlid, *Oreochromis aureus*, have been established in Florida waters since the 1960s. Where established, both are known to reach great abundance. Both have been shown to feed effectively on small particles such as bacterioplankton attached to detrital particles, phytoplankton, and microzooplankton. As feeding physiology positively correlates with water temperature, it was hypothesized that Florida's subtropical warm waters would lead to both species directly removing significant amounts of planktonic organisms (first-order effect), which would have an important cascading effect on higher trophic level organisms that depend on the availability of plankton for food (second-order effect).

In three month-long experiments in 1420-liter outdoor mesocosms under different water temperatures (depicting summer, winter, spring/fall) the suppression of phytoplankton, rotifer, cladoceran, and copepod biomass through the grazing of *Corbicula* and *Oreochromis* appeared very seasonal in nature. The cool winter water temperatures of north Florida (8°-20°C) enabled *Corbicula* and *Oreochromis* to significantly suppress phytoplankton and microzooplankton (rotifers) biomass, with significant increases also occurring in macrozooplankton grazers (cladocerans and copepods). The physiological stress of elevated summer water temperatures (25°-32°C) brought the cessation of feeding by *Corbicula* as well as widespread mortality to most of the clams. Both nutrient levels and phytoplankton and zooplankton biomass increased in mesocosms containing clams as well. The increases seen were much lower in fish-containing mesocosms, indicating the noticeable role that *Oreochromis* played in grazing these particles. Optimal water temperatures (17°-29°C) for the invasive clam and fish grazers seen during the spring months produced the classical cascading approach where grazers (macrozooplankton, fish, clams,) were essentially able to remove the base of the food chain (phytoplankton, bacterioplankton, microzooplankton).

In controlled 37-liter microcosm experiments, *Corbicula* significantly reduced bacterioplankton, phytoplankton, and rotifer biomass (first-order effect). After seven days under optimal water temperatures (19°C), the filter-feeding clam almost completely (99%) stripped the water column of plankton. As useable food available to larval fathead minnows (*Pimephales promelas*) was absent, significant mortality occurred among the larval fish, presumably due to starvation (second-order effect). The importance of this finding is obvious. Larval fish entrained over areas of abundant invasive mollusk beds and/or in competition with invasive fish for food may experience high mortality due to starvation, as small particles are essentially stripped out of the water column. The ecosystem changes brought about by invasive grazers will be discussed in more detail.

NOTES

Differences in Composition of Macroinvertebrate and Fish Communities with Invasive and Native *Gammarus* spp. (Crustacea: Amphipoda)

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In Irish rivers, the amphipod *Gammarus pulex*, introduced to enhance fish feeding, replaces the native *G. d. celticus* in lowland stretches. Both species are associated with different macroinvertebrate communities, which may in part be due to natural longitudinal physicochemical change. However, this hinders assessment of any direct community impacts of the invasive as compared to the native species. Here, we report on a fortuitous circumstance that allowed us to uncouple fish and macroinvertebrate community effects of *Gammarus* species from environmental effects.

The lowland stretch of the Lissan, an important salmonid nursery stream, is dissected by a weir which has slowed the upstream invasion by *G. pulex*. During late summer 2000 and late winter 2001 we took physicochemical measurements and macroinvertebrate samples from three contiguous 150 m reaches of this stretch with *G. pulex* only, mixed *Gammarus*, and *G. d. celticus* only communities. We also assessed effects of the invasion on the diet and population dynamics of juvenile brown trout, *Salmo trutta*.

We found no biologically significant differences in physicochemistry among the three reaches. Invertebrate densities and biomass in the *G. pulex* reach were significantly higher than the other reaches due to high invader abundance. *G. pulex* numerically dominated its reach, whilst *G. d. celticus* abundance was relatively low in its reach. Diversity and species richness of macroinvertebrate communities were lower in the *G. pulex* than the *G. d. celticus* reach, with the mixed *Gammarus* reach intermediate. Ordination indicated distinctly different associations of invertebrate community samples and taxa that were best explained by the distributions of the *Gammarus* species.

Density and biomass of juvenile trout populations were significantly higher in the invaded reach than in mixed and *G. d. celticus* reaches. In spite of higher densities, loss rates of trout in the invaded reach were lower than in the other reaches. Trout in the invaded reach ingested significantly greater invertebrate biomass than in mixed and *G. d. celticus* reaches, due mainly to high consumption of *G. pulex.*

Although this study shows negative impacts on the macroinvertebrate community, the initial aim of the introduction of *G. pulex*, to supplement fish feeding, may have succeeded. We report on temporal stability of native macroinvertebrate communities after recent surveys (2003) showed continual upstream expansion of *G. pulex* in the Lissan. We also discuss possible mechanisms of impact and implications for freshwater communities, which are increasingly subject to amphipod invasions.

NOTES

The Influence of Eurasian Watermilfoil on Littoral Zone Structure and Function in an Oligotrophic Lake

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Eurasian watermilfoil has invaded thousands of lakes in North America with often the same over-riding consequence – extensive infestation and alteration of the littoral zone. Because of its rapid progression throughout a water body upon introduction, few opportunities have allowed studies on the ecological sequence of trophic change. Milfoil typically appears more frequently in nutrient-rich waters but in 1985 was discovered in Lake George, New York, an oligotrophic lake. An aggressive physical management program has limited its lake-wide spread, thus providing a unique opportunity to study the impact of this invasive species on littoral zone structure and function. In 2003 four sites with well-developed beds were selected for study. Two of the beds in Northwest Bay and Sawmill Bay, are larger and experience greater wave motion than the two smaller and secluded beds in Moonlight Harbor and Paradise Bay. Perimeters of each bed were measured utilizing GPS, thus enabling bed area to be determined. Exacting measurements provide a means of detecting bed fluctuations and encroachment on native plant communities. Submersed aquatic vegetation (SAV) biomass, height, and density were determined for each bed, as well as, the bed transition zone, and the adjacent native plant community. Epiphytes, phytoplankton, and zooplankton were sampled from each location within each site to evaluate the effect of milfoil canopy structure on the littoral zone food web.

Within the beds milfoil dominance was nearly 100% whereas in the adjacent native community 5-6 species were common. Shoot height and density per m^2 were 3 and 4 times those found in the native communities, respectively. Water chemistry results showed that phosphorus and nitrogen concentrations were typically higher within the beds as compared to values in the native plant communities. Chlorophyll values were always 2-4 times higher within the beds than at the edge or within the native communities where chlorophyll levels were equal to values found in pelagic surface waters. Epiphytic algae, in both the beds and native areas, were dominated by Chlorophyta and Chrysophyta. Interestingly, the larger beds, Sawmill Bay and Northwest Bay, were primarily dominated by Chlorophyta, while the smaller, developing beds in Moonlight Harbor and Paradise Bay, consisted primarily of Chrysophyta. This trend was independent of whether the samples were taken in the center, edge, or outside the bed. Phytoplankton data also implied a trend consistent with the size of the beds. In the smaller beds, Moonlight Harbor and Paradise Bay, a greater biomass per volume of phytoplankton were found outside the milfoil beds while the greater biomass in the larger beds of Northwest Bay and Sawmill Bay were found in the center of the beds. With the exception of Sawmill Bay, the dominant groups of phytoplankton in the native areas were not dominant groups in the center or edge of the beds. Zooplankton data has been collected but is still under analysis. This study has shown the magnitude of impact of the immediate surrounding waters, the potential for nutrient pumping by milfoil, and its subsequent influence on other components of the littoral food web.

N O T E S

Golden Apple Snail, *Pomacea canaliculata* (Lamarck): An Alien Invasive Species, its Environmental and Economic Impact Assessment in Asia and Lessons Learned in the Philippines

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In recent years, the golden apple snail (GAS), *Pomacea canaliculata* (Lamarck), is getting more attention due to its rapid and new invasions in Asia and North America. GAS is native to South America, but has a high degree of plasticity and has polyphagous feeding habits. At present, the Global Invasive Species Programme lists GAS in the "100 of the World's Worst Invasive Alien Species". This presentation summarizes the mosaic and magnitude of problems brought about by this freshwater mollusc in non-native countries highlighting extensive economic, social, and environmental damages; aside from the negative impacts on local biological diversity, and health hazards to rice farming communities. Important issues for managing this aquatic agricultural pest are addressed by international collaboration of countries, which either experienced or are currently facing its invasion through the development of a global scientific information database in CD-ROM. This is to raise large-scale awareness, foster the information transfer between countries, researchers, policy makers, organizations and society, to monitor new invasions and manage them from the ecosystem context. The lessons learnt in this process will be shared and future directions of this non-profit initiative will be highlighted.

N O T E S

Channeled Applesnail: Current US Distribution and Potential Threat to Coastal Ecosystems and Agriculture

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South American channeled applesnail (*Pomacea canaliculata*) is a large (> 100 mm) gastropod that feeds heavily on both aquatic and terrestrial macrophytes, with additional depredations documented on native mollusks. It has been introduced at locations throughout the Indo-Pacific Region where it has become a major threat to crops. The species has also been introduced at several sites in the US It has become established at sites in Florida and Southern California, but not in agricultural areas. However, there have been recent indications of apparent ecological problems associated with populations in Florida.

Channeled applesnail first became a subject of agricultural concern in July 2000 when reproducing populations were discovered in a rice irrigation canal and adjacent bayous between Houston and Galveston in southeastern Texas. Surveys conducted in late 2000 and early 2001 documented this snail at over a dozen locations in Harris, Galveston, and Brazoria counties in southeastern Texas and one location in Tarrant County in northern Texas near Fort Worth. In June 2001, Tropical Storm Allison flooded much of southeastern Texas and dispersed channeled applesnails even more widely. By mid-2002, rice farmers in Galveston and Brazoria counties reported these snails entering rice fields, but without noting crop damage. In late 2002, channeled applesnail spread westward into Fort Bend County. In 2003, large populations were noted in southern Waller County and in eastern Galveston County. In 2004, still others were discovered in Chambers County.

Because of the massive agricultural damage to crops in the Indo-Pacific, including Hawaii, the US Department of Agriculture (USDA) has been especially concerned about the presence of channeled applesnail in the Texas rice belt that supports a billion dollar industry annually. USDA subsequently initiated preparation a risk analysis of the species and legal restriction of the entire family (except of spiketop applesnail, *P. bridgesi*). Similarly, because of the potential environmental damage associated with this species, Texas Parks and Wildlife Department added channeled applesnail to its list of legally-prohibited harmful and potentially harmful exotic shellfishes in April 2001. Efforts to examine ecological impacts in coastal marshes were initiated in late 2003.

NOTES

Ecosystem-level Impacts of Zebra Mussels in Lake Winnebago, Wisconsin

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The response of the fish community in Lake Winnebago, Wisconsin to the expansion of zebra mussels has been investigated over the past several years. More recently, studies have been initiated to evaluate impacts of zebra mussels to water quality, invertebrates, aquatic food web structure, and ultimately to population dynamics of important fish species. Baseline fisheries data have been collected during the last 25 years using trawling sufficient to detect small changes in the prey base and different trophic guilds. Zebra mussel densities and size distributions have been measured since early in the infestation. Water quality, invertebrate, and food web studies were also initiated before infestation by zebra mussels.

To date, zebra mussels have been increasing an order of magnitude yearly during the last three years. So far, impacts to the fish community have been negligible and water quality and invertebrate densities remain essentially unchanged. However, as zebra mussel densities continue to increase, substantial changes are possible. Statistical, as well as energy/mass balance-flow models such as Ecopath and Ecosym, will be employed to improve understanding of how zebra mussels affect aquatic communities and to compare energy pathways with similarly infested systems such as Green Bay, Bay of Quinte, and Oneida Lake. Taken together, these actions should improve risk assessment and our understanding of ecosystem-level impacts of zebra mussels.

NOTES

Effects of Zebra Mussels on Habitat Use and Foraging Success of Juvenile Lake Sturgeon (*Acipenser fluvescens*): Implications for Reintroduction Efforts

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Juvenile lake sturgeon (*Acipenser fluvescens*) forage in benthic soft sediments using their barbels to locate prey. Zebra mussels can thickly blanket soft sediment habitats potentially impacting the foraging success of juvenile sturgeon. Previous experiments have demonstrated that a number of fish species have reduced ability to consume infaunal prey in the presence of zebra mussels. To measure the potential impact of zebra mussels on juvenile sturgeons we established laboratory foraging trials without mussels, with low density mussels, or with high density mussels. We used burrowing (*Chironomus*), crawling (isopods), and swimming (amphipods) prey species in separate replicated trials. Number of prey consumed in a fixed period of time was used as a measure of sturgeon foraging success. The sturgeon consumed fewer prey items in either zebra mussel treatments than on bare sand. In addition we evaluated habitat preference of juvenile sturgeon by placing them in mesocosms with equal areas of bare sand, zebra mussels, and loose gravel. The gravel pieces spanned a similar size range as the zebra mussels. The habitat type occupied by the sturgeon was recorded at regular intervals. In sharp contrast to all other species we have evaluated using this protocol, sturgeon spent most of their time on bare sand. Lake sturgeon are endangered in Lake Champlain and threatened through most of their range in North America. Our results have implications for restocking efforts particularly in waters infested with zebra mussels.

N O T E S

The Impact of the Zebra Mussel Invasion on Phytoplankton, Zooplankton and Benthic Macroinvertebrate Communities in a Large Irish lake

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Dreissena polymorpha is a recent introduction to the Irish fauna. Research into the zebra mussel invasion of the Erne lakes and resulting ecological impact began in June 1998. Data will be presented on the zebra mussel invasion and the subsequent changes in phytoplankton, zooplankton and benthic macroinvertebrate communities and how these alterations of the food web may be driving changes in the fish population.

The Department of Agriculture and Rural Development (DARDNI) has been carrying out research on the Erne lakes since 1973. Data collected during the present study and by DARDNI on phytoplankton and zooplankton abundance and community composition was used to compare pre and post invasion communities. A series of dredge surveys covering the range of substrates in the Erne system was carried out every six months from June 1998 and spatial and temporal trends in the density and biomass of zebra mussel and *Anodonta* sp. populations were documented. Post invasion benthic macroinvertebrate communities were also investigated using grab surveys and kick sampling.

After becoming established in Lower Lough Erne in 1996, zebra mussels colonised the whole Erne system, including some inflowing rivers, within three years. Zebra mussel density and biomass have continued to increase. The total population in the Erne lakes in 2003 was estimated as 2.3×10^{10} mussels (4152 tonnes). The filtering capacity of the population was estimated using filtering rates from the literature. Zebra mussels are capable of filtering Upper Lough Erne every 2.35 days and Lower Lough Erne every 16 days. This level of planktivory makes them strong resource competitors with unionids, larval and some older fish.

A comparison of phytoplankton abundance and community composition before and after the zebra mussel invasion revealed a large decrease in chlorophyll *a* concentration. However there was little change in phytoplankton community composition with all taxonomic groups decreasing in abundance. The impact on the zooplankton population followed the same pattern, with a large decrease in zooplankton density, but little change in community composition. Changes among rotifer, copepod and cladoceran populations will be discussed. Colonisation of the unionid population by zebra mussels was rapid and there was a decline in unionid density, biomass and condition. Few live *Anodonta* sp. are now found in the Erne lakes. Implications of these food web changes for fish populations will be discussed.

N O T E S

Good, Bad, Ugly or Just the Latest Addition to the Fauna? Changes in the Fish Population of Lower Lough Erne, Ireland, Following Invasion and Effective Water Column De-trophication by Zebra Mussels

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Lower Lough Erne has a simple fish community structure. This is typical of Irish lakes and is due to island isolation and postglacial colonisation resulting in the presence only of species either adapted from species with a marine capability or introduced by man. Since the 1970s, the fish biomass has been dominated by roach *Rutilus rutilus* and European perch *Perca fluviatilis*. Other major species inlcude pike *Esox lucius*, bream *Abramis brama*, trout *Salmo trutta* and eels *Anguilla anguilla*, and the threatened pollan *Coregonus autumnalis*. Of this fish fauna of Lower Lough Erne, only eels, trout and pollan are considered to be native since the last glaciation.

Before the introduction of zebra mussels *Dreissena polymorpha* circa 1996, lower Lough Erne behaved as a eutrophic lake, with regular summer algal blooms, reduced water clarity, and roach forming up to 65% of the total fish biomass. Zebra mussels were introduced in 1996 and had reached significant population levels by 1999, severely grazing algal populations. Since then, recruitment of perch relative to roach has increased dramatically and should this continue perch will soon replace roach as the dominant fish species. The fish populations would therefore appear to be responding to the zebra mussel invasion as if to an effective reduction of trophic status brought about by grazing of plankton by zebra mussels.

Data will be presented on fish population structure in terms of numbers and biomass, based on a time series of multi-mesh gillnet surveys conducted pre- and post-zebra mussel invasion. These data will be discussed in relation to wider issues including eutrophication, preservation of indigenous biodiversity, and human use of aquatic resources.

N O T E S

The Invasion of Eurasian Watermilfoil (*Myriophyllum spicatum*) and Curlyleaf Pondweed *(Potamogeton crispus)* in Lake Tahoe: The Risks of Benign Neglect

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Lake Tahoe is the second deepest lake in the United States (505 ml) and has achieved international recognition for its unique bathymetic features and water clarity. While most research has been focused on understanding the reasons for the steady loss of clarity over the past 40 years, non-native invasive aquatic macrophytes such as *Myriophyllum spicatum* have also been steadily spreading over the past ten years. In September 2003, *Potamogeton crispus*, another invasive macrophyte was discovered for the first time in ten years of surveying. Both species were probably introduced via watercraft since the main populations of *M. spicactum* (ca. 60 ha) and the incipient populations of *P. crispus* occur at the largest boat marina at the south end of the lake. During summer months, thousands of small and large motor-boats and sailboat and personal watercraft ("jet skis") are trailored into and out of the lake. Both species of aquatic plants are found in many Sierra foothill and valley water bodies (including the Sacramento- San Joaquin Delta), and transit time to reach Lake Tahoe is only one to three hours. In spite of warnings to regulatory agencies and stakeholders regarding these invasive plants, neither California nor Nevada (both two states having legal boundaries on Lake Tahoe) has initiated any form of inspections, attempts to manage or decrease continued introductions into the lake. Apparent conflicts in California state water quality regulations have also stopped any proposed uses of selective herbicides to reduce the spread of *M. spicatum*. The refusal to acknowledge the threat to the littoral ecosystem from invasive plants, coupled with a lack of action, has resulted in continued introduction and dispersal of two of the most pernicious submersed aquatic weeds in the US.

NOTES

Study on Invasive Alien Species in North Tipperary

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A five-year Heritage Plan has been developed for North Tipperary, one of thirty-two administrative districts in the Republic of Ireland. Actions prioritized in the County Heritage Plan include the collection of baseline data on the extent of invasive alien species in the county and the identification of strategies for reducing their spread in wild habitats. Arising from this is a commissioned study on the history, current extent and future implications of alien species in North Tipperary.

The county has a range of habitats vulnerable to degradation by alien colonisation, including freshwater habitats, upland blanket bog, native woodland, and grasslands. Historically, an alien mammal, American muskrat, was the subject of a successful extermination campaign in the early 20th century. A recent invader, the zebra mussel, is poised to expand its range and has consequences for biodiversity and requires varied measures for management. Invasive water plants *Crassula helmsii, Hydrocotyle ranunculoides* and *Azolla filiculoides* are all sold from horticultural outlets in the county and these have the capability of becoming established in the wild. These are recognized problem species in the UK; elsewhere in Ireland *Azolla* is well established in the Barrow River system and there are recent records from Tipperary. Both *Azolla* and *Crassula* are extending their ranges in the wild in Northern Ireland. *Crassula*, although not recorded yet in the wild in Tipperary, is proving to be vigorous and persistent in ornamental ponds.

The Heritage project has two components, a desk study of the existing literature, and a limited field study of the effects of a sub-sample of species on local biodiversity, from this information actions will be developed which will include dissemination via the many public groups including schools.

NOTES

Proactive Assessment of Invasion Potential in the United States for European Freshwater Aquaculture and Aquarium trade Fishes

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Invasive species pose both a biological and an economic risk to US ecosystems. Unfortunately, once such species become established, they are almost impossible to eradicate, except in unusual circumstances (e.g., northern snakehead release in Maryland). Methods for proactively anticipating the threat of invasive species on a continental scale can help focus management activities and limit biological and economic impacts. In this contribution, I use ecological niche modeling to predict invasive potential into North America for 32 species of European/Eurasian freshwater fishes either currently, or proposed to be, in aquaculture and/or aquarium trade.

NOTES

Using Predictive Habitat Modeling to Design Surveillance for Marine Pests

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Eradication and control of non-indigenous species are often only possible if an incursion is detected early. Active surveillance monitoring for known pests can be used to facilitate early detection and eradication, but needs to be targeted efficiently so that sampling effort is directed toward sites and habitats where there is the greatest risk of incursion. Marine environments present particular logistical challenges for early detection, since sample collection is often expensive. We reasoned that the most likely place for an incursion to be found is in suitable habitat within the dispersal range of founding individuals. Here, I describe the development and use of predictive habitat distribution and dispersion plume models as tools for identifying these areas and prioritising the allocation of sampling effort for early detection.

I compared the performance of qualitative (expert derived) and quantitative (data derived) distribution models for two established (*Theora lubrica* and *Musculista senhousia*) and two prospective (*Sabella spallanzanii* and *Asterias amurensis*) marine invaders in New Zealand. Spatial Habitat Suitability Index (HSI) models were constructed for each harbour and species using published literature and expert review. The models were developed by combining ranked suitability indices for four environmental variables that are known to be important correlates of species distributions in estuarine environments: water depth, substratum type, vegetation cover, and salinity. The composite score (the habitat suitability index, HSI) was then mapped onto a grid of the environmental variables as a surrogate of habitat suitability. To test the HSI predictions, we used predictive statistical modelling techniques to compare the performance of the habitat suitability indices and the environmental data set as predictors of the distribution and abundance of *Theora* and *Musculista* in an independent data set. The simple, qualitative HSI models provided useful predictors of the distribution and abundance of the established pests and performed as well as quantitative predictors. Performance of the models was further enhanced when simulated patterns of dispersion of particles from nearby ports was incorporated as predictor variables. I show how these relatively simple techniques can be applied to the design of early detection surveys.

NOTES

Current Use and Future Potential of Genetic Probes in Marine Invasion Science and Management

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"Out of sight, out of mind" is an adage that goes some way to explaining the slow development of marine invasion science and management compared to its terrestrial counterparts. Many marine species are transported through the world's oceans at sizes that render them invisible to the naked eye and at developmental stages that make them indistinguishable from their native counterparts even under the microscope. While we have known that their DNA differs, this has been of little value, because genetic approaches were practically limited to identifying individual specimens in a research laboratory environment. Advances in genetic technology are removing these practical limitations and offer us a new way to look at the marine environment. In particular, nested PCR provides a way to differentiate target species from mixed biological samples (biofouling and ballast water) and in this paper we describe the development of genetic probes for three marine invasive species of concern to Australia and the application of nested PCR to samples from biofouling, ballast water and environmental samples. We conclude by looking at the further development of these genetic technologies to support marine invasion science and management and recommend that a collaborative international approach will be required if scientists and managers are to reap the rewards of these genetic technologies.

NOTES

Efficacy of a Starch-based Reagent as a Proactive Control for Mussels (*Dreissena* spp.) and Other Molluscs

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The potential for a starch-based reagent to control planktonic mussels (*Dreissena* spp.) was tested in a small scale, flow through test stand in late 2002. An Entergy power plant on the lower Mississippi River in the State of Louisiana was used as the study site. The plant's service water system was tapped to provide a source of mussels (D- and umbonal form) and a continuous flow of raw river water to treatment and control test tanks. The discharge from the tanks was returned to the plant system. Reagent was injected into the treatment stream at dose rates ranging from about 4 mg/L to <20mg/L. The potential for the starch reagent to cause environmental impact are considered limited based on pre-study, independent laboratory toxicity tests on Ceriodaphnia and fathead minnow. The LD_{50} for these organisms was, respectively, 99,000 and 59,000 mg/L in these toxicity tests. Also, whole effluent toxicity tests of the plant discharge water during the study indicted there was no effect on representative organisms. The reagent-vendor produced the product by mixing water and food-grade starch and activating it by exposing the mixture to a non-chemical, proprietary technology. The cost of production was reported to be relatively inexpensive; a mortality rate of 100% was observed in 96 hours or less in the planktonic mussels treated with the activated starch.

A continuation of the starch-based reagent study, on a larger scale is scheduled for the late winter and spring of 2004 at the same site. The mortality rate in planktonic zebra mussels will be confirmed, though the primary goal will be to evaluate the effect on settlement stage mussels by determining the reduction in fouling rate. Possible effects on the planktonic and/or adult Asiatic clam (*Corbicula fluminea*) will also be evaluated.

Results of the 2004 study will be presented. Funding for the 2004 study is to be from the Electric Power Research Institute (EPRI) and Entergy.

NOTES

Water Treatment with Chlorine Dioxide as an Efficient Antifouling Technique

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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 of the last century, two major incidents forced the industry to look for alternative methods: 1) invasion of zebra mussels into lakes and rivers in North America causing problems with fast growing mussel layers in piping and heat exchangers and 2) the increasing sensibility concerning ecological problems caused by chlorination by-products.

Chlorine dioxide was found as an efficient oxidizing biocide with lots of advantages over commonly used chlorine. There are various studies showing its excellent activity as a molluscide as well.

Due to its specific chemistry, chlorine dioxide reacts only as an oxidant, for that reason no chlorination of organics in water will appear. This is an important feature to avoid high values of undesired compounds such as trihalomethanes and other AOX. Unlike chlorine, chlorine dioxide doesn't react with ammonia. For that reason consumption of the disinfectant caused by high ammonia concentration and unpleasant odour of chloramine will not appear.

Chlorine dioxide's independence from water's pH-value is caused by its solubility as an undissociated gas. In particular river water can have extremely changing pH-values depending on origin, season and pollution. Many rivers show natural conditions up to pH 9.5. Under these conditions chlorine is inactive, whereas chlorine dioxide acts without loss of disinfection capacity. The same situation has to be regarded in sea water applications as well as in cooling water circulations, where high pH-values are desired to avoid corrosion.

Two major factors are responsible for an approximate 4-fold increase in activity of chlorine dioxide compared to chlorine. On the one hand we need lower concentrations due to its independence from pH. On the other hand chlorine dioxide is able to penetrate membranes of bacteria and other microorganism by diffusion; thereby damaging the organisms immediately without destroying cell membranes as a first step. For that reason chlorine dioxide is, beside ozone and hydrogen peroxide, the only disinfectant able to destroy and remove biofilms in piping and tanks.

Chlorine dioxide has a much longer half-life than other strong disinfectants such as ozone. Its depot action lasts for days instead for hours at chlorine or minutes at ozone. For that reason chlorine dioxide is particularly recommended for microbiological protection of tank systems and widespread piping.

Two examples are presented for treatment of clear seawater and extremely dirty river water:

1) the power plant ENEL near Rome (Italy) uses water directly out of Mediterranean Sea for it's cooling purposes; continuous treatment of 40 000 m^3/h with 0.05 ppm chlorine dioxide avoids any growth of mussels and algae in piping and heat exchangers, 2) In the Refinery of Capuava (Petrobras), Brasil with domestic and industrial waste water discharge extremely polluted river water was treated with chlorine gas until September 2003; since October 2003 they have been running tests with additional dosage of chlorine dioxide to reduce the amount of chlorine. The results are excellent concerning reduction of microbiological activity, turbidity and TOD.

N O T E S

Zebra Mussel Distribution in Riba-roja Reservoir (NE Spain) and First Results on Population Control Possibilities

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

During a survey of water intakes of the Hydroelectric Power Station of Riba-roja Reservoir (Ebro River, NE Spain), in May 2001, the team of divers detected the presence of a high-density population of zebra mussels attached to grilles — up to 200 000 individuals per square meter. One year ago the zebra mussel was cited in the Ebro River as a new invasive species, but in very low density.

ENDESA, the ownership power company of the Riba-roja powerhouse, made up a Working Group in June 2001 with researchers from Universities as well as from its own research staff. The first goal was to elaborate a Programme of control or eradication of zebra mussel populations in the Riba-roja Reservoir. This programme was made public in December 2001 and it contains two main research lines, one focused on the ecology and the life cycle of the zebra mussel, and the other applied physical and biological experimentation for control or eradication strategies in hydraulic infrastructures and natural environments. Simultaneously, a surveillance plan to determine the spatial distribution of zebra mussel was put into operation.

This paper shows the first results of zebra mussel vertical distribution in the Riba-roja Reservoir and its ecological interpretation. We also give a broad outline of the ENDESA Programme for control of zebra mussel populations, and the preliminary outputs of its application.

N O T E S

Zebra Mussel Control at Darlington Nuclear Generating Station

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Darlington NGS is a four unit 3400 MWe station located on the north shore of Lake Ontario about 70 km east of Toronto. The station uses once-through design for cooling water systems. The water conveying system consists of an underwater intake structure, intake shaft, tunnel, outlet transition and an open channel (forebay). The circulating water and service water pump houses are located along the forebay with their intake channels perpendicular to the forebay.

Zebra mussels come into the station through the water conveying system in two forms: veligers and mussel shells.

a) During breeding season, veligers come in from the lake and attach to the intake structure and slots, forebay, pumpwells, and service water piping when the flow velocity is low. While all surface areas are favourite spots for veliger settlement, the most vulnerable areas are the slots. The slots and the external portion of the intake structure were cleaned in March 2001. However, when the slots and the intake structure were inspected in the summer of 2003, heavy fouling by zebra mussels and algae was observed. Results of the inspection will be presented.

b) Recently, mussel shells are found coming in continually from the lake. These shells are likely originated from the dead mussels in the neighbourhood of the station. The shells are probably churned up during fouled weather and carried by the current to locations nearby. If these shells happen to move over the intake structure, they could be sucked in and ended up in the forebay and pump channels. During the last two years, about 298 (year 2002) and 594 (year 2003) tonnes of shells were removed from the forebay. Our cleaning strategies and locations most susceptible to mussel shell settlement will be discussed.

N O T E S

The Response of Brazilian Utilities to the Invasion of *Limnoperna fortunei*

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Freshwater mussel species *Limnoperna fortunei*, native to Asia, invaded Brazilian waters through the southern portion of the Paraná river, probably as an extension of infestation of the Buenos Aires Harbor in Argentina. The *Limnoperna*, commonly called the golden mussel, is considered a pest in China, Korea, Japan and Taiwan. There are documented environmental and economical problems caused by this mussel in these locations.

After the first news of golden mussel in dam facilities, (Yacyreta Binacional) in 1998, a conference was held in Itaipu Binacional facility. Most of the Brazilian hydroelectric power plant environmental experts were present at this conference as well as some Argentinian researchers, who were the first to study the problem in South America. CIA. Energética de Minas Gerais, Cemig, took part of this conference.

Cemig, the electric energy utility of the Brazilian state of Minas Gerais, is one of the largest and most important electric energy distributors in Brazil. This is due to the technical skill of the company, large customer base and also to its strategic location. The state of Minas Gerais is located in the southeast region of Brazil and it is one of the most central states of the country. Cemig services approximately 96% of the territory of the southeastern state of Minas Gerais. This covers over 560 000 square kilometers (219 000 square miles), an area equivalent to that of France. Operating 48-generation plants based predominantly on hydroelectric power, Cemig supplies more than 16 million people with electric energy.

After the 1998 conference Cemig decided to make an effort to slow down the spread of the golden mussel. At that time Darrigan (1997) estimated the spread to be 240km/year. Another decision from the conference was to study the behavior and biology of the mussels in the South American environment, monitor the spread and learn how to control damage caused to power plants. To accomplish these objectives and to train people, Cemig developed a three-year research program and engaged a research center – Fundação Centro Tecnológico de Minas Gerais (CETEC) to carry it out. The program was implemented at the Volta Grande dam research facility, located on the Grande River as this is the most studied of Cemig's reservoirs and also strategically located. The program consists of the following three steps;

1. Compile bibliography and baseline data of Volta Grande reservoir;
2. Field assessment of the current ecosystem situation;
3. Test products for the control of the golden mussel at Cemig's power plants.

This paper will report on the progress of the three-year program and the results obtained to-date.

NOTES

Functional Changes in Freshwater Benthic Communities After *Dreissena polymorpha* (Pallas) Invasion

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In freshwaters, dreissenids, including the aggressive invader *Dreissena polymorpha*, are the only bivalves that attach to hard substrates. They can become enormously abundant and dramatically change benthic invertebrate communities in terms of total biomass, species composition, and the relative abundance of functional groups. We analyzed the relative abundance of functional feeding groups across trophic levels for benthic communities before and after zebra mussel invasion in 8 Belarussian lakes. For three lakes we have data before and after invasion, for four lakes we have data after invasion only, and one lake in the same region has not been invaded. We found that the relative abundance of functional feeding groups in the benthic community were different in lakes before and after zebra mussel invasion. If *D. polymorpha* is considered with the rest of the benthic community, the benthic structure is characterized by an extremely high dominance of one trophic group – filterers, which account for > 96 % of the total biomass of benthic invertebrates. Before invasion, planktonic invertebrates filtered a volume equivalent to the volume of the lake within few days, and were 200 times more effective than benthic invertebrates, which took several years to filter an equivalent volume. After *Dreissena* invasion, the total average biomass of benthic invertebrates, including zebra mussels, increased 22 times. The filtering efficiency of the benthic community increased >70 times, and the time required to filter the volume of the lake was not significantly different than that for zooplankton.

The dramatic changes can alter the relative roles of the plankton and benthos in a variety of ecosystem functions.

NOTES

An Assessment of the Direct and Indirect Impacts of Aquatic Invasive Species on Lake Trout Restoration in the Great Lakes

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After lake trout (*Salvelinus namaycush*) were decimated by the combined effects of over fishing and the aquatic invasive species sea lamprey (*Petromyzon marinus*) during the middle part of the last century, their restoration in the North American Great Lakes is now facing new and escalating impacts of aquatic invasive species. These impacts affecting early life stages are both direct and indirect and represent the most significant impediment to restoration of lake trout in the Great Lakes. Alewives (*Alosa pseudoharengus*) that first entered the Great Lakes in the 1800s cause lake trout larval mortality both directly through predation, and indirectly through a diet-mediated thiamine deficiency causing larval mortality. Rainbow smelt (*Osmerus mordax*) that were introduced into the Great Lakes basin in 1920s, are also associated with a diet-mediated thiamine deficiency. Zebra mussels (*Dreissena polymorpha*) after entering the Great Lakes in the 1980s, colonized the substrate used by lake trout to spawn on and likely facilitated the spread and high population abundances of two invasive lake trout egg and fry predators by providing an abundant food source. Rusty crayfish (*Orconectes rusticus*) that eat zebra mussels, invaded the Great Lakes in the 1980s and because of its size, aggressiveness, and high abundance is now the dominant lake trout egg predator in near-shore reefs of northeastern Lake Michigan. Round gobies (*Neogobius melanostomus*) that entered the Great Lakes in the 1990s and also eat zebra mussels are still in their ascendancy but already show signs of becoming the most significant lake trout egg and fry predator in the Great Lakes because of their high abundance, aggressiveness and ability to eat large numbers of lake trout eggs and larval stages.

N O T E S

An Evaluation of the Roach (*Rutilus rutilus*) Invasion in Ireland

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Roach were first introduced to the Munster Blackwater in 1889. The initial spread of this species was slow but, by the mid-1970s roach were becoming increasingly widespread. In 1981 two by-laws that were aimed at preventing the spread of roach were introduced. These banned live transfer of the species, and also their use as live bait. Despite this, the anthropogenic redistribution (deliberate and accidental) and natural colonisation has continued. Currently, roach are present in most major river catchments in Ireland. The introduction of roach in Ireland has had significant consequences, both positive and negative. It is a fast-growing and prolific opportunist species that has impacted on the fish community structure in most catchments it has invaded. In cyprinid fisheries, the closely related rudd (*Scardinius erythrophthalmus*) has been the most adversely affected species, although a decline in bream (*Abramis brama*) populations may also be a consequence of direct or in-direct competition with roach. Roach hybridise readily with rudd and bream. In recent years, surveys have revealed that roach x bream hybrids are becoming more numerous than roach in some locations. The roach is now a major angling species, forming the mainstay of the Irish coarse angling product. The spread of roach within Irish waters is concomitant with a profound increase in tourist match anglers using these waters. Tourist angling in Ireland has greatly benefited from the roach invasion, with far greater numbers of British match anglers visiting this country in the past two decades. The return to the national exchequer in respect of tourist angling revenue has been significant. The impact of the roach colonisation on fish community integrity and on the coarse angling product is discussed.

NOTES

Invasive Plant Species in Irish Aquatic Habitats

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An account of invasive plant species recorded in, or near, Irish waters is presented. Although more than 900 alien species have been reported for Ireland, only a small number of these may be considered to be invasive and potentially harmful from a biodiversity or economic perspective. The principal invasive aquatic species include *Azolla filiculoides* (Water Fern), *Lemna minuta* (Least Duckweed), *Crassula helmsii* (New Zealand Pigmyweed), *Myriophyllum aquaticum* (Parrot's Feather), *Lagarosiphon major* (Curly Waterweed), *Elodea nuttallii* (Nuttall's Waterweed) and *Nymphoides peltata* (Fringed Water-lily). Riparian species that impact biodiversity, the stability of banksides, fish productivity and recreational usage of many Irish watercourses include *Heracleum mantegazzianum* (Giant Hogweed), *Fallopia japonica* (Japanese Knotweed) and *Impatiens glandulifera* (Himalayan Balsam). The latter species are native to Asia while the natural ranges for the others include the Americas, New Zealand and southern Africa. Climate warming, of which there is evidence in Ireland, will particularly favour some aquatic alien species that can be expected to expand their range. It is concluded that most alien species that inhabit aquatic systems in Ireland originate from gardening stock. The authors suggest that some sort of inspection system and code of practice must be put in place for commercial garden centres to mitigate the threat, and ecological impacts, from the escape of invasive aquatic plant species.

N O T E S

Exotic and Endemic Flora on Reference and Non-reference Sites From Iberian Fluvial Systems

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Exotic plant species from aquatic and wet habitats of Portuguese freshwater systems were compared between reference conditions, i.e., near-natural river corridors, and non-reference conditions in order to detect differences in the susceptibility of the river ecosystem to invasion. The occurrence and abundance of endemic species was also studied. We recorded vegetation at 272 sampling sites from two river types having differences in the geological background. Abiotic variables and human disturbance metrics were collected from a Geographic Information System (GIS) database or recorded on site. Selection criteria for reference site-groups included the physical alterations of riverbanks and valley floor, state of the woody formations, artificial sediment load, and water quality parameters.

Possible relationships among the observed values of richness and cover of both exotic and endemic species and the underlying factors were estimated with Pearson Product-Moment Correlations, and with Spearman´s Correlation for interval data and for dummy variables. Comparisons of exotic and endemic species richness and cover among groups of river types from reference/non-reference conditions were performed using t-tests, and Mann-Whitney U tests for non-normal data.

A total of 568 *taxa* were identified, of which 44 were exotic, and 28 were endemic. The most abundant exotic species were perennials, such as the rhizomatous grasses, knotgrass (*Paspalum distichum* L.), and giant reed (*Arundo donax* L.), and the hydrophytes water-hyacinth (*Eichhornia crassipes* (Mart.) Solms-Laub) and pacific mosquitofern (*Azolla filiculoides* Lam.). Though always present on reference sites, exotic species are consistently more spread in non-reference sites on both river types, with calcareous background presenting a higher invasibility. In siliceous river types, the richness and cover of endemic species were significantly lower in the non-reference sites than they were in the reference ones, whereas no differences were detected between the corresponding calcareous groups. In addition, there were no significant differences in exotic and endemic species richness and cover between the two river types, whether from the reference and the non-reference groups. Exotic richness and cover were positively related with the direct man-induced disturbances within the fluvial system, for instance the physical alteration of river banks, and with the use of the floodplain, such as the 'urban occupation', the 'intensive agriculture', and the 'nutrient inputs'. Endemic species also respond to anthropogenic variables, rather than to geographical variables, with its richness and cover increasing towards lower human impacts on fluvial systems and related floodplains.

N O T E S

Blurring of Biogeographic Boundaries: A Multivariate Analysis of the Regional Patterns of Native and Nonindigenous Species Assemblages in Pacific Coast Estuaries

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Many, if not most, invaders have wide physiological tolerance limits and generalist habitat requirements. Consequently, as a group, nonindigenous species should have wider geographic distributions compared to native fauna. In turn, these broader distributions of nonindigenous species should tend to blur regional differences in community composition. To test whether "biogeographic blurring" is occurring, we compared the discreteness of assemblages of native versus nonindigenous estuarine benthos across biogeographic zones on the Pacific Coast of the USA. Each of 187 benthic grabs from the US EPA's EMAP survey of the soft-bottom benthos of small estuaries in Oregon, Washington, and California was assigned to one of three biogeographic provinces and to one of five salinity classes. The three biogeographic provinces were the Californian Province south of Point Conception (34.449° N) to the Mexican border, the Columbian Province north of Cape Mendocino (40.440° N) in Northern California to the Canadian border, and a Transition Province between Point Conception and Cape Mendocino. A total of 429 native, 53 nonindigenous, 113 cryptogenic (species of uncertain origin), and 247 indeterminate (species that can not be classified) species were identified in the EMAP survey, though only the native and nonindigenous species are used in the present analysis. Analysis of similarity (ANOSIM) with a two-way crossed design was used to test if the species composition of the native or nonindigenous species assemblages differed among the three biogeographic provinces after accounting for salinity. The "R" statistic was used as a measure of separation among the biogeographic provinces, with larger R values indicating greater separation.

After accounting for salinity, the native species assemblages showed strong regional separation (overall $R=0.443$). In pairwise tests, the native assemblages of the Columbian and Transition Provinces were significantly separated ($R=0.259$), indicating that Cape Mendocino is an ecologically significant break for native fauna. Point Conception in Southern California represented an even more discrete faunal break, with both the Columbian and Transition Provinces strongly differentiated from the Californian Province ($R=0.608$ and 0.576, respectively). In contrast, the nonindigenous species assemblages did not show a significant difference among the biogeographic provinces (overall $R=0.13$, NS). Thus, the composition and relative abundances of the nonindigenous species were not sufficiently different among these Pacific Coast estuaries to form discrete biogeographic provinces. Because nonindigenous species constitute only a moderate component of the total benthic assemblages in these small estuaries, the present regional patterns of the composite benthic assemblages are not strongly altered by the occurrence of nonindigenous species. However, as the number and abundance of nonindigenous species increases, regional differences in benthic community composition will decrease, blurring the distinctiveness of biogeographic boundaries within these estuaries. One potential ecological consequence of such "homogenization" is the loss of beta diversity, or species turnover, at the biogeographic scale. Another possible consequence are shifts in the taxonomic composition of the "reference" or "control" communities used in assessing pollution impacts. Such shift in the composition of control sites will confound the detection of pollution-related impacts over time.

Effects of Nonindigenous Species on the Taxonomic Diversity of Estuarine Assemblages

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The effects of the few numerically dominant invasive species on benthic community abundance patterns have been documented in a number of estuaries. What is less appreciated is that the entire suite of nonindigenous species may alter the taxonomic composition of a community or biogeographic region. Recently, the "average taxonomic distinctness" (AvTD) and the "variation in taxonomic distinctness" (VarTD) have been proposed as measures of taxonomic breadth. AvTD measures the average taxonomic distance between pairs of species within an assemblage while VarTD measures variation in the taxonomic distance among species. These indices have been used to assess pollutant effects, but are used here to quantify the taxonomic diversity of nonindigenous species compared to the native species in two surveys of soft-bottom benthos. The first is the U.S. EPA's EMAP program, which conducted a probabilistic-based survey of the "small" estuaries of Oregon, Washington, and California (USA). The sampling frame included all Pacific Coast estuaries other than Puget Sound, San Francisco Estuary, and main stem of the Columbia River. A total of 842 benthic species were collected from 187 random benthic grabs taken from over 90 different estuaries/sub-estuaries. Of these species, 429 were native, 53 nonindigenous, 113 cryptogenic (species of uncertain origin), and 247 indeterminate (species that can not be classified). The second study was a compilation of monitoring programs within the San Francisco Estuary in which 235 native, 63 nonindigenous, 21 cryptogenic, and 212 indeterminate species were collected from 590 benthic grabs.

Our initial hypothesis was that nonindigenous species would have a lower taxonomic distinctness than the natives. However, there was no difference in AvTD between native and nonindigenous species among the small estuaries of the Pacific Coast or within the San Francisco Estuary. The lack of differences in AvTD does not appear to be a scale effect as there was no difference in AvTD between natives and nonindigenous species when evaluated within individual grabs from the EMAP survey. However there were differences among specific taxonomic groups, and the nonindigenous polychaetes had a significantly lower AvTD compared to the native polychaetes in both the Pacific Coast estuaries and the San Francisco Estuary, reflecting the high number of exotic spionid polychaetes in both studies. In contrast to AvTD, VarTD was significantly higher in the entire suite of nonindigenous species than for the natives. Compared to a random subset of native species, the nonindigenous species display relatively greater diversity at the family and order levels. At least in these two studies, the suite of nonindigenous benthic species was not taxonomically impoverished compared to the natives, which reflects, in part, the mixing of invaders from different oceans and biogeographic zones. In contrast, previous studies have shown that pollution stress tends to reduce average taxonomic distinctness. Thus, invasive species and pollutants appear to have fundamentally different impacts on the taxonomic diversity and composition of benthic communities.

NOTES

Is the Biological Integrity of the Baltic Sea Threatened by Invasive Non-native Species?

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In the Baltic Sea, more than 100 alien species have been recorded of which ca. 70 have established themselves in some parts of the sea; ca. 20 NIS can be classified as nuisance organisms, seven of which have caused significant damage. Centres for xenodiversity (Gr. xenos = strange), i.e. areas that host many well-established invaders, include the Gulf of Finland, the Gulf of Riga, the coastal lagoons and Polish estuaries. These hot spots serve as entrance gates for invasions into the Baltic and function as bridgeheads for secondary introductions within the sea. The theoretical framework of the project is based on the threats to biological integrity, defined as the capability of maintaining a balanced, integrated, adaptive biological system having a full range of elements and processes expected in the region.

The goals of the project are to 1) assess the Finnish coastal sea as recipient and donor area for non-native organisms, and 2) study their impact on biotic communities. The Gulf of Finland is a special area for the study of bioinvasions, because of i) the salinity gradient from 0 to 6 psu to allow both fresh- and brackish-water organisms to establish reproducing populations; ii) intense shipping (intra-Baltic and international) and ports of different size; iii) numerous invasion corridors, both geographical and man-made, opening into it (the Volga-Baltic and Lake Ladoga shipping routes; ballast water discharge, hull fouling, intentional introductions into adjacent freshwater bodies). In addition to the existing harbours, ongoing development of new ports in the NE Baltic will further increase the risks of introductions — 4-fold increase in ships' traffic in the Gulf of Finland is expected from 1990 to 2010.

The specific objectives of the project are i) to investigate which phytoplankton species, dinoflagellates in particular, occur in ballast water tanks and in bottom sediments in harbours, ii) to reveal the bloom potential in the Baltic by studying how the environmental conditions affect the germination of alien dinoflagellate resting stages, and iii) examine the species concept and ecology of the potentially toxic dinoflagellate Prorocentrum minimum. Further, we intend to iv) describe the succession of selected key species, especially the North American polychaete Marenzelleria viridis; and v) focus on biological risk assessment of harbour areas, including shipping patterns and statistics of selected ports in Finland. Based on environmental conditions in the harbours and physiological requirements of potential invaders, their invasion probability will be assessed, taking into account the predictions of climate change and consequent changes in hydrographical conditions.

NOTES

Invasive Blooms of the Green Alga *Caulerpa* in Southeastern Florida and the Bahamas Supported by Anthropogenic Nitrogen Enrichment

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Humans are the primary vector in the global epidemic of biotic invasions in aquatic ecosystems. Less well known is how anthropogenic modification of ecosystems could facilitate biological invasions. We provide two case studies of how anthropogenic nitrogen enrichment has supported successful invasions of the green algal genus *Caulerpa* – one in coral reef communities of southeastern Florida, USA, and the other in shallow seagrass communities of Green Turtle Cay, Abacos, Bahamas.

In 20 to 50 m depths on fringing coral reefs off southeastern Florida, a succession of green macroalgal blooms began in 1990 with *Codium isthmocladum* that overgrew corals, octocorals, and sponges. By 1997, *Caulerpa verticillata*, which is normally found in nutrient-rich mangrove ecosystems, invaded these reefs and became the dominant cover by 2000. In May 2001, we discovered that *Caulerpa brachypus* var. *parvifolia*, an aggressive invasive species endemic to the tropical Pacific and not previously reported for Florida, had appeared as a competing invasive species. Tissue analysis for stable nitrogen isotope ($\delta^{15}N$) values of these invasive *Codium* and *Caulerpa* species between Jupiter and Deerfield Beach, FL averaged between + 6 and + 8 o/oo, with higher values on shallow reefs and lower values on deeper reefs. These values were well above values reported for upwelled nitrate (+ 4.7 o/oo) and natural nitrogen fixation (+ 0.5 o/oo) but closely matched values reported for sewage nitrogen (> + 5 o/oo) from the highly populated watershed.

In 2001 we also discovered that extensive areas of the benthos in Black Sound, Green Turtle Cay, Bahamas, previously dominated by turtle grass, *Thalassia testudinum*, were now replaced by thick mats of the green rhizomatous macroalga *Caulerpa ollivieri*. Prior to this discovery, *C. ollivieri* had not been reported for either the Bahamas or Caribbean region and is native to the Mediterranean Sea. *Caulerpa ollivieri* collected in February (dry season) and July (wet season) 2003 at four stations had mean $\delta^{15}N$ values of + 4.01 ± 1.21o/oo (n = 20) and + 3.96 ± 1.68 o/oo (n = 20), respectively; these values are enriched above that of nitrogen fixation but closely match sewage nitrogen from the watershed. The mean concentration of dissolved inorganic nitrogen (DIN = ammonium + nitrate + nitrite) was over ten-fold higher in nearshore waters of Green Turtle Cay directly impacted by sewage discharges (14.0 ± 6.60 µM, n = 12) compared to seven offshore coral reef sites (0.87 ± 0.47 µM, n = 28).

Because nitrogen is a key element regulating primary productivity and eutrophication in coastal marine waters, anthropogenic nitrogen enrichment appears to drive these “invasional meltdowns” with their associated loss of biodiversity and fisheries production. To moderate the conditions supporting invasive *Caulerpa* blooms, planners and resource managers must consider methods to reduce nitrogen loads from sewage and other sources. For example, *C. prolifera* decreased from 280 ha in 1988 to less than 0.2 ha in 1995 as seagrasses expanded following reductions in wastewater-nitrogen loading into Hillsborough Bay, Tampa, Florida, USA.

NOTES

The Ecology and Ecological Impact of a Highly Invasive, Marine Invertebrate on Hawaii's Coral Reef Communities

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Carijoa riisei, a shallow-water soft coral species (order Stolonifera) native to the tropical Western Atlantic, is the most invasive of the 287 nonindigenous marine invertebrates in Hawaii. *C. riisei* was first discovered in Hawaii in 1972 and has since spread to all the main islands. In 2001 and 2003, deep-water surveys near Maui discovered *C. riisei* killing 80-90% of black coral colonies (*Antipathes dichotoma* and *A. grandis*) and overgrowing large beds of scleractinian corals (*Leptoseris* sp.) at depths of 65-115 m. As an alien invasion on a coral reef ecosystem, the potential scale and severity of this impact may be unprecedented. This bio-invasion now threatens the $30 million precious coral industry in Hawaii with potentially wider ecological implications throughout the Pacific. Despite this emerging notoriety, relatively little is known about *C. riisei* and the process of invasion in tropical coral reef communities. In 2002, the *Carijoa* research project was launched with support from Sea Grant to determine the ecology and ecological impact of this highly invasive alien in Hawaii.

Preliminary results reveal not only traditional r-selected characteristics commonly associated with opportunistic invaders but also k-selected traits typical of dominant competitors. Time series analysis of gonad development suggests that *C. riisei* is highly fecund and spawns continuously throughout much of the year. Analysis of distribution & abundance imply that viable habitat results from both the paleoceanography of the Hawaiian Islands and modern anthropogenic activity. While Hawaii's extremely depauperate shallow-water soft coral fauna should contribute to the region's susceptibility to nonindigenous soft coral species in general, no additional alien soft coral species have successfully colonized the archipelago. *C. riisei's* unique life history characteristics appear to give it a differential advantage over other soft coral species for dispersal via maritime vectors.

Management of the proliferation and dispersal of *C. riisei* presents a challenging ecological problem with potentially significant economic impact. In the Western Pacific, several populations of *Carijoa* have been identified. However, taxonomy has not been resolved at the species level, and whether these populations also represent alien invasions is unknown. The abundance and success of these *Carijoa* populations are also unknown. The *Carijoa* project has recently been expanded to incorporate molecular genetic techniques to determine the phylogenetic origin and dispersal history of *Carijoa* in the Pacific.

NOTES

Introduction of the Polychaete *Marenzelleria viridis* and its Influence on Macrozoobenthos Long-term Trends in the Northern Baltic Sea

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Since the first records of *Marenzelleria viridis* (Polycaeta, Spionidae) in 1990, the species has rapidly established itself in the coastal soft-bottom macrobenthic communities in the northern Baltic. Native macrozoobenthos in this area is characterised by a low species number (generally <10) and high dominance of single species, resulting in low diversity communities. The low species number is attributed to the geological history and low salinity of the sea area, with only a few species adapted to the brackish environment (salinity <8 psu). Long-term data sets demonstrate both high variability of macrozoobenthos abundance and major changes in species composition. The species poor communities have been considered vulnerable to any changes in community structure because some functions rely on only a few or single species.

In this study, we describe and analyze the succession and distribution of *M. viridis* and relate that to general changes in macrozoobenthos communities. The material consists of different monitoring data sets and the community changes are analysed with multivariate statistics. Also, time series techniques are applied to detect common trends in the communities. Based on the results, *M. viridis* has become common but not very abundant in the coastal waters. Other changes in the communities include a decline in previously abundant amphipod (*Monoporeia affinis*) communities and an increase of the Baltic clam (*Macoma baltica*). Due to a general decline of the communities it can be suggested that *M. viridis* is becoming increasingly important in the functioning of the coastal benthos. However, the long-term data show that many of the changes in native species have started already prior to the establisment of *M. viridis* and are obviously independent of the introduction of the species. Recently, *M. viridis* has also invaded deep (100-250 m) soft-bottom habitats in the open Gulf of Bothnia. This may result in resource competition with native fauna since these communities are highly dominated by only one species, the deposit feeding amphipod *M. affinis*.

NOTES

Reproductive Potential and Predatory Pressure of the Gastropod *Rapana venosa* in a Locality of the Northern Adriatic Sea

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Experimental evaluations of the reproductive potential and predatory pressure of the invasive muricid *Rapana venosa* were conducted in the period 2001-2002 along the littoral of Cesenatico (Emilia-Romagna, Italy). Reproductive potential was estimated by weekly scuba diving collection of *R. venosa* egg cases, laid on three rocky artificial reefs located 300 metres from the beach. In a month-long experimental period, weekly deposition rate varied from a minimum of 994 ± 592 to a maximum of 2780 ± 1001 egg cases /115 m^2 (each egg case bearing 800-1000 larvae). Local fishermen and scuba divers reported continuous reproduction and mating activities of *Rapana* in the study area from the end of March to the end of September in a water temperature range of 12-28°C.

Prey selection and daily feeding rates were assessed by caging individually eight adult *Rapana* (size: 99-114 mm SL) for 44 days in the natural environment together with a specific number of prey belonging to three common Northern Adriatic species of bivalves: *Mytilus galloprovincialis*, *Tapes philippinarum*, *Anadara inaequivalvis*. Results showed higher consumption rates of small size *A. inaequivalvis* specimens, an invasive non-indigenous bivalve of no commercial value, which is widespread in the Northern Adriatic. Our estimate of average daily consumption rate in the wild is comparable with results reported in literature for laboratory experiments in a controlled environment.

The large availability of prey in the study area appeared to sustain well the resident population of the alien, which is slowly increasing in size without demonstrating a clear invasive attitude. Commercially valuable shellfish stock does not appear to be at risk of depletion. High risk of secondary dissemination of the gastropod propagules via ballast water is supported by the observed reproductive potential, which would provide an impressive amount of larvae along the coast throughout spring and summer in proximity of large Northern Adriatic port facilities, such as Ravenna and Ancona.

N O T E S

Differences in Habitat Structure and Associated Macrofauna Between Native Kelp Beds (*Laminaria* spp.) and Meadows of the Invasive Green Alga (*Codium fragile* ssp. *tomentosoides*) Along the Atlantic Coast of Nova Scotia

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The rocky subtidal zone of the Atlantic coast of Nova Scotia is generally dominated by large kelps, mainly *Laminaria longicruris* and *L. digitata*. Kelp beds provide a structurally complex habitat for diverse communities of benthic invertebrates and demersal fish, and form the base of food webs that support important fisheries. Over the past decade, however, kelp beds have progressively been replaced by meadows of an invasive green alga *Codium fragile* ssp. *tomentosoides*. We compared the influence of *Laminaria* and *Codium* canopies on habitat architecture and faunal assemblages at a moderately exposed site near Halifax. Within adjacent monospecific stands of *Laminaria* or *Codium*, we systematically alternated 4 x 10 m plots that we cleared of kelp or *Codium* and undisturbed plots with intact canopies. We recorded densities of benthic invertebrates and fish in each plot, and the cover, density, and morphology of *Laminaria* or *Codium* in plots with canopy, at 2-4 week intervals from June 2003 to July 2004.

Thallus volume of *Laminaria* and *Codium* was estimated from morphometrics by regression, and used to estimate understory and interstitial (between frond) volume per unit area from measures of individual plants and their density. The percentage cover of *Laminaria* or *Codium* varied seasonally, ranging from 26-95% for *Laminaria* and 9-91% for *Codium*. Understory volume was 1.7-2.5 times greater under kelp than *Codium*, whereas interstitial volume was up to 1.7 times greater in the *Codium* meadow than in the kelp bed. Ordination by multidimensional scaling followed by analysis of similarities showed that the faunal assemblage of cleared plots differed significantly from plots with an intact canopy within stands of each algal type, and that the assemblages within canopy covered plots differed significantly between the two algal types. Differences in habitat architecture and associated fauna between *Laminaria* and *Codium* suggest that a shift from kelp beds to *Codium* meadows may profoundly influence ecosystem structure and function in the shallow rocky subtidal zone.

NOTES

Effects of Mussels on the Invasive Alga, *Codium fragile* ssp. *tomentosoides*, on Artificial Structures in the Adriatic Sea (Northeast Mediterranean)

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As a consequence of the progressive exploitation of marine resources, artificial structures are proliferating in shallow coastal waters. Along the north-east coast of Italy (Adriatic Sea), artificial breakwaters extend, almost uninterrupted, for 100s of km. These structures, aimed at preventing the erosion of sandy shores, are parallel to the shore and provide both wave-exposed and sheltered habitats. These structures support a diverse intertidal assemblage, including macroalgae, mussels, oysters and limpets, but they also provide suitable substrata for colonization of the invasive green alga, *Codium fragile* ssp. *tomentosoides*. Spatial and temporal patterns of distribution, abundance and growth of *Codium*, were quantified at low-shore levels in exposed and sheltered habitats on breakwaters in Cesenatico, for a period of about two years. Since the mussel, *Mytilus galloprovincialis*, is the main space-occupier, we investigated its role in determining the patterns of recruitment and growth of *Codium.*

Mussels were experimentally removed from some blocks, simulating the effects of natural and human disturbances. This experiment was repeated in spring, summer and winter to test for the importance of the timing of disturbance. To evaluate whether the effects of mussels on *Codium* varied according to wave-exposure, removals were done both on the landward and the seaward side of the breakwaters. Furthermore, following the observation of juvenile thalli of *Codium* embedded in the matrix of mussels on the seaward side of breakwaters, the hypothesis that survival of *Codium* could be positively affected by mussels was tested. Mussels were, therefore, removed around juvenile thalli which had settled directly on the primary substratum and their survival was measured over a period of about two weeks. The results of this study suggest that these artificial structures have the potential to enhance the dispersal of invasive species, by providing hard substrata within areas lacking of natural rocky reefs. In particular, sheltered conditions on the landward side of breakwaters can enable *Codium* to monopolise space. The effects of mussels on rates of recruitment are dependent upon the time at which they are removed. Finally, mussels can reduce mortality of *Codium* on the seaward side of breakwaters by stabilising the thallus. The results of this study suggest that disturbances, either natural (e.g., storms) or human (e.g., collection of bivalves for food or bait), by removing dominant taxa, can affect the ability of *Codium* to colonise human-made structures.

N O T E S

The Reward Rapid Release™ Test: A Water Management Tool for Sensitive Use Sites such as Reservoirs, Canals, and Lakes

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The limitation in aquatic herbicides and the proliferation of aquatic invasive weed species has created the need for improved technology in herbicide use and water quality. In order to assist water resource managers, Syngenta has developed a new fast acting test to facilitate the use and release of diquat-treated water. The Reward Rapid Release™ test is based on an immunochromatographic test strip developed by Syngenta for use in water management systems. The test strip utilizes diquat antibodies to detect low levels of diquat in water. A field test kit was developed to allow plant managers and water treatment personnel to qualitatively determine the concentration of diquat in sensitive areas such as potable water intakes, reservoirs, and irrigation canals both quickly and accurately. Negative test results may enable utilization of treated water much sooner than the water use table listed within the Reward® label. Laboratory validation studies indicate the test strip is accurate and reliable. The development and technical attributes of the monitoring system will be discussed along with its practical application merits for aquatic plant managers.

NOTES

Nutritional Status of *Hydrilla verticillata* and its Effect on Two Different Biological Control Agents

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A complex of abiotic and biotic factors is known to impact the establishment and success of biological control agents. One area of recent interest in hydrilla biocontrol research has focused on the nutritional and physical status of the host plant as it relates to agent effectiveness. Experiments using the ephydrid fly *Hydrellia pakistanae* have demonstrated hydrilla nitrogen content impacts not only larval development time but also the number of eggs oviposited. Eggs per females were over two-fold higher for larvae reared on hydrilla containing higher protein levels (as estimated from nitrogen content). However, nitrogen content only partially explains changes in female status and productivity. Higher weight females (typically indicative of having higher egg production) occurred when hydrilla nitrogen was high and crowding was low. However, the nutritional effect was minimized when crowding levels were high with lower weight females occurring regardless of nitrogen content. The hydrilla biocontrol pathogen, *Mycoleptodiscus terrestris*, also responds to plant nutritional condition. Hydrilla plants that have high nitrogen content are more susceptible to pathogen ingress and subsequent disease development. This is most likely related to an approximate 3.5 fold increase in spore production that provides secondary inoculum. In contrast, it appears that plants with low nitrogen content stimulate the fungus to enter a survival mode as evidenced by an approximate 3.5-fold increase in microsclerotia, a type of melanized survival propagule.

NOTES

Developing an Integrated Approach to the Management of Hydrilla

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For the past 30 years, the management of hydrilla in the United States has relied mainly on the use of grass carp as well as chemical and mechanical control technologies. These technologies provide, at best, short-term control at a prohibitively high cost. In addition, implementing these strategies does not normally take into consideration other factors within the ecosystem, such as nutrient inputs and native plant diversity, which may be influencing the formation of economically important hydrilla infestations.

Recently, two new technologies have emerged that offer the possibility of combining all available techniques into an integrated ecosystem management approach to hydrilla control. These new technologies include host-specific insect agents, specifically, two species of leaf-mining flies, *Hydrellia pakistanae* and *H. balciunasi*, and an ecosystem approach where stable native aquatic plant communities are established in an effort to exclude or inhibit the formation of large infestations of hydrilla.

The development of an integrated, ecosystem approach to hydrilla management, where all aspects of the environment from nutrient loading to native plant community structure are taken into consideration, represents a significant advance over more traditional management methods. This presentation will examine the promise of these new technologies, alone and in combination with more traditional existing methods, for managing hydrilla within an ecosystem context.

NOTES

Invasion and Management of the Water Primrose (*Ludwigia* spp.) in France: A Panorama

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Water primrose (*Ludwigia* spp) was accidentally introduced in France, from South America, at the beginning of the 19th century. Two species of this taxon are present: *L. peploides* subsp. montevidensis and *L. grandiflora* subsp. hexapetala. Restricted first to the southern part of the territory, these ornamental plants, freely sold in France, are widely dispersed for three or four decades, mainly in Mediterranean and Atlantic countries but also in isolated places in the northeast. Today, they are considered in France as the most harmful exotic aquatic plants.

Their large ecological amplitude allowed them to colonize all kinds of aquatic ecosystems, such as wetlands, ditch networks, strands of pond and lakes, backwaters and slowly parts of rivers. Their easy vegetative reproduction and their strong capacity to create propagules (fragments of stems) permit them to colonize interconnected sites very quickly.

Finally, their great biomass production allows them to occupy favorable biotopes completely. This total colonization of aquatic biotopes by water primrose creates unfavorable conditions to the indigenous macrophyte populations and many others aquatic organisms (invertebrates, fishes). It also produces important nuisances opposite the human waterbody uses, especially in the south and the west. Consequently, for about ten years, many managers had to do regulation interventions on these plant populations. This management consisted in applications of herbicides, mechanical and manual extractions.

Over the past decade the management interventions in some sites have been improved about work organization, material adaptation and people recruiting to do these interventions. Experimentations are in progress to test the best means in pulled plant recycling.

A coordination within institutional managers is under development to facilitate information exchange between different sites and several meetings have already taken place to confront information on these plants and their management.

In order to increase, in the French context, the knowledge on the biology and the ecology of these plants, and facilitate their management, new research has been recently undertaken on their genetics, their capacities of primary production, their phenometry in different types of biotopes, and the possibility for their seeds to germinate and produce viable plants.

These subjects are found in a specific research project in a national program started in 2003 on the biologic invasions (INVABIO). This project includes research on the biology and the ecology of these plants, their ethno botanical representation and the economic conditions of their management in different parts of France.

The balance of this situation, that can be drawn up currently from different examples, shows a great diversity of the situations, the necessity of setting up a global analysis of the particular management of these plants, as well as the needs that remain to satisfy for this management.

N O T E S

Biocontrol Potential for *Azolla filiculoides* and *Hydrocotyle ranunculoides* in the UK and Europe

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Aquatic weeds are already a major issue for water managers in the UK and Europe. The withdrawal from the market of Diquat for use in water, and the likely reduced availability of other aquatic herbicides, mean the development of alternative control methods is absolutely crucial. Sustainable approaches, in particular biological and environmental management are urgently required.

Fortunately aquatic weeds are recognised as very good targets for classical biological control especially with host specific beetle species. Unfortunately, Europe has no history of using this tried and tested approach to weed management despite the wealth of research that has been carried out in Europe on behalf of countries such as North America and Australia and New Zealand. The potential for using classical agents to manage some of the UK's most pernicious aquatic weeds is examined. Floating pennywort, *Hydrocotyle ranunculoides*, is highlighted as a promising target due to the discovery of the South American weevil, *Lixellus elongatus*, which appears specific.

The UK is already benefiting from the actions of *Stenopelmus rufinasus* a host-specific curculionid natural enemy of the floating aquatic fern *Azolla filiculoides*. This serendipity is the result of the accidental introduction of the weevil as early as 1921 with imported *Azolla*. This has probably been repeated many times in the past 80 years as a result of poor national quarantine systems and is likely to continue since the plant is still available in garden centres, despite long being recognised as an invasive pest.

This paper examines the situation in the UK and compares it with that in South Africa, where the weevil was purposefully released as a classical biocontrol agent against *Azolla* with spectacular success. The circumstances within the UK are more complex, as the climatic conditions are not as favourable for the growth and development of the weevil and climatic matching was not part of the sourcing process. Preliminary laboratory-based experiments indicate that temperature significantly affects the feeding activity of the weevil and hence its ability to reproduce. It is suggested that the cold winters and cooler summers are responsible for the patchy distribution of the weevil and its partial success as a classical agent.

The commercial use of weevils for controlling aquatic weeds has already been developed in the USA under the trade name of MiddFoil® for the control of *Myriophyllum spicatum*. We report laboratory and field studies which show the ability of *S. rufinasus* to severely damage *Azolla* and even eliminate even very large infestations of the weed with weevil numbers building up to 3-4000/m^2. We also show that the weevils can suppress the growth of *Azolla* throughout the summer months highlight the negative impact of mechanical weeding on the weevil population followed by a massive expansion of the *Azolla* mat from fragments left behind. It is proposed that early inundative release of weevils in will prevent major infestations and provide annual control. Whether *S. rufinasus* is commercially viable will be tested in 2004 and will depend on the market size and willingness of land managers to use utilize this alternative. However its value as an educational tool for a skeptical public, more used to foot and mouth disease and sudden oak death, cannot be understated.

Reward AccuGel™: A Precision Placement Formulation of Diquat for the Management of Invasive and Nuisance Plants in Both Static and Flowing Systems

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Controlling invasive weed species in environmentally sensitive sites is an expanding problem in North America and around the world. It is particularly difficult to control invasive and nuisance weeds in areas of water movement such as large lakes, canals, streams, and rivers. Reward AccuGel™ is a novel, gel formulation of diquat, developed by Syngenta, which can be precisely placed to remove invasive and nuisance vegetation in sensitive aquatic and wetland areas with minimal off-target movement or effects. Reward AccuGel™ is a viscous gel, specially formulated for the control of submersed weeds in both static and flowing systems. The gel sinks down to the target plants where it binds because it is heavier than water and releases diquat at the target sites. In flowing waterways such as irrigation canals and streams, Reward AccuGel™ can be applied upstream and allowed to sink and move to the target area, where it binds in the plant biomass with enough exposure time to provide control. Lower use rates may be realized since the material is applied directly to the plants instead of the water column itself. Reward AccuGel™ was found to be highly effective for controlling *Hydrilla verticillata*, *Myriophyllum spicatum*, *Potamogetan pectinatus*, and *Lemna minor*. Data from various field and laboratory trials around the USA will be discussed and its potential use in invasive weed management programs.

N O T E S

Diquat Gel Formulation for Control of Aquatic Weeds

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The liquid formulation of diquat (Reward®) is a commonly used aquatic herbicide that can control a wide range of invasive aquatic plants. Unconventional herbicide formulations, such as gels, have the potential to improve plant control particularly in situations where exposure times are short due to rapid water exchange. An alginate gel formulation of diquat (AccuGel®) was evaluated for efficacy against several submersed aquatic plants, hydrilla (*Hydrilla verticillata*), Eurasian watermilfoil (*Myriophyllum spicatum*), sago pondweed (*Stukenia pectinatus*), American pondweed (*Potamogeton nodosus*), and Brazilian elodea (*Egeria densa*), and results compared to the effectiveness of the commonly used liquid formulation of diquat. The study was conducted in the outdoor mesocosm facility near Lewisville, TX, consisting of 30, 7000-L fiberglass tanks with three replicate tanks per treatment. Treatments were diquat gel and liquid diquat at 0.185 mg/L and 0.37 mg/L, and at water exchange half-lives of 3 and 6 hrs, respectively. In addition, a static exposure of diquat liquid at 0.37 mg/L and a 0 mg/L reference were evaluated. A 50% clay mixture was used as a sediment base, amended with 15 gm of Osmocote (18-6-12) slow-release fertilizer, and placed in 5-L plastic containers. Eight containers for each of the 5 plant species were placed into each of the 30 tanks. Three apical shoots of each species were planted per container, except sago pondweed, which was planted using winter buds. Tanks were filled with Lake Lewisville water previously treated with aluminum sulfate to remove excess phosphorous. Plants were allowed to grow 5 weeks before applying herbicides. Each tank was fitted with a calibrated flow valve to provide water exchange half-lives. Water samples were collected prior to herbicide application approximately 45 cm below the surface and analyzed for pH, alkalinity, temperature, and turbidity. Additional samples were collected approximately 45 cm below the water surface from 0 to 48 hrs post-treatment. At 3 weeks after treatment (WAT) shoots were cut at the sediment surface, placed in an oven, and dried to a constant weight to determine percent control and survival. Both formulations showed 80 to >90% control for Eurasian watermilfoil, sago pondweed, and Brazilian elodea. However, in most cases the gel resulted in significantly improved control of four species compared to similar liquid treatments. Except for the liquid treatment at 0.37mg/L static exposure, no treatment resulted in good control of hydrilla. While the published literature and extensive practical use of diquat show that the liquid formulation provides good control of hydrilla, results from our study indicate that longer exposure times may be required to achieve acceptable control of that species.

NOTES

The Effects of *Spartina anglica* Eradication Treatments on Estuarine Benthic Macro-invertebrates

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An experiment was initiated to study the short-term effects of *Spartina anglica* eradication treatments on estuarine benthic macro-invertebrates within *S. anglica* swards. Eradication treatments applied included application of glyphosate and Dalapon herbicides, smothering with black plastic sheeting and cutting regimes. Benthic core samples were taken for analysis of macro-invertebrate abundance from two *S. anglica* sward areas in summer prior to application of eradication treatments and during the subsequent summer, one year after treatment applications. There was no significant difference between benthic macro-invertebrate abundances between the different eradication treatment groups and the experimental control groups prior to and one year after treatment applications.

The ecology of the *S. anglica* sward benthos remained suitable for colonization by the main macro-invertebrate taxa found in the sward benthos one year after eradication treatments. The most probable change in benthic macro-invertebrate communities after *S. anglica* eradication treatments will be related to longer-term changes in benthic environmental conditions associated with the removal of *S. anglica* rather than by the application of the eradication treatments. Traditionally the effects of *S. anglica* eradication methods on estuarine macro-invertebrates have been studied using laboratory studies. This study suggests that longer-term investigations should be carried out to examine changes in the abundance of estuarine macro-invertebrates in relation to habitat alteration after *S. anglica* eradication.

N O T E S

The Integrated Management Approach to Control of Eurasian Watermilfoil: Cost Benefits and Long-term Effectiveness

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Once introduced into a body of water, an exotic species can rarely be eradicated. Control measures are generally aimed at containment and reduction of propagation. Often government regulations preclude the use of aquatic herbicides in sources of drinking water. In such cases, physical control practices are the method of choice for rooted submersed aquatic species such as Eurasian watermilfoil. In young introductions mechanical harvesting only exacerbates spread throughout the new habitat. Integrated sequential physical management procedures based on site-specific density of growth have been demonstrated to be most effective. In the current review, a 3-pronged approach was utilized: hand picking of small infestations, suction harvesting of small beds of moderately scattered cover and benthic mats for denser small beds of less than an acre. Success of such an approach is predicated on swift recognition of the invading species and a commitment to its containment. In 1988, faced with the introduction and potential for rapid spread in Lake George, an oligotrophic lake in upstate New York, we undertook to develop an integrated approach in hopes of curtailing the invasion in the lake.

This paper examines the success and failure of 15 years of management. Of the 146 sites where milfoil was present in 2003, 115 were reported cleared of Eurasian watermilfoil growth via physical control efforts. Fighting milfoil has become an annual maintenance effort draining the resources of the state agency currently managing the program. Now 15 years later how does one weigh the costs with the success and/or failure of the effort? Mapping selected sites of Eurasian watermilfoil growth and aquatic plant community assessments have demonstrated that native plant communities have suffered from the runaway expansion of milfoil, even at the current levels of management effort.

NOTES

NISbase: A Distributed Network for Invasive Species Information

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During the past decade, many non-indigenous species (NIS) database workshops have been held around the world to discuss NIS data sharing. These workshops have all concluded that XML and distributed databases are probably the best answer to this problem. With this in mind, NISbase has been developed as a XML-based distributed database system for NIS information. Designed by the Smithsonian Environmental Research Center and the United States Geological Survey, and built around existing NIS databases, NISbase enables end-users to search multiple data providers for species summaries and collections records from a single interface, much like Expedia.com searches multiple airlines for schedules and fares. Currently, NISbase includes five data providers from the United States and Australia with an emphasis on marine and aquatic NIS. The technical expertise required for participating in NISbase as a data provider has been intentionally kept to a minimum to allow for greater participation. Also easily implemented is the search portal, allowing for the potential creation of various regional and thematic NISbase portals.

NISbase can be accessed at http://www.NISbase.org

NOTES

The Aquaculture Compendium and the Crop Protection Compendium: Global Knowledge Bases for Aquatic Invasive Species

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CAB International publishes an award-winning series of multimedia Compendia on CD-ROM and the Internet. The Crop Protection Compendium provides information on 10,000 pests, diseases, weeds and their natural enemies compiled by more than 1000 specialists. It will be enhanced in 2004 with datasheets on over 300 invasive species, a number of which are aquatic species of regional or global concern. In addition, the production of a global Aquaculture Compendium is underway, for publication in 2005. This will include information on a range of invasive aquatic animals, plants and disease agents, concentrating on species in husbandry and their health. The development costs of Compendia are funded by Consortia, made up of government departments, development assistance organizations and private companies. This international group of stakeholders has an essential role in guiding and assisting the production of the Compendia. The Programme is part of CAB International's not-for-profit 'Information for Development' Programme.

At the core of each Compendium are many thousands of datasheets on individual species. These reviews contain detailed information on aspects of taxonomy; biology and ecology; distribution; means of movement and dispersal; management; production; invasiveness; impacts and control. Datasheets are illustrated and species distributions are mapped by a GIS system. There are a number of routes into the data, via various powerful searches; identification keys; a taxonomic hierarchy; and context-rich case studies. This wealth of knowledge is combined using the specially developed and unique Compendium Technology, which allows full searching and 'soft-linking' (a spontaneous linking facility within and beyond Compendia) across all the datasheets as well as entries in the glossary, bibliography, and library of background literature. Datasheets are authored by international experts, edited to a standard format and externally verified. Invasive molluscs and aquatic plants are already included in the Crop Protection Compendium. All commercial aquatic species that have been recorded as invasive in at least one location will be identified and relevant information collated. Most importantly, the Aquaculture Compendium will contain datasheets on over 300 diseases of aquatic species, many of which have the potential to spread.

The Invasive Species components of the Crop Protection Compendium and the Aquaculture Compendium will provide easily accessible and detailed sources of information on aquatic invasive species for decision makers and researchers alike. These Compendia are proven to assist users in assessing risks and evaluating impacts and control of potentially harmful organisms. The information is intended to assist in assessments regarding the importation of living organisms for consumption or reproduction, and the 'hitch-hikers' (diseases, parasites and phoronts) they may carry. This has important implications for biosecurity. Emphasis will be put on the invasive aquatic species already included in the Crop Protection Compendium and a prototype of the Aquaculture Compendium, also diseases in the existing Animal Health and Production Compendium. Compendia will be demonstrated during the conference, noting common aspects of the search and find technologies.

N O T E S

A US-Canadian Aquatic Species Inventory and Invasive Species Warning System

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Any non-native organism introduced to a habitat, other than the one in which it evolved, has the potential to become 'invasive' with dire ecological and economic consequences. Invasive species are second only to habitat destruction in causing biodiversity declines. Expanding human populations, the rapid global expansion of maritime trade (e.g., foreign ocean-borne trade is expected to double by 2020), and global warming further complicate this issue. Human-facilitated transport of species from one region to another includes hull fouling, ballast water releases, aquaculture practices, dumping of live bait, and purposeful introductions for bio-control. Reversing the damage caused by invasive species will take a concerted effort to prevent, detect, alert managers, assess invasion risks, initiate control measures, and evaluate remediation results.

National Ocean Service (NOS), the US Geological Survey (USGS), Smithsonian Museum, Bishop Museum, and other organizations are creating a peer-reviewed inventory of Hawaiian species. Additionally, they are now testing a prototype reporting, warning, and information system for the early detection of Hawaiian invasive species. The inventory and warning system began as a NOS pilot project in fiscal year 2002. In fiscal year 2003, USGS, the Smithsonian Museum, other organizations joined the initiative and began to make their biological databases interoperable. In fiscal year 2004, we began planning several pilot projects for the early detection of alien species in US coastal waters, and now are adding data from other regions to the Hawaiian pilot databases to begin building an aquatic species inventory and warning system for the entire United States and Canada.

Website users will be able to check regional survey results against a peer-reviewed inventory of species known to reside in US and Canadian aquatic ecosystems, map species distributions, search by species name or geographical region, and then download relevant data. If a species is reported as not on the 'official' inventory of species and taxonomists confirm it to be alien an aquatic ecosystem, then a warning message will be posted automatically to participating managers. Soon thereafter, the baseline species inventory will be changed and a species tracking report will be filed identifying who made the revision to the inventory, when, and why. Additionally, the website homepage will have information on invasive species, including risk assessments on the likelihood of a species becoming invasive. With sustained effort, the two-country aquatic species inventory and warning system could be in place as early as fiscal year 2008.

There is broad consensus on the need for such a system. With timely warnings, and other information from this initiative, managers should be more prepared to prevent future occurrences of alien species and mitigate impacts of invasive species already resident in US waterways. Reducing the potential for an alien species becoming established in an ecosystem will help maintain the habitat structure and function as it has evolved, thus preserving biological diversity. This system could reduce some of the pressure on protected species becoming extinct by preserving ecological niches for those organisms. Ultimately, we hope to slow down the trend of increasing alien species in aquatic ecosystems.

NOTES

SGNIS: Expanding the Knowledge Base Globally

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The SGNIS web site contains high-quality science and has been the web presence for the National Sea Grant College Program on non-indigenous issues since 1996. All research and outreach documents on the site's white pages have been subjected to peer-review making this one of the few genuinely peer-reviewed sites on the web. People who use the site can be confident that the available materials are of the highest quality.

Over 327 000 users from 125 countries used SGNIS in 2003, downloading nearly 4 million files. In addition to conducting a literature search (standard full-text search or search by 49 keywords, 18 product types, and 6 user types), researchers and other users can download the entire document or product they select on demand, 24 hours a day.

To date, the SGNIS database contains over 1700 Aquatic Invasive Species products or publications. Within the site, are over 922 completed research findings, 384 papers from six conference proceedings, 91 issues of newsletters, 106 slides in the graphic library, 96 outreach and education products and 579 articles on the site's gray literature section. Contributions to SGNIS have been made by over 100 organizations (20 of which are Sea Grant Programs) and 148 professional scientific journals.

SGNIS currently houses a selection of slides presented in two formats, one of a high-quality format to be used in report or brochure formats, and the other is a medium-quality suitable for some papers or media use. The slides undergo the same peer-review process as our publications. The slides selected are based upon scientific accuracy, long-term usefulness for public education, scientific presentations, and technical quality.

SGNIS also contains a kids section entitled "Nab the Aquatic Invader" which engages youth from grades 4-10 in learning through a variety of enjoyable activities. Young people are welcomed as junior detectives and super sleuths and invited to participate in "crime-solving fun" as they engage in each learning activity. Care was taken to ensure that activities are usable over modems, compatible with all browsers and compatible with teacher training materials and curricula developed for youth by Sea Grant Educators.

NOTES

The National Aquatic Nuisance Species Clearinghouse

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Aquatic invasive species have become a worldwide problem as the global economy has increased the transport of raw materials and finished products from continent to continent. Stakeholders interested in the introduction, spread, impacts, prevention, management and control of nonindigenous aquatic nuisance and invasive species require timely, reliable scientific information and fast, easy access to published research pertaining to such invasive organisms. In 1990, with financial assistance from the North American electric generation industry and the National Sea Grant College Program, New York Sea Grant established the Zebra Mussel Information Clearinghouse. The Clearinghouse quickly became the world's most comprehensive library of zebra mussel research.

But, the Clearinghouse is no longer "just" a zebra mussel information source. Since mid-1997, it has been the mission of the *"National Aquatic Nuisance Species Clearinghouse"* to:

- facilitate and coordinate aquatic nuisance, nonindigenous aquatic species, and aquatic invasive species information (ANS/NAS/AIS) sharing among researchers world-wide;
- provide continuity to the timely dissemination of findings of ANS/NAS/AIS research projects; and,
- and facilitate ANS/NAS/AIS prevention, management and control technology transfer between researchers and stakeholder audiences worldwide.

The Clearinghouse serves as a major link between the global aquatic invasive species research community and a wide array of university, government agency, industrial, and special interest stakeholders, and plays a high-profile role as a primary nexus for identifying completed, current, and proposed ANS/NAS/AIS research activities and for linking researchers with similar interests.

The Clearinghouse currently addresses more than thirty marine and freshwater aquatic nuisance and aquatic invasive species in a continually updated library and searchable database of around 7,000 documents on specific organisms, as well as the more general topics of biological macrofouling, ballast water, exotic aquatic organisms, and global and North American invasive species policy issues.

All Clearinghouse information is accessible to any researcher, agency, industry, utility, student, or other individual or group anywhere in the world having need of the information via electronic mail, fax, telephone, written requests, or visits to the Clearing-house. A keyword outline and full text searchable electronic database of the Clearinghouse's Technical Library Bibliography is available on the Clearinghouse's user-friendly World Wide Web home page (www.aquaticivaders.org). Citations include: author(s), title, document source and date, an annotation, type of publication, document length, language in which the document is written, whether the document is available from the Clearinghouse or direct from some other source, and the copying/mailing fee from the Clearinghouse. Most documents are available directly from the Clearinghouse on interlibrary loan and can be ordered via a convenient online "shopping basket." The web site also contains a series of detailed maps charting the range expansion of the zebra mussel and the "quagga" mussel in North America since 1989, information on a number of other informational and educational materials available from the Clearinghouse as well as extensive "hot links" to other North American and international ANS/NAS/AIS web sites.

The Clearinghouse's quarterly publication, *Aquatic Invaders*, presents North American and global papers on a variety of ANS/NAS/AIS and related topics such as: research, policy, impacts, new introductions, ballast water, education and outreach, and control measures as well as highlighting library holdings, useful web sites, and meeting announcements. A special 13th International Conference on Aquatic Invasive Species has been made available to all conference attendees as part of their conference registration materials.

The Federal Aquatic Nuisance Species Task Force and its various Regional Panels, the National Invasive Species Council, and numerous other state, federal, and international agencies and institutions utilize the Clearinghouse as a major channel for extending information on zebra mussel, aquatic nuisance, nonindigenous, and invasive species spread, research, and policy initiatives to all interested audiences. The Clearinghouse is now, clearly, an international aquatic invasive species resource for the 21st Century.

NOTES

Educators Respond to Invasive Species: Interactive Web-based Activities for Learning and Decision Making

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What kind of ballast treatment is best? Should we import a biological predator to control an invader? What is the best technique for control of a specific invading organism? Questions such as these are the subjects of an interactive Internet site developed by educators with the support of the Sea Grant program of the United States. Secondary school students learn about the origins, characteristics, and impacts of the invaders and then practice a structured decision making approach to determining how to deal with the issues. Knowledge of the invaders is one educational outcome, but knowledge of how to make reasoned decisions is a major result as well.

Other web sites produced by the Environmental Communications faculty and students at The Ohio State University include an on-line short course in Alien Species Education for teachers. Participants take components of the site, including games and art ideas, into their classroom settings and involve students in learning science and geography through the lessons. They submit student products, take quizzes and develop an instructional activity as a means of course assessment. Both the course and the decision making activities are based on the content of an educational database that currently includes information and images of over 30 invading species.

To reach young people directly, an education Web site focusing on aquatic invasive species has been developed for grades 4-10, by Illinois-Indiana Sea Grant and other programs in the Great Lakes Sea Grant Network. "Nab the Aquatic Invaders! Be A Sea Grant Super Sleuth" engages students using a detective theme to investigate invasive species concepts such as biology, spread, impacts, and control measures. On the site, students assist five detectives in solving cases as they learn about 10 exotic aquatic species such as silver carp, purple loosestrife, green crab, and nutria. After reading species "rap sheets," they'll have the knowledge necessary to understand how exotic aquatics affect the water environment and ways humans can help prevent the further spread of these organisms.

We will highlight the features of the site to show the instructional methods used to encourage creative thinking and problem-based learning. In addition, we will show how students' understanding will be assessed through the "Book'em" section, which culminates their investigative mission.

Additional information about the sites and an opportunity to view them will be offered through a poster session entitled "Classroom Technology for Learning and Decision Making About Invasive Species."

NOTES

Species Invasiveness and FishBase

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Introduction records (3043) of finfish comprising 170 species of fish with more than three reported international introductions were analyzed with respect to successful or unsuccessful establishment in the wild. Records with unknown success of establishment were ignored. The percentages of successful establishments were used to rank the invasiveness of the species. Those with more than 25% successful establishments were considered invasive.

Several biological traits of these species were then analyzed and correlated to establishment and invasiveness: maximum lengths, longevity in the wild, salinity tolerance, temperature range, food range, trophic level, type of parental care and resilience/productivity (derived from available data on age at maturity, maximum age, growth and fecundity). Analysis was done using available information in FishBase.

Salinity tolerance was classified with respect to occurrence in fresh, brackish or saltwater as follows: the number of these salinity categories inhabited by a species gave a score from 1 to 3. Temperature and general environmental tolerance was derived from the native latitudinal range of the species. The number of large food groups (e.g. nekton, benthic animals, etc.) in the diet of the species was taken as an indication of the breadth of the diet. Trophic level of the species was a continuous variable from 2 for herbivores to >4 for top predators and parasitic fishes. Degree of parental care was classified from non-guarders, guarders to internal bearers. Resilience/productivity categories ranged from 'Very low' to 'High'.

Preliminary correlation analyses with percent establishments as dependent and all of the above independent variables resulted in explanation of 20% of the variance in the data set. Resilience, maximum lengths and longevity in the wild were the strongest predictors of invasiveness whereas trophic level apparently did not play a role in species establishment. Next steps to improve prediction of invasiveness are discussed.

N O T E S

Exploring the Concept of a World Atlas of Invasive Aquatic Species: Food for Thought from the UNEP World Conservation Monitoring Centre and the GEF/UNDP/IMO Global Ballast Water Management Programme (GloBallast)

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The UNEP World Conservation Monitoring Centre (WCMC) (www.unep-wcmc.org) was founded in 1979 and became an international non-profit cross-cutting specialist agency of the United Nations in 2000. Its main role is to organize and disseminate knowledge on the status, conservation and sustainable use of biodiversity and ecosystems worldwide, with particular focus on: 1) analysis of the state of global biodiversity, assessments of the trends and provide early warning of emerging threats in support of international action; 2) conventions and policy support to international agreements and programmes that promote biodiversity conservation and sustainable management, with particular attention to the Convention on Biological Diversity, and; 3) biodiversity information services to support international action by providing expertise, tools, techniques and information for public awareness, education, capacity-building and cross-sectoral cooperation, with special capacity in managing very large databases on species and protected areas, and in mapping and GIS.

The GEF / UNDP / IMO Global Ballast Water Management Programme (GloBallast) (http://globallast.imo.org), is a Global Environment Facility (GEF) — funded technical cooperation, institutional strengthening and capacity building programme being implemented by the United Nations Development Programme (UNDP) and executed by the International Maritime Organization (IMO), to assist developing countries to reduce the impacts of invasive aquatic species, especially those transferred through ships' ballast water and sediments. GloBallast is working to achieve these objectives by assisting countries to prepare for implementation of the *International Convention on the Control and Management of Ships' Ballast Water and Sediments'*, recently adopted IMO member States, and is undertaking a wide range of technical cooperation activities in six regionally representative demonstration sites world-wide.

The IMO – GloBallast Programme and UNEP-WCMC are currently considering a joint project to scope-out the possible development of a World Atlas of Invasive Aquatic Species. The development of such an Atlas is still very much in the conceptual stage, and IMO-GloBallast and UNEP-WCMC are currently seeking input and feedback from potential Atlas users and contributors. It is proposed that a comprehensive collation of data on all aquatic invasive species will be carried out by making the many and varied existing databases interoperable. This would support a global review of the state of our knowledge of aquatic invasive species, an assessment of the impact on biodiversity and an analysis of the existing and potential policy responses. Published in a high-quality high-impact professional format which has proved to be very successful for similar reviews (e.g., the World Atlases of Coral Reefs (2001), Biodiversity (2002), Seagrasses (2003). See http://www.ucpress.edu/books for biodiversity, coral reefs and seagrasses atlases and Great Apes http://www.unep-wcmc.org/species/GRASP/. The research behind the book would employ innovative information management and spatial analysis techniques.

However, as details are entirely flexible at this stage, UNEP-WCMC and IMO-GloBallast invite you to a side event in the Abbey Suite at 5:30 pm on Thursday, September 23. Further information on the atlas concept will be presented by the UNEP-WCMC and IMO facilitators, then the meeting will open up to a round-table discussion to garner feedback from the participants on setting the direction for the Atlas.

NOTES

Bioinvasion of the Pacific Oyster into the East Frisian Wadden Sea, Germany: Will *Mytilus*-beds be Replaced by Oyster-reefs?

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In the East Frisian Wadden Sea (western part of the German North Sea coast), the indigenous oyster *Ostrea edulis* (Linnaeus, 1758) disappeared at the beginning of the 20th century as a result of overexploitation. As a substitute, the Pacific oyster *Crassostrea gigas* (Thunberg 1793) was introduced and, as in many other regions of the world, escaped from cultures. Unlike in the northern Wadden Sea, where a population of *C. gigas* is constantly replenished by a local oyster culture, the East Frisian Wadden Sea is invaded from oysters spreading east. These originate from cultures set up in the 1960s in the Oosterschelde estuary, The Netherlands, where the oysters established wild populations functioning as a source for the invasion of the Dutch Wadden Sea. By the late 1990s, the first Pacific oysters were recorded in the western part of the German Wadden Sea.

This situation offers the opportunity to investigate several aspects of the invasive biology of *C. gigas* and its effects on the ecosystem being invaded. Is the progressive invasion by *C. gigas* dependent on the long-distance dispersal of larvae and/or on the size of the local reproductive stock? Would a temperature rise due to climate change favour their establishment? A project we started in early 2003 has revealed a regional gradient with declining abundances of Pacific oysters from a maximum of 424 700 ind/ha in westerly to 900 ind/ha in easterly areas of the East Frisian Wadden Sea. Size-frequency distributions show that the populations originate from one to two large spat falls which probably occurred 2001 and 2002, whereas the few large individuals might originate from earlier and smaller spat falls. The recorded settlement sites of Pacific oyster larvae include shells of blue mussels (*Mytilus edulis*), cockles and periwinkles, but also oyster shells themselves, a strategy in support of the development of oyster reefs. Thus, will oyster reefs replace mussel beds in the Wadden Sea one day? Our surveys show that the majority of the Pacific oysters occur at sites of (former) mussel beds in the intertidal. While studies on competition for space are under way, preliminary lab experiments on competition for food indicate that *C. gigas* is competitively superior to *M. edulis* in terms of filtration rate. We will discuss the prospect of a further establishment of Pacific oysters in the East Frisian Wadden Sea and implications on this tidal flat ecosystem and the blue mussel fishery in the region.

NOTES

Invasive Macroalgae on Hawaii's Coral Reefs: Influence of Biodiversity on Invasion Success and Ultimate Consequences to Ecosystem Function

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While a number of fish, invertebrate and algal species have been introduced to coral reef regions around the world both intentionally and accidentally invasive species have generally not been considered among the primary threats to these ecosystems. In general invaders in tropical ecosystems tend to be restricted to protected or highly disturbed environments such as harbors and bays and when they have escaped to open coastlines they have generally remained benign. It is unclear why invasive species have not become more problematic in the tropics but perhaps these systems are more resistant to invasion than other ecosystems. Hawaii's reefs are an exception to the above statement where a number of nonindigenous macroalgal species have successfully established in a variety of reef habitats. The goals of this study were to examine relationships between invader success and biodiversity, to examine interactions between invaders and other benthic reef species, to identify other physical and/or biological factors that may enhance (or co-vary with) invasion success and to quantify the long term consequences of such invasion events to the structure and function of Hawaii's reefs.

NOTES

Testing Intertidal Community Invasibility: The Role of Nutrient Supply and Perturbations

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More than 20 years after its arrival, the Japanese seaweed *Sargassum muticum* has successfully colonised many intertidal habitats in the northern coast of Spain. Studies on the invasion of this species have mostly focused in the biology of the invader, considering its invasive abilities as the factor that would explain the success of the invasion. Nevertheless, susceptibility of local communities to invasion should also be considered. To date, invasibility of local communities by *Sargassum muticum* has been mostly ignored.

Here we present the results of a manipulative experiment designed to test how resources availability determines the invasibility of a native intertidal algal assemblage by *Sargassum muticum*. The experiment was set up in a *Gelidium latifolium*-dominated algal assemblage in March 2003. Levels of two resources (nutrients and space availability) were manipulated in plots using a fully orthogonal design (three levels per resource: high, medium and low). In order to simulate the invasion by *Sargassum muticum*, fertile plants of the invader were attached to the plots by the summer of 2003.

Percentage cover of the different species of macroalgae on the plots was recorded at the beginning of the experiment and monthly from December 2003. Density and size of the new *Sargassum* recruits were recorded in September (when they became conspicuous to the naked eye) and monthly from December 2003.

Although highly variable, recruitment of *Sargassum muticum* was higher in plots with more availability of space and nutrients. Furthermore, the size of the plants of *Sargassum* and their cover was higher in plots with higher levels of nutrients. The results of this work support the idea that a community becomes more susceptible to invasion whenever there is an increase in the amount of unexploited resources, which agrees with the theory of invasibility proposed by Davis, Grime and Thompson in 2000.

NOTES

Timing of Gamete Release in the Native Brown Seaweed *Cystoseira humilis* and the Invader Species *Sargassum muticum*

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Sargassum muticum (Yendo) Fensholt is a monoecious brown seaweed originating from the coasts of Japan, China and Korea. After been introduced and spread along the Pacific coast of North America, it was recorded in Europe in 1971 and rapidly spread from the British Isles. As of today it can be found throughout Europe from Norway to Portugal as well as in the Mediterranean. Clearly, *S. muticum* is an aggressive invader, exhibiting a combination of opportunistic features (high growth rates, large reproductive output) and perennial persistence (great regenerative capacity and long lifespan). In its introduced areas *S. muticum* has caused displacement of native species through over-growing and shading underlying species (*Laminaria saccharina*, *Zostera marina*, eel grass beds and *Halidrys siliquosa*). In addition, this species is a pest and fouling organism which is reported to interfere with recreational use of waterways, particularly when it becomes detached from holdfasts and floats off forming large masses as it blocks propellers and intakes. It is also a fouling organism on oyster beds and a nuisance to commercial fishermen, fouling their nets.

At its southern distribution limit in Europe, the southwest coast of Portugal, *S. muticum* develops in tide pools. Along this exposed coast, sheltered tide pools form a specific habitat in which colonization by the species starts. Pools invaded are originally inhabited by *Cystoseira humilis* Kützing. Important for the initial settlement and further spread might be differences in gamete release between the competitive native and alien species. Therefore, we tested if gamete release in both species has the same timing, and if the pattern of release could be related to the lunar cycle. Expulsion and release of gametes was monitored daily for more than two months in three pools for each species. Our result show clear differences in the timing of gamete release between the two species. Timing seems to be more related to the tidal cycle than the lunar cycle. Egg expulsion in *S. muticum* took place during spring tides, which occur in the morning, whereas in *C. humilis* it was during neap tides (concentrated around mid day). This might have consequences for fertilization success and gamete dispersal and survival.

NOTES

Asterias amurensis Management Strategy Evaluation Part 1: Integrating Population Biology and Oceanography to Determine the Limits of Natural Dispersal and Population Growth

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The Northern Pacific seastar *Asterias amurensis* is an active predator that was first found in southern Australia in the Derwent estuary, Tasmania in 1986. Since that time the population has grown to over four million seastars. In 1998, significant numbers of juvenile seastars were found in Port Phillip Bay and the population in the Bay has since grown to over 100 million. *Asterias amurensis* larvae are present in the water column for about 3 months, providing ample scope for their natural advection from these two sites. However, only sporadic outbreaks of juveniles have been observed along the east coast of Tasmania and across the south coast of Victoria.

Understanding the magnitude and direction of larval movement by currents and movement by ships is necessary to effectively manage vectors and to predict where future invasions of *Asterias amurensis* are likely to occur. A population model of the seastar was developed from data collected in the Derwent Estuary. This model estimates larval production in the Derwent estuary by incorporating growth, mortality, egg and sperm production and density dependent fertilisation success. The population model predicts that approximately 10^{11} larvae are produced in the Derwent, with approximately 99% advected to the open ocean. Larval mortality and settlement sucess can be estimated by calculating the number of larvae needed to maintain a steady population in the Derwent estuary, given the known advection rates out of the estuary.

Port Phillip Bay produces approximately 10^{12} larvae due to its larger population size, and exports 90% to oceanic waters. Larvae in the Tasman Sea and Bass Strait are moved along the east coast of Tasmania and across the south coast of Victoria. Populations that establish on the coast are not self sustaining as larvae are swept away by the prevailing oceanic currents. However, if populations establish in estuaries, the likelihood of successful invasion significantly increases with retention and time. Estuaries in Tasmania, Victoria and South Australia that are most at risk of invasion by *Asterias amurensis* can be identified. Larvae may arrive in some of these estuaries through natural dispersal or vessel traffic may facilitate invasions. However, for many of the ports/estuaries in South Australia, the only vector introducing larvae will be shipping.

NOTES

Asterias amurensis Management Strategy Evaluation Part 2: Defining and Testing the Effectiveness of Management Options

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The threat of marine organisms arriving in Tasmania in ballast water sourced from Japan was first noted in 1973. Nothing was done. The Northern Pacific seastar *Asterias amurensis* was identified in Tasmania in 1992 and the population estimated at 28 million individuals. The threat of the seastar spreading to mainland Australia was recognised, but again nothing was done. Between 1995 and 1997 four adult seastars were collected in Port Phillip Bay, on the mainland 700km away. In 1998, 103 juveniles were collected from mussel ropes in Port Phillip Bay. By 2000, the population was estimated at 150 million individuals, with a biomass of ~3 000 tonnes. Total biomass of demersal fish in the Bay is ~4 000 tonnes. The Port of Melbourne in Port Phillip Bay is a major shipping hub for Australia and it is to be expected that the seastar will be spread throughout southern Australia. Can anything be done? Of course it can, but of all the management strategies available to us – ballast water regulation, biofouling reduction, population reduction through physical removal, biological control or genetic manipulation, early warning and emergency response – which will work best? And how will we know whether or not a strategy is working, or whether we are achieving the goals set by managers? Management Strategy Evaluation has been developed to answer these questions and applied to the harvest of marine fisheries and whales, and more recently to ecosystem management. In this paper, we present the first results of applying Management Strategy Evaluation to reducing the spread of the Northern Pacific seastar.

NOTES

A Model for Forecasting the Propagation Potential of the Invasive Indo-Pacific Lionfish, *Pterois volitans/miles* in the Western Altantic with Inferences on Ecosystem Effects

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With the recent discovery of Indo-Pacific lionfish in the western Atlantic, questions regarding the rate of population expansion, predicted distribution, and ecological impacts are valid concerns. We are developing a stage-based matrix model to predict the rate of lionfish population growth. Reproductive parameters such as fecundity and seasonality of spawning will be determined by spawning and rearing experiments, and by analysis of field collected specimens. To date we have successfully spawned lionfish and are working to develop rearing techniques to provide egg and larval survival and growth rate estimates. We will also use larvae to determine thermal effects on survival, as lionfish native habitat is significantly warmer than the western Atlantic as a whole. This information will provide forecasting capabilities regarding range expansion and more importantly the rate of population growth in the western Atlantic. As lionfish are venomous and voracious predators, we are conducting laboratory tests to determine potential lionfish prey, and thus estimate predation effects on local reef fish communities. We are also working to determine if lionfish are vulnerable to predation in their new habitat. This research will provide early analysis of lionfish population growth accounting for both reproductive biology, critical thermal limits during the larval life stage, and predation pressure. The results of this research will provide increased knowledge of issues associated with marine finfish invasions and will provide further methodology to assess the impacts of future invasions.

NOTES

Impact Analysis of the Red King Crab *Paralithodes camtschaticus* on Macrobenthos of the Barents Sea: The Maiden Estimates with Sea Urchin *g. Strongylocentrotus*

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The red king crab, which was introduced to the Barents Sea from the Far East in 1960s, has formed a stable, self-reproducing population, causing limitations on crab fishery. Recently, this invader has become a dominant species in coastal benthic communities of the Norwegian and Barents Seas. In spite of this, the effects of the crab population on the ingenious bottom fauna remain obscure. In order to evaluate the predator activity for adult crabs in the coastal zone of the Barents Sea, stomach sampling was made during 1999-2000. The effect of crabs on benthos was estimated both on the basis of weight/caloric value of the stomach contents and on the basis of calculation of live weight/caloric value of benthic organisms caught and eaten by the crab (i.e., biomass actually eliminated from the communities).

The sea urchin species g. *Strongylocentrotus* are among the principal diet items of red king crabs. The frequency of sea urchin occurrence in food of the adult crabs in different seasons ranges from 8 to 25% (on average, 15%). The total rate of elimination of medium-sized (mean size, 30-50 mm) sea urchins by the adult crabs can be estimated at 45 (~50) x 10^6 specimens per year. Hence, an adult part of the red king crab population in the Barents Sea can consume annually at least 15% of stock of the Murman coast population of sea urchins *g. Strongylocentrotus.*

Thus, the result was as an example that traditional calculations of the predation rate by red king crabs on the basis of stomach contents proved to be at least an order of magnitude lower than the actual rate of elimination of benthos biomass by the population of the invader.

NOTES

An Asian Carp Rapid Response Plan for the Chicago Sanitary and Ship Canal Dispersal Barrier

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Constructed in 1910, the Chicago Sanitary and Ship Canal forms a unique man-made link between the Mississippi River basin and the Great Lakes basin by connecting Lake Michigan with the Des Plaines River. The canal reversed the flow of the Chicago River, carrying water away from Lake Michigan. Originally built to convey wastewater away from Chicago and to facilitate navigation, this waterway also may serve as a two-way corridor for the spread of aquatic invasive species.

In April 2002, an electric barrier was energized with the intent of preventing the spread of invasive fishes via the Chicago Sanitary and Ship Canal. The electric barrier was constructed as a demonstration project and has an anticipated service life of only 36 months. During its first 18 months of operation the barrier has suffered one 25-hour failure of the four pulse generators associated with an erroneous assumption about the electric supply and one electrode has shorted out likely due to metallic debris in the canal. Monitoring of the barrier using radio-tagged common carp indicated one tagged fish crossed the barrier array at the same time a barge was passing through the barrier site.

The short service life of the barrier is of concern because the barrier will have to be shut down for maintenance. Currently, two species of Asian carp, the bighead carp (*Hypophthalmichthys nobilis*) and silver carp (*Hypophthalmichthys molitrix*) are known to be less than 36 kilometers downstream of the barrier. The State of Illinois and the US Army Corps of Engineers are supporting design and development of a second, larger electric array with a longer service life to be placed 300 meters downstream of the existing array. The second array must be completed prior to failure of the electrodes in the first array to prevent the Asian carp from passing through the barrier site to Lake Michigan.

To avert the spread of Asian carp into the Great Lakes, a committee of stakeholders and regulatory agencies was assembled to develop a rapid response plan to be implemented in the event that the Asian carp threaten to pass the barrier site. The response plan involves piscicide application on an 8.9 km canal reach to eliminate Asian carp from the canal between the barrier and a downstream lock and generating station. The plan includes a comprehensive outreach component to engage public understanding and support of the proposed plan.

This paper will discuss the Asian carp rapid response plan, the near term and long term objectives of the Chicago Sanitary and Ship Canal Dispersal Barrier project, performance of the barrier and monitoring results, potential new barrier components and developments towards a system with a longer service life.

NOTES

The Potential for an Acoustic Based Barrier to Prevent Entry of Carp Species Into New Habitats

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The dispersal of unwanted fish species, once introduced, has been recognized as a major problem since the lamprey eel gained access to the Great Lakes through the Welland Canal and spread into all the Great Lakes between 1921 and 1946. Currently, there are fears that several species of the Asian Carp will spread into the Great Lakes through the Chicago Ship and Sanitary Canal.

Carp are considered to be in the “hearing specialist” category of fish species. An acoustic-based system that takes advantage of the carp’s hearing sensitivity could help limit the dispersal of carp into new areas and protect vulnerable areas such as wetlands in areas where carp are already present. We propose an adaptation of an existing system used to prevent ingress of clupeids (herring, alewife and shad) into cooling water intakes. Although the inner ear of the clupeids is configured differently from carp, clupeids are also considered hearing specialists and the acoustic behavioral barrier takes advantage of their ability to sense acoustic pressure.

Experiments conducted by the New York Power Authority (NYPA) using a 125 kHz acoustic system at the Fitzpatrick Nuclear Power Plant on Lake Ontario demonstrated 96% effectiveness in keeping clupeids from the cooling water intake, day and night, with little or no habituation to the acoustic pulse.

We propose that the current acoustic barrier design is likely to be effective in limiting the spread of the Asian carp. The system should be tested on various carp species, under field conditions, to verify its effectiveness.

This paper will introduce the fundamental concepts of fish hearing, transducers and underwater acoustics and will provide a historical perspective of the state of the art in acoustic fish deterrence. It will also describe the configuration of the acoustical barrier and the testing program required to verify the effectiveness of the barrier against carp.

NOTES

Eradicating the European Carp from Tasmania

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European carp (*Cyprinus carpio*) was discovered in 1995 in two Tasmanian lakes. The decision was made to eradicate the carp from these lakes before they could spread downstream and further degrade the environment and recreational fisheries. Draining or poisoning the lakes was not a preferred option because of engineering and environmental constraints. The carp would be eradicated from the lakes through fishing. Unlike many fisheries, our objective is total eradication of the population – this fishery has no catch restrictions and no direct commercial value. We describe the approaches used to maximise the effectiveness of our fishing effort – the many gear types used, recruitment reduction, radio-tagged Judas fish, sex-ratio biasing, etc. We describe the difficulties that we are facing in removing the last few fish – gear avoidance, changes in behaviour, eagles stealing the tracker fish, etc. To support the eradication effort we developed a model, which uses daily catch and tag return data to find maximum likelihood estimates of population size, tag shedding rates and mortality rates. We present the results from this model. Lastly, we comment on the lessons learnt from this eradication and the implications for the eradication of other carp populations through fishing.

NOTES

Invasion of Ctenophore *Mnemiopsis leidyi* into the Caspian Sea and Measures to Control its Population Size

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Zooplanktivorous ctenophore *Mnemiopsis leidyi* was introduced into the Black Sea with ballast waters from the ships in the early 1980s. Its native habitat is in temperate to subtropical estuaries along the Atlantic coast of North and South America, where it is found in an extremely wide range of environmental conditions. *M. leidyi* had an explosive outbreak in the Black Sea and expanded into the Azov, Marmara, Eastern Mediterranean through the straits and in some its areas through ballast water, and recently into the Caspian Sea with ballast water of the oil tankers.

Thus the Black Sea became the second donor area for Mnemiopsis invasion for the seas of the Mediterranean basin and the Caspian Sea. It was determined that the relatively high salinity (18-22%), high temperature and high prey (zooplankton) concentration are the most important conditions for *M. leidyi* population growth in recipient areas.

As a result, during ten years *M. leidyi* became the most distributed in different conditions of the estuaries and coastal areas of the World Ocean and its effect on the ecosystems in native and particularly in non-native habitats and economical loss may estimate in millions US dollars.

In 1997 GEZAMP suggested to introduce another ctenophore *Beroe ovata*, a specialized predator for zooplanktivorous ctenophore like *M. leidyi* to control its population in the Black Sea. These suggestions were not implemented in time, but *B. ovata* appeared in the Black Sea spontaneously as *M. leidyi* from the same area. The Black Sea ecosystem began rapidly to recover.

Using this positive natural example we performed experiments testing the feasibility of *B. ovata* introduction as an effective predator on *M. leidyi* to the Caspian Sea. Our experiments in the Caspian Sea water showed that *Beroe ovata* could live at minimal salinity 7-8%, could feed on Mnemiopsis, had normal metabolism rate and could reproduce at the minimal salinity 10%. But optimal salinity with higher reproduction rate was estimated at 11.00 % and higher. Ovae obtained at this salinity could develop, larvae hatched and continued development and growth.

Thus physiological evidence suggests that in Caspian water with salinity 10-13%, *B. ovata* reproduces, grows and ingests *M. leidyi*. Released to the sea, it could establish reproducing population. This salinity is characteristic for the Middle and Southern Caspian, and it is a main area of Mnemiopsis distribution. If we could receive positive effect after *Beroe* introduction it would be important event of man's actions on recovering Caspian biodiversity and fishery.

NOTES

The Spread and Attempted Control of the Invasive Seaweed, *Caulerpa taxifolia*, in New South Wales, Australia

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Caulerpa taxifolia is a marine green macroalga that is endemic to tropical and sub-tropical regions around the world. The alga hit the headlines in 1984 when an invasive strain was discovered in the Mediterranean Sea. From Monaco, *C. taxifolia* has spread to the French coast and numerous other countries. *C. taxifolia* was first discovered in NSW, Australia in April 2000 and is now present in 9 waterways, growing primarily on soft sediments at depths of 0.5 – 8 metres. Infestations, which range from sparse distributions of scattered runners to dense beds 40 cm thick, cover approximately 8.1 km^2 of seafloor in NSW. Here we outline the invasion of *C. taxifolia* in NSW and describe the methods used to control the alga. The application of coarse sea salt at a concentration of approximately 50 kg/m^2 was considered the most effective method of control as it was relatively cheap and experiments demonstrated that it killed the alga and had relatively minor effects on native biota (seagrass and infauna). One week after salting, mean frond density of *C. taxifolia* had decreased by 70 – 95% and was significantly less than in unsalted control plots. Both seagrass and infauna were affected by salt, but abundances had generally recovered 6 months after salt had been applied. Salt can be applied to small areas by divers, but larger-scale application is achieved using a 7 m flat-bottomed boat with a purpose-built hopper which holds 1 tonne of salt. The effectiveness of salting depends on the method of application used. Moreover, application appears to be most effective in the cooler months when *C. taxifolia* dies back naturally and salting at this time also allows the native seagrass, *Zostera capricorni*, to recover during Spring/Summer. Results of large-scale salting have been mixed. In one waterway, a single application of salt has resulted in the apparent removal of almost 5200 m^2 of *C. taxifolia*, whereas in another, repeated salting of a 3000 m^2 infestation has led to a considerable reduction in the density of the alga, but no overall change in the boundaries of the infestation. To date, salting has been used effectively only on soft sediments in water < 6 m. Further research is being planned to examine the effects of repeated salting on native biota and to investigate natural fluctuations in abundance of *C. taxifolia.*

N O T E S

Appearance of Zebra Mussels in a Reservoir of the Ebros Basin: Control Strategies

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The zebra mussel was discovered in Spain three years ago; scientists thought that it could have arrived in the year 1999 on a vessel. Not many actions have been taken to control or eradicate the invasion. We present the actions that have been carried out in the past and the control strategy designed for this year.

The measures carried out by the Ebro Hydrographic Confederation are prevention of new introductions and establishment of zebra mussel in new areas. The first source of the zebra mussel population came from a reservoir called Riba-roja with a surface of 2.152 hectares. The Ebro Hydrographic Confederation has elaborated new navigation rules to control the zebra mussel invasion. Other actions have been: identification of confirmed high-risk areas; the locking of all illegal jetties; and the requirement that external submerged surfaces and internal circuits be cleaned when vessels come in and out of infected areas.

This year we want to start a control strategy to reduce the zebra mussel population. We would act over the reservoir's population. Between the control methods proposed the most interesting is to lower the reservoir's water level gradually, to a maximum of 6 meters, to cause the desiccation of zebra mussels at high temperatures during the summer, while studying environmental and economic impacts of this measure of control on the river ecosystem downstream. On the other hand, we are studying the possibility of removal of the mussels by hand, using divers.

NOTES

Vectors for Introduction of Alien Macroalgae in Europe: Oyster Transfers

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Transport of shellfish is a common feature in European aquaculture. During the early 1970s, the Japanese cupped oyster *Crasssotrea gigas* has been introduced in France. Some macroalgal introductions have been associated with this event, such as the primary introduction of *Undaria pinnatifida* and *Sargassum muticum*.

Some areas such Mediterranean coastal lagoons have been more affected by these macroalgal introductions. This is the case for the Thau Lagoon (south coast of France) where 45 exotic species have been observed, mainly native from the Japan and Korea area.

An experiment has been carried out to assess the risk of transferring exotic macroalgae to other European culture areas. Indeed, the Thau Lagoon is a growing site for oyster culture in France and there is much exchange of livestock with the Atlantic coasts and other parts of Europe.

Oyster shells have been processed by farmers (cleaning with high pressure spray followed by a short stay in the lagoon) and conditions of a normal transfer have been recreated (emersion in isothermic boxes). Shells are then cultured in tanks. Around 20 species of macroalgae (with some exotics present only in the lagoon) were found after a 40-day period of culture.

Short or long duration transfers have no effect on the flora. Consequently, propagules of exotics are constantly introduced from the Thau Lagoon to other shores. Short immersion in hot seawater seems to be an efficient treatment against macroalgal epibiontes.

NOTES

Vector Management Tools for Invasive Marine Species: Reducing the Spread of Biofouling Pests With Aquaculture Transfers

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In New Zealand, a push for the rapid expansion of the mussel farming industry had led to permits being granted for open coastal aquaculture blocks covering several thousand hectares. In recognition of the biosecurity risks associated with both new developments and existing operations, aquaculture companies are becoming increasingly aware of the need to ensure that their inter-regional transfer practices for equipment and seed-stock do not result in the inadvertent spread of pest species. This paper will provide an overview of recent research in New Zealand aimed at development of management tools that will allow the aquaculture industry to meet these challenges. In particular we discuss research into environmentally-friendly sterilisation methods for mussel seed-stock based on freshwater, heat and acetic acid. We will present results of lab-based research, and preliminary findings from field-scale validation trials.

N O T E S

Implementing A Sea Lamprey Control Program in the Laurentian Great Lakes

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The sea lamprey (*Petromyzon marinus*) is a primitive, jawless fish that invaded the upper Laurentian Great Lakes through shipping canals in the 1920s. During the parasitic phase of its complex life cycle, it feeds exclusively on blood and body fluids, often killing host fish. Sea lampreys were a major contributor to the decline of valuable commercial and sport fish in the Great Lakes and remain a considerable threat to the health of the ecosystem.

To combat the sea lamprey, the governments of Canada and the United States established the Great Lakes Fishery Commission in 1955. Since the 1950s, the sea lamprey control program has relied on the removal of sea lamprey larvae with selective lampricides on a 3-5 year cycle. Selection of streams for these treatments has evolved from qualitative evaluations to quantitative comparisons of cost effectiveness.

Alternative control efforts include: construction of barriers to block spawning migrations, enhanced trapping to remove animals from spawning runs, and the release of sterilized males to reduce spawning success. Application of these alternatives requires measurement of their effectiveness and their efficiency. Cutting-edge research into new alternative control methods has focused on migratory and spawning pheromones as a way to disrupt the sea lampreys spawning behavior.

Sea lamprey control has been a success, reducing populations by 90% in most areas of the Great Lakes. This program is an example of successful management of an aquatic invasive species that has met the requirements of a complex ecosystem and complex institutional arrangements. Lessons learned from the successes and challenges faced during the 50-year history of this integrated control program may be applicable to other large-scale species management programs.

NOTES

Benefit-Cost Analysis of Water Hyacinth Control Methods in Lake Victoria, Kenya

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NOTES

Filtration Rates of the Invasive Pest Bivalve *Limnoperna fortunei* as a Function of Size and Temperature

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Limnoperna fortunei (Dunker, 1857) is a freshwater bivalve mollusc native to the rivers of Southeast Asia that appeared in Hong Kong in 1965, between 1980 and 1986 in Japan, Taiwan and Korea, and in Argentina in 1990. Most of these invasions are thought to have occurred via ships ballast water. Presently the geographic range of this species in South America covers the entire Paraná-Uruguay-Río de la Plata watershed, including Argentina, Uruguay, Paraguay, Bolivia and Brazil, extending over 3000 km upstream from its original place of entry – the Río de la Plata estuary. Shortly after arrival, *Limnoperna's* bysally attached populations reach densities in excess of 150 000 ind. m^{-2} clogging pipes, filters, heat exchangers, condensers etc. in industrial and power plants that use raw water, chiefly for cooling purposes. In addition, similarities between the zebra mussel and *L. fortunei* suggest that the latter may have an even stronger environmental impact than *Dreissena*. It is anticipated that *Limnoperna's* filtering activity affects strongly trophic interactions and the availability of food for both pelagic and benthic species, and the rates of other ecosystem processes including mineralization of nutrients, oxygen availability and sedimentation rates, yet research in this direction has so far been practically absent. In order to contribute to the assessment of these impacts, laboratory filtration experiences were performed using monocultures of the alga *Chlorella vulgaris*. Experimental conditions included two mollusc sizes (15 and 23 mm), and three water temperatures (15, 20 and 25°C) covering the normal thermic seasonal range in the lower Paraná river and Río de la Plata. Filtration rates obtained were, for the larger mussels: 9.9, 13.1 and 17.7 ml mg tissue dry weight $^{-1}$ h^{-1} at 15, 20 and 25°C, respectively, and for the smaller ones: 17.7, 20.8 and 29.5 ml mg^{-1} h^{-1}. Differences between sizes and between temperatures (except for those between 15 and 20°C) were statistically significant. These results indicate that although in absolute terms larger animals have higher clearance rates, as a function of body mass smaller individuals feed more actively. Within the range of experimental values used, filtration rates were positively associated with water temperature. These clearance rates (125-350 ml $individual^{-1}$ h^{-1}) are generally higher that those reported for other suspension feeding bivalves, including the invasive species *Dreissena polymorpha*, *D. bugensis* and *Corbicula fluminea*. These high filtering rates, associated with very high densities (up to over 150 000 ind. m^{-2}) suggest that the environmental impact of this mussel may be swiftly changing ecological conditions in the areas colonized.

NOTES

Density of *Limnoperna fortunei* in Paraguay River, Brazil

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Limnoperna fortunei (Bivalvia, Mitylidae) was introduced into South America in 1991 in the La Plata River (Argentina). It arrived in the ballast water of ships coming from Asia, where this species is native. It was first observed in 1998 in the Paraguay River, Brazil. *Limnoperna* was introduced into the Pantanal region as hull fouling of vessels using the Paraguay-Parana waterway. This study provides details of its occurrence, density and impacts. From 2002 to 2003, observations and sampling on natural and artificial substrates in the Paraguay River were made.

On artificial substrate, from October 2002 to September 2003, the density was between 3.9 to 7019.9 individuals m^{-2}. On natural substrate (rocks) was found up to 10 000 individuals m^{-2} in September of 2000 and 21 950 individuals m^{-2} in September of 2003. The densities observed were quite low compared to those found in Southern Brazil, where values up to 100 000 individuals m^{-2} have been recorded in the last three years. In the Paraguay River, the population density of *L. fortunei* can be negatively impacted by periodic low levels of dissolved oxygen and decreases in pH to between 6 and 7. Such conditions are frequently present during the periodic flooding or inundation of this area. Under these conditions, a high mortality of *L. fortunei* was recorded in March of 2002, on both natural and artificial substrates.

In 2003 the values of dissolved oxygen and pH decrease in April to June, there wasn't mortality but the density of adults and larvae stage was very low in this period. Despite low densities, *L. fortunei* can colonize water cooling systems of boats, obstructing water circulation and causing motor overheating. Accumulation in water supply equipment, such as pumps and pipes has also been observed.

N O T E S

A 10-year Study of the Population Dynamics of *Corbicula fluminea* including Eventual Extinction in the Clear Fork of the Trinity River in North Central Texas

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A population of the introduced Asian clam, *Corbicula fluminea*, was sampled biweekly to monthly in the Clear Fork of the Trinity River, Tarrant County, Texas, from 1980 to 1990. The population invaded the river in 1972 and by 1980 had reached densities of 3000-4000 clams m^{-2}. Between 1982 and 1983, densities reached maximal vales of 7000-13000 clams m^{-2}. In 1984 densities declined rapidly to <4000 clams m^{-2} and, thereafter, continued to decline with each successive year until the population became extinct in early 1990. Individual growth rate and maximum size declined during the 1984-1990 period of density decline, while life span generally increased. During the 1980-1984 period of maximum density, the population consistently displayed a bimodal pattern of reproduction, leading to distinct annual spring and fall cohorts. During the subsequent period of density decline, the bimodal pattern of reproduction was lost with only a single reproductive effort occurring in some years. This documented pattern of rapid increase in density after initial colonization, followed by slow density decline is considered characteristic of many aquatic species invasions. The potential causes of the density decline in this Asian clam population and its eventual extinction will be discussed.

N O T E S

Genetic Identity and Invasion Dynamics of the Quagga Mussel *Dreissena rostriformis (=bugensis)* in the Volga River Basin and Great Lakes as Revealed by Microsatellite Analyses

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The quagga mussel *Dreissena rostriformis (=bugensis)*, a species native to the Dnieper and Bug Limans (northern Black Sea), has been dispersed by human activities elsewhere in the basin, throughout much of the Volga River and northern Caspian Sea, and to the Laurentian Great Lakes. We used six published microsatellite markers to survey populations throughout its native and introduced range to identify relationships among potential source populations and resulting introduced populations. We also considered whether genetic diversity could be related to possible dispersal vectors or conform to an isolation-by-distance model of random diffusion. Mussels from 12 sites in Eurasia, including the Caspian Sea *(D. rostriformis (=rostriformis))* and one in Lake Erie, were sampled. Field surveys in the Volga River basin suggest that the species first colonized middle reaches of the river around Kubyshev Reservoir in 1992, and thereafter spread both upstream and downstream. Genetic analysis revealed considerable gene flow among populations consistent with a panmictic population of quagga mussels that have not experienced population bottlenecks or founder effects. Neighbor-joining analyses suggested the Bug Liman as the source of the Kubyshev (Kama River) Reservoir invasion – likely the first invasion in the Caspian Sea basin – and the Dniester Liman population as the source of the Cheboksary Reservoir invasion. The Caspian Sea population was genetically more distinct than other populations, a finding supported by genotypic assignment analyses, and likely has not served as an inoculum source to the mid- or upper Volga River to date. The lack of an isolation-by-distance relationship among samples indicates that quagga mussel spread is more consistent with long-distance dispersal, most likely mediated by commercial ships (i.e., ballast water transfer), rather than natural dispersal.

NOTES

Population Genetics of Zebra Mussel *(Dreissena Polymorpha,* Pallas), an Exotic Bivalve Mollusc Recently Introduced in Ireland

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Dreissena polymorpha (Pallas) is an invasive mussel indigenous to the Caspian Sea, but has spread throughout most of Europe and eastern North America. The mussel was first reported in Ireland in the lower Shannon system in 1997, but was probably introduced in 1994 or even earlier. The zebra mussel has spread rapidly up the Shannon system and its connecting canals, and is now in the Erne system. The source population(s) of Irish zebra mussels is at present unknown.

Ten selected populations from Ireland (Limerick, Lough Derg, Lough Key, Assaroe, Dublin), England (Thames Estuary), Holland (Meuse River), Romania (Prut River) and North America (Lake Ontario and Lake St. Clair) were tested for genetic heterogeneity at five trinucleotide microsatellite loci.

Heterozygosity levels observed in Irish populations were well within the range obtained for European and Great Lakes populations, suggesting that the Irish founder population(s) were large, or that there were several introductions after foundation. Significant heterozygote deficiencies were observed at all five loci, which could be interpreted as evidence for population subdivision but is more likely due to the presence of null alleles. Tests for linkage disequilibrium failed to show significant disequilibria between any microsatellite locus pair.

Comparisons between Irish, European and North American populations indicated significant genetic differentiation. On the other hand, the sample from the UK population clustered together with Irish populations, most likely reflecting an English origin for Irish zebra mussels.

NOTES

Oyster Invader Achieves Higher Densities in Marine Reserves

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The Pacific oyster *(Crassostrea gigas* Thunberg) has been grown in commercial culture in Washington State, USA., for nearly a century. Although cultivation has been a commercial success, the region has long been considered to be too cold for successful reproduction of oysters in the wild. However, since the mid 1990s *C. gigas* has been found invading shorelines in the San Juan Archipelago in the northern Puget Sound, Washington. Marine reserves in the San Juan Archipelago are among the sites now inhabited by Pacific oysters. In surveys of three intertidal reserves and 5 non-reserve sites, we found that densities of Pacific oysters were significantly greater in marine reserves than at matched reference sites outside reserves. Marine reserves are emerging as management tools for protection of nearshore biological diversity and essential fish habitat. We tested whether marine reserves provide resistance to this invader in marine reserves and matched areas outside reserves. Unexpectedly, we found densities of both oysters to be significantly higher in marine reserves than in comparable unprotected areas. Although we have not yet identified the mechanisms responsible for our findings, human harvest is not a causative factor. Physical or biological aspects of the reserves themselves may directly or indirectly enhance the success of Pacific oysters at these sites.

NOTES

Dominance of the Noxious Cyanobacterium *Microcystis aeruginosa* in Low-nutrient Lakes is Associated with Zebra Mussels

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By surveying 61 inland lakes in Michigan, USA, we examined the hypothesis that invasion by zebra mussels (*Dreissena polymorpha*) promotes dominance of the noxious cyanobacterium *Microcystis aeruginosa*. After accounting for variation in total phosphorus (TP) concentrations, lakes with *Dreissena* had lower total phytoplankton biomass, as measured by chlorophyll a and algal cell biovolume. This reduction in algal biomass may account for increased soluble reactive phosphorus (SRP) concentrations and decreased dissolved organic carbon (DOC) concentrations observed in lakes with *Dreissena*. While total chlorophyll *a* increased with TP in lakes with and without *Dreissena*, the dominance of cyanobacteria did not increase with TP in lakes with *Dreissena* due to increased relative abundance of cyanobacteria, and *Microcystis* in particular, at low TP concentrations. The observed positive influence of *Dreissena* invasion on Microcystis dominance in lakes with TP <25 gL^-1 was surprising because it contradicts well-established patterns of increasing dominance of cyanobacteria with nutrient enrichment. As *Dreissena* continue to spread into North American waters, monitoring of nutrient levels may no longer be sufficient to evaluate the risk of dominance of lake phytoplankton by highly undesirable cyanobacteria.

NOTES

Distribution and Dynamics of *Dreissena polymorpha* Within and Among Lakes: 12 Years of Observations

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The dynamics of populations through time are critical for understanding their impacts on ecosystems. However, to date we have surprisingly few such data for *Dreissena polymorpha* (Pallas). Zebra mussel population densities and biomass were followed over 12 years subsequent to initial colonization in three Belarussian lakes, across depths and substrate types. *D. polymorpha* were first noticed in Lake Naroch in 1989, the population density peaked in 1993, and then did not change significantly in next 10 years. Likewise, in lakes Batorino and Myastro the zebra mussel densities did not change significantly over 9 years. Highest density did not always correspond to highest biomass within or among lakes, and biomass is expected to be a better predictor of ecosystem impact. Significant differences in biomass and density among habitat types were found, therefore accurate predictions of lake-wide population size or effect would be dependent on the abundance of different substrate types. Maximum population density in all lakes was not observed until 7 to 12 years after initial introduction. However, the timing of initial introduction is often very difficult to determine. In most cases populations of zebra mussels can only be followed after mussels are abundant enough to be easily detected. European and North American data suggest that zebra mussels reach maximum density 2–3 years after populations are large enough to be detected.

N O T E S

Massive Invasion of an Estuarine Transition Zone Has No Detectable Effect on Zooplankton Community Structure

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Over the past 15 years, the zebra mussel, *Dreissena polymorpha*, has colonised the entire St. Lawrence River system. Large numbers of veligers, the filter-feeding larval stage of the zebra mussel, have been advected into the estuarine transition zone (ETZ) from upstream sources. In 1994 they suddenly became the numerically dominant component of the tidal freshwater zooplankton assemblage of the ETZ during summer months, comprising up to 90% of the zooplankton assemblage. In subsequent years, they also dominanted the true estuarine assemblage of the ETZ. These major numerical changes in community structure have not, however, been reflected in changes in the abundance of pre-invasion taxa. Abundance of potential planktonic competitors such as rotifers and the cladoceran *Bosmina longirostris* fluctuated between years but did not decline following the invasion. Only densities of the copepod *Eurytemora affinis* declined in the years following the invasion (2000 and 2001), but this change could not be definitively associated with the invasion. Synchronous variation among different zooplankton groups suggests that environmental forcing related to or correlated with temperature anomalies is the major cause of inter-annual variation in the structure of zooplankton assemblages. The negative correlation between veliger abundance and salinity indicates that the ETZ acts as a sink for the larval stages of the zebra mussel. Their precise fate remains uncertain, but our study suggests that this invasion has had little or no impact on the structure or function of this pelagic community in spite of their numerical dominance, and these results are consistent with related studies examining the trophic impacts of this invader on specific components of the food web.

NOTES

Global Distribution of the Alien Marine Amphipod *Caprella mutica*

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The oceans present few barriers to the spread of non-native “alien” species, and over the last few years introductions and the global distribution of alien species have risen through increases in ballast water discharge, aquaculture-related activities and recreational yachting. Geographic isolation is necessary for the maintenance of global biodiversity. The increase in human dispersal mechanisms provides a significant threat to global marine biodiversity.

The majority of introductions of alien species are accidental and certain species have significantly altered community structure and ecosystem function. One of the most numerous invaders in the marine environment are the Crustaceans, and between 1790 and 1999 they accounted for half the invasions in North America. This group is also the dominant phyla of repeat invasions. Caprellid amphipods are marine crustaceans, which inhabit the littoral zone to depths of over 2000m and one species in particular, has markedly increased its global distribution within the last 25 years.

Caprella mutica is a large caprellid amphipod indigenous to the coastal waters of sub-boreal North-East Asia. This species is described from Peter the Great Bay, Vladivostok Russia, Possjet Bay and Akkeshi Bay, Japan. *C. mutica* has a long history of introductions. It was introduced to the North East Pacific before 1979 and was first reported in Europe in the early 1990s in the Netherlands and Norway. More recently, *C. mutica* has been identified on the western north Atlantic, the West coast of Scotland, the South coast of England, Ireland, and Australasia. As an alien species, *C. mutica* is found predominantly on artificial man-made structures such as fish farm cages, shellfish lines, floating docks, marinas, and boat hulls, and on the fouling organisms associated with these substrates including seaweed, hydroids, ascidians, mussels and barnacles.

Records from around the world will be used to present the global distribution of *C. mutica*. Characteristics contributing to its success as a global invader will be discussed and likely introduction vectors identified.

N O T E S

Are Artificial Structures Facilitating the Spread of Invasive Species in Estuaries?

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Biological invasions, defined as the arrival, establishment and diffusion of species, threaten native biodiversity in many coastal regions. The majority of research on invasions by exotic marine species has focused on the process of initial invasion, particularly via ships' hulls and in ballast water. Far less is known about the diffusion or small-scale spread of exotic species after they have invaded a waterway. Here we present re-analysed data from a series of experiments originally designed to test hypotheses about the factors that cause artificial structures (e.g., pontoons and pilings) to be different habitats from natural hard surfaces (sandstone rocky reefs). The organisms studied were sessile marine animals and plants (i.e., epibiota) growing on vertical surfaces and they were classified as introduced or native according to a variety of criteria, including phyletic relatedness, molecular affinities and biogeographic distribution. After species had been classified, data from previous experiments were re-analysed to test for differences in the proportions of native and exotic species on different surfaces.

In extant epibiotic assemblages, and those recently established on settlement panels, native epibiota were more prevalent on reefs than on pilings or pontoons, whist exotic species were generally more common on pontoons. When comparing settlement on panels made of different materials, it was found that there were similar numbers of exotic species on each type of panel, but fewer native species on wooden panels. The composition of a surface and its position in the water column influenced the recruitment of native epibiota, but had limited effects on exotic epibiota. Finally, in an experiment designed to determine the effect that movement of the substratum has on the settlement of epibiota, it was found that the proportion of exotic species increased with increasing movement. This final result supports the notion that there has been selection for exotic species that can tolerate fast water movement, which is perhaps not surprising given that many species have probably been introduced on the hulls of ships. In combination, these experiments indicate that artificial structures tend to support a greater proportion of exotic species than do natural surfaces at least in part because of the composition of structures, their position in the water column and the degree to which they move. Thus, by adding artificial structures to waterways, it is quite likely that we are facilitating the spread of exotic species, which may use these structures, much like stepping stones, to gain access to areas that were previously uninvaded.

N O T E S

Tracking Progression of a Marine Invasion: Five Years of Observations of the Marine Gastropod *Rapana venosa* in the Chesapeake Bay, Virginia, USA

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The oriental predatory marine gastropod *Rapana venosa* was first reported in the Chesapeake Bay, Virginia in mid 1998. The suspected vector of introduction is ballast water transport of larvae from the Eastern Mediterranean Sea. *Rapana venosa* is long lived, grows rapidly to a terminal size of approximately 170 mm, is thick shelled and immune to most predators at 2-3 years of age, is sexually mature at 1-2 years, and can produce multiple egg masses per year. Each egg mass contains distinct egg cases that hatch to release free swimming, planktotrophic veliger larvae that metamorphose in 3-4 weeks. Post larvae prefer hard substrates. Field observations suggest a change of preferred habitat at 2-3 years of age with migration to soft substrate and shellfish becoming the preferred prey. There are no recorded major parasites or diseases of *Rapana*.

We have recorded range expansion and population demographics of *Rapana* in the southern Chesapeake Bay through a collaborative bounty program ($5 per live animal, $2 per dead shell) with commercial fishermen who catch *Rapana* as by-catch to the local hard clam (*Mercenaria mercenaria*) and blue crab (*Callinectes sapidus*) fisheries. Both fisheries have seasonal and spatially distinct activity. Clam fishing is pursued with a mechanical tong on soft substrates, and is limited to larger *Rapana*. Crab pots have escape rings and mesh sizes that determine the minimum size of crab and thus *Rapana* retained. Crab dredges have teeth spacing and mesh size specifications to effect size limit on the retained crabs. Despite these limitations, the number of collaborators (over 115) ensure that we have effected over 100 000 sampling events for *Rapana* in the past five years. Over 5000 *Rapana* have been collected, allowing portrayal of the establishing population in terms of absolute numbers (using the by-catch as a proxy), and changing demographics driven by mortality, and recruitment. Demographics, laboratory generated estimators of size specific fecundity, and computer simulations of circulation can be used to estimate propagule production in the lower James River, Ocean View and Mobjack–York River populations.

We offer contrasting predictions for the future of these populations. The relatively closed circulation patterns of the James River suggest continuing population increase in this region. The population on the exposed shoreline of Ocean View is a source of larvae to the general counterclockwise circulation of the Chesapeake Bay and, we hypothesize, service recruitment on the eastern shoreline of the bay and, eventually, export of larvae to the inner continental shelf. The Mobjack-York River population is currently small and exists in a region of less retentive circulation than the James River – long term stability may depend as much on its being a sink for larvae from elsewhere as on its self recruitment capability. The varying profiles of propagule production and source sink dynamics of these populations provide opportunity to test a variety of invasions models driven by the counteracting forces of dilution by dispersal versus survival of critical numbers of propagules to establish founder populations at the progressing invasion front.

NOTES

Taxonomic Distinctiveness Magnifies the Impact of Bioinvaders in Aquatic Ecosystems

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Biological invasions can result in substantial ecological disruptions, including the loss of native species. However, most invasions cause no detectable impact. The ability to distinguish invaders likely to have a major impact from those having only minor effects is essential for prioritizing management efforts. Unfortunately, there exist few predictable patterns of impact for invasions, reflecting their context-dependent nature. A promising approach toward identifying predictable patterns is to test hypotheses that incorporate characteristics of both the invader and the invaded system.

We present a general test of the hypothesis that an invader's impact is determined by the invaded system's evolutionary experience with taxonomically-similar species. The rationale for this hypothesis is that taxonomically-unique invaders are less likely to encounter predators or parasites that can control their abundance (and, thus, limit their impact), and are more likely to encounter naïve competitors and prey that are poorly-adapted to them.

A meta-analysis compared the taxonomic distinctiveness of high-impact and low-impact invaders in several aquatic systems. It revealed that high-impact invaders—i.e. those that displace native species—are more likely to belong to genera not already present in the system. Each system tended in the direction consistent with the hypothesis, despite variation in native species richness, surface area, latitude, and habitat type (lake, river basin, or coastal marine).

This finding suggests that risk assessments seeking to prioritize invasion threats should consider a potential invader's taxonomic relationship to resident species in the target community.

NOTES

New Invasive Phytoplankton Species Throughout the Suez Canal

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The phytoplankton community in the surface as well as the water column of Suez Canal was studied monthly from March 1995 to May 1996. The results revealed clear spatial heterogeneity in the phytoplankton species composition corresponding to ecological differences between the northern, middle and southern regions of the Canal. However, a temporal resemblance in the phytoplankton composition was observed either between the northern and middle parts or between the southern and middle parts, coincided with the current direction in the Canal. It appears that the number of phytoplankton species inhabiting the Canal has increased since its opening, with a new addition of 92 species in the present study. The species reported to be transported via the Canal between the Red Sea and the Mediterranean Sea had been established as a characteristic Canal microflora. Additional species considered in this study appear to be immigrants between the two seas.

N O T E S

Patterns of Spread of Introduced Pacific Oysters *(Crassostrea gigas)*

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Pacific oysters *(Crassostrea gigas)* have been cultivated in the northern Wadden Sea (North Sea, Germany) since 1986. Due to successful natural spatfalls a wild oyster population developed on native mussel beds (*Mytilus edulis*) within the area. Wild oysters are mainly found attached to the shells of living and dead mussels, because they need hard surfaces to settle on and mussel beds represent the only hard substrata that are available on the sandy tidal flats of the Wadden Sea.

The first oyster in the area, which had dispersed as a larva was discovered 5 years after the oyster farm had commenced. Data on abundance and size-frequency distribution of oysters on intertidal mussel beds around the island revealed that recruitment was patchy and occurred in only 6 out of 18 years (1991, 1994, 1997, 2001, 2002, 2003). Significant proportions of these strong cohorts survived for at least five years. The first quantitative survey in 1995 revealed a mean density of 3.6 wild oysters m^{-2} on mussel beds close to the oyster farm. A second investigation in 1999 showed an increase in range, but not in mean abundance. Only after two consecutive strong spatfalls in 2001 and 2002 abundances of more than 300 oysters m^{-2} (mean density 153.7 m^{-2}) on mussel beds were observed in 2003. The population extended its range from intertidal to subtidal locations as well as from the island of Sylt at least 50 km north- and southwards along the coastline. Analyses of mean monthly water temperatures indicate that spatfalls coincided with above-average water temperatures in July and August when spawning and planktonic dispersal occurs.

We conclude that *Crassostrea gigas* will become a prominent member of intertidal mussel bed communities in the northern Wadden Sea. High late summer water temperatures will facilitate the speed of the invasion.

NOTES

Phylogeography: A Way to Track Gammarid Invasion Routes

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Through the connection between the Baltic and the Black Sea drainage areas, Polish inland waters are an important part of the so-called “central corridor” for the invasion of Ponto-Caspian fauna to Western Europe. At least five Ponto-Caspian gammarids: *Dikerogammarus haemobaphes, D. villosus, Pontogammarus robustoides, Obesogammarus crassus,* and *Chaetogammarus ischnus* are known to invade successfully the territory of Poland. However, the exact pathways and demography of the invasions remain poorly known. A molecular phylogeographic approach to this problem, based on the analysis of geographic distribution of genealogical lineages may help to solve that problem.

Two case studies will be presented and discussed: 1) which, if not both, of the two possible water connections (Kuronian Lagoon-Vistula Lagoon, or Prypet-Bug canal) allowed *P. robustoides* to penetrate into inland and coastal waters of Poland; 2) does the invasion of *D. haemobaphes* progress westwards along the “central corridor” namely on the way: Bug -Vistula-Bydgoski Canal-Warta-Oder.

N O T E S

Eradication of *Caulerpa taxifolia* in the US Five Years After Discovery: Are We There Yet?

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Caulerpa taxifolia was discovered June 12, 2000, at Agua Hedionda Lagoon near San Diego, California, the first documented introduction of this invasivel marine alga in the Western Hemisphere. Due to a 15-year history of spread to more that 20 000 ha in Mediterranean Sea, *C. taxifolia* was placed on the US Federal Noxious Weed list in 1999. Response to the California introduction was rapid and effective. Within 17 days after discovery, colonies were covered with plastic and chlorine (sodium hypochlorite) was injected beneath the sealed plastic. Extensive SCUBA surveillance was initiated and additional, small colonies of *C. taxifolia* were contained and treated. The continuing eradication program has been conducted via the Southern California Caulerpa Action Team (SCCAT), which is comprised of several federal and state agencies, private groups and non-governmental organizations. The formation of SCCAT provided a coordinating mechanism that has been able to resolve several problems including funding, permitting requirements, quality assurance, and successful negotiations with landowners and other business interests to modify use of the infested site. Continued monitoring of efficacy (surveillance for undiscovered colonies) now accounts for most of the $US 1.2 million annual costs. If no new colonies are found by December 2004, eradication will be deemed successful. The criteria for quality assurance and eradication will be discussed as part of an overall model for rapid response to invasive species.

NOTES

Differential Excretion of Ammonia and Phosphate by Three Dreissenid Taxa

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Eutrophication of Lake Erie stimulated passage of the Canadian/USA Great Lakes Water Quality Agreement (1972) to limit excessive growth of plankton. As annual phosphorus loading decreased to the 11 000 tonne target level by the mid-1980's, phytoplankton populations declined. With the invasion and expansion of dreissenid mussels throughout Lake Erie in the late-1980s and early 1990s, phytoplankton population biomass was expected to decrease even further. Subsequent to the establishment of the zebra mussel (*Dreissena polymorpha*), however, phosphorus concentration and algal abundance have increased, as has the fraction of the central basin hypolimnion exhibiting low oxygen. Furthermore, the frequency of harmful algal blooms (such as toxic *Microcystis*) has also increased. Other researchers (Arnott and Vanni, Heath *et al.*, James *et al.*, Vanderploeg) have previously pointed to the importance of N and P excretion by zebra mussels in assessing their impact on ecosystems, but the Lake Erie situation has been complicated by the successful invasion of both deepwater and littoral zone forms of the quagga mussel (*D. bugensis*). In fact, the latter has mostly supplanted zebra mussels in the nearshore zones of the whole lake. Accordingly, we measured the size-specific excretion rates of all three taxa as a first step toward testing the hypothesis that the change to quagga mussels is responsible for recent trophic changes in the lake.

In July 2002, deepwater quagga mussels were collected from eastern basin monitoring stations using PONAR grabs while littoral quagga and zebra mussels were collected in the western Lake Erie by diving off South Bass Island, Ohio. Each taxon was divided into five shell-length classes (<10mm, 10-15mm, 15-20mm, 20-25mm, and 25-30mm) and replicated excretion experiments run for 6 h in filtered east basin water at room temperature (22-24°C). Ammonia-nitrogen and phosphate-phosphorus concentrations were determined spectrophotometrically and the results expressed as a function of soft-tissue dry weight biomass within each size class and taxon.

Size-specific nitrogen and phosphorus excretion rates increased with mussel length up to the 20-25 mm size class. Nitrogen excretion rates ranged from 0.5 to 20.8 µg NH_4-N mg dry weight biomass^{-1}·day^{-1} whereas phosphorus excretion rates ranged from 0.03 to 2.3 µg PO_4-P mg dry weight biomass^{-1} day^{-1}. Deepwater quagga mussels showed the highest excretion rates for both N and P, but this is likely due to their transfer to room temperature, high above their 6°C *in situ* temperature. Zebra mussels excrete more P than do littoral quagga mussels at all sizes but <10 mm, but their ammonia excretion rates did not differ. Nitrogen: phosphorus excretion ratios are similar between zebra and littoral quagga mussels, averaging 20:1, well below Smith's (1983) threshold of 29:1, and thus favor N-fixing cyanobacterial growth.

The experiments show that dreissenid excretion of ammonia and phosphate is high, and has the potential to alter phytoplankton dynamics. We found no evidence that the change to dominance by quagga mussels in the lake has altered algal dynamics via a higher rate of nutrient excretion.

NOTES

The Impact of Dreissenid Ammonia and Phosphate Excretion on Lake Erie

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The invasion and expansion of dreissenid mussels throughout Lake Erie in the late-1980s and early 1990s was expected to decrease phytoplankton population biomass. Since 1995, however, phosphorus concentration and algal abundance have increased, as has the fraction of the central basin hypolimnion exhibiting low oxygen. Furthermore, the frequency of harmful algal blooms (such as toxic *Microcystis*) has also increased. The Lake Erie situation has been complicated by the successful invasion of both deepwater and littoral zone forms of the quagga mussel (*D. bugensis*). In fact, the latter has mostly supplanted zebra mussels in the nearshore zones of the whole lake. In this paper, we apply our previously determined size-specific ammonia and phosphate excretion rates of all three taxa to the changes in their abundance in the western Lake Erie littoral zone to test the hypothesis that the change to quagga mussels is responsible for recent trophic changes in the lake. The west basin has the highest dreissenid populations of the three basins, so if their impact will be greatest there.

We used the excretion equations we have generated to estimate the amount of N and P excreted per day for mussel populations at our Western Basin Lake Erie study site. From benthic surveys conducted in May 1993, 1998, and 2003, we obtained dreissenid abundance and size-frequency data (2-mm size classes) at Peach Point, South Bass Island, Ohio. Size-class midpoints were then used to calculate the size-class average dry weight biomass from length-weight regression equations, and the N and P excretion rates from our length-excretion equations. The size-specific excretion rates and biomass values were then multiplied by the frequency distribution and summed to estimate areal excretion rates and biomass.

Since 1993, the total density of mussels at Peach Point has declined from >60 000 to ~20 000 individuals$\cdot$m^{-2} in 2003, and total dry weight soft-tissue biomass has decreased from >500 g$\cdot$m^{-2} to ~300 g$\cdot$m^{-2}. In 1993, the biomass was 100% zebra mussels, decreasing to 65% in 1998, and 18% in 2003. N excretion has decreased from 153.2 mg N m^{-2} day^{-1} in 1993 to 51.7 mg N m^{-2} day^{-1} in 2003, whereas phosphorus decreased from 11.3 mg P m^{-2} day^{-1} to between 3.15 mg P m^{-2} day^{-1} in 2003. The decrease in total biomass is much more important to the nutrient recycling rate than is the change to dominance by quagga mussels.

We estimate that the dreissenid population at Peach Point in 1998 excreted 3.76 mg P m$^{-2}\cdot$day^{-1}, only 61% of the crustacean zooplankton population excretion rate, and 18% of the water column soluble reactive phosphorus concentration. Benthic dreissenids, therefore, could turn over water column soluble phosphorus once every 5.56 days and, with zooplankton, every 2.13 days. However, these are only first-order estimates and neglect the vertical mixing processes that supply food and advect excreted products back into the water column. Veligers, rotifers, and Protozoa may be important contributors to turnover as well.

Dynamics of Zebra Mussel *(Dreissena polymorpha)* Populations in Lough Key, Ireland

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The zebra mussel *(Dreissena polymorpha)* arrived in Ireland in the early 1990s. This invasive species was introduced to the lower Shannon navigation, *via* the fouled boat hulls of second hand leisure craft – probably imported from Britain. The Shannon River (386 km long) is a popular waterway and boating was the main vector for zebra mussel spread upstream to the upper Shannon navigation, including Lough Key (9 km^2).

A Lough Key zebra mussel monitoring programme began in 1998, during the early stages of invasion. This has produced a six-year time series for both relevant water quality monitoring and zebra mussel (larval, juvenile and adult) population studies.

Water parameter sampling included temperature, chlorophyll *a*, transparency, total phosphorus, molybdate reactive phosphorus (MRP) and phytoplankton. Zebra mussel larval densities and size distributions were analysed during the annual summer spawning period. Concurrently the settlement of juveniles in the lake was also estimated using PVC settlement plates.

Adult zebra mussel populations (size distributions, biomass/m^2 and numbers/m^2) were recorded throughout the survey period. This involved monitoring zebra mussels on three substrates; stone; unionids *(Anodonta)* and aquatic plants. In 2001, a specialised acoustic bathymetric and sediment survey (RoxAnn™) identified suitable habitat areas for zebra mussels throughout the lake. A remotely operated vehicle (ROV) video analysis of shallow areas was also carried out around lake-shores and islands. The following summer, a specialised transect survey was used to estimate the total number of zebra mussels in Lough Key. In addition eight snorkel sites were sampled each August to estimate changes in biomass on different substrates between years.

The data time series produced in the Lough Key survey highlights the changes in water quality and zebra mussel populations from the early stages of invasion, through the exponential growth stage. Data from the last few years suggest that the overall density of zebra mussels in the lake has remained relatively stable since 2001.

NOTES

Changing Distributional Trends for Dreissenid Mussels in the Upper St. Lawrence River, Lake Ontario, and Eastern Lake Erie

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Since 1990, before dreissenid mussels had colonized most of Lake Ontario and the St. Lawrence River, we have conducted surveys of navigational buoys to track the spread and changing distribution of these invasive species in these waters. Most of the area was colonized by the summer of 1993, but the distributional patterns have changed since that time, both in terms of total dreissenid abundance and ratio of the two species, *Dreissena polymorpha* and *Dreissena bugensis*. The present report describes the general distribution and species ratios resulting from new colonization of navigational buoys during the 2003 shipping season, including the addition of data from Eastern Lake Erie, with emphasis on continuing changes in distributional trends.

From 28-31 December 2003, we examined 240 navigational buoys that had been deployed throughout the Canadian portion of Eastern Lake Erie and Lake Ontario, and both the Canadian and US portions of the upper St. Lawrence River. Buoys were examined at their winter dry-dock storage locations in Clayton, Ogdensburg, and Massena, New York, and Prescott, Ontario following their removal from the water at the end of the navigation season. Mussel coverage below the water line of each buoy was ranked by visual estimation from 0-4 based on the following: 0 = no mussels; 1 = 1-25% coverage; 2 = 26-50% coverage; 3 = 51-75% coverage; 4 = 76-100% coverage. Approximate ratios of *D. polymorpha* to *D. bugensis* were estimated for each buoy. Co-occurring benthic macroinvertebrates were also identified and ranked in the same manner as the mussels.

Mussel distribution was extremely variable throughout the study area. In Lake Erie: mussels near Pelee were *D. polymorpha* and ranked 4; those near Nanticoke were *D. bugensis* and ranked 1-2. In Lake Ontario: mussels in Toronto Harbour were mostly *D. polymorpha* and ranked 1; those near Oshawa were all *D. bugensis* and ranked 1; those in the Bay of Quinte were all *D. polymorpha* and ranked 3-4; and those near Kingston were mostly *D. polymorpha* and ranked 1-3. In the St. Lawrence River, mussels in the upper Thousand Islands had a variable but nearly equal species ratio and ranked 1-3, those just below the Thousand Islands were mostly *D. bugensis* and ranked 1; were absent from most buoys through the narrow stretch of river, but were mostly or entirely *D. bugensis* where they did occur; and were mostly *D. polymorpha* and ranked 4 in the Long Sault Small Craft Channel.

Through the narrow section of the river, there was a strong negative correlation between abundance of mussels and caddisfly (Trichoptera) larvae (both Brachycentridae and Hydropsychidae). Conversely, in the Thousand Islands region, there was a weak positive correlation between mussels and amphipod crustaceans.

This year's work extended the range of our studies to western Lake Ontario and Lake Erie, and provided more extensive coverage of the St. Lawrence River than we have been able to achieve in the past. The trends of reduction in numbers of total mussels in the riverine areas, with large densities persisting in lacustrine harbor areas, follows a pattern that has been unfolding for several years. Likewise, differences in relative abundance of the two mussel species at various sites appears to be following trend that generally favors *D. polymorpha* in lacustrine harbors, and *D. bugensis* in most riverine settings. We plan to continue the buoy work as an annual project, in an effort to establish long-term population patterns for the mussels, and to assess the impact of mussels on the caddisflies and amphipods.

We gratefully acknowledge the assistance of Chuck Lemaire, Canadian Coast Guard, and Greg MacKinnon, US Department of Transportation, who coordinated access to the navigational buoys.

A Very Geographically-isolated Zebra Mussel — *Dreissena stankovici:* Comparison with Other *Dreissena* spp.

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Described in 1982, *Dreissena stankovici* is an unusual zebra mussel in that it has only been documented from two lakes in the Republic of Macedonia. In this paper we explore reasons why this species, in contrast to other *Dreissena* spp., is not more widespread in distribution. We review diagnostic genetic markers and also discuss the morphological differences that separate this species from *Dreissena polymorpha* and *D. bugensis*, including: presence/absence of a sharp shell keel ascending to the dorsal side, angle of the anterior dorsal edge of the shell (when viewed laterally), presence/absence of latero-ventral ridge, shape of the ventral surface, presence/absence of a pronounced depression in ventral shell surface by byssus, shape of cavity (septum) containing anterior adductor muscle, periostracum color/stripe pattern, and size/shape of the sensory papillae near the inhalant and exhalant siphons. Unusual life cycle characteristics are also reviewed, including periodicity of spawning and larval settling. Just as it is a rare species, it also has some rare endosymbionts associated with it, and using data from both dissections and histological observations, the differences between its endosymbionts versus those in other European *Dreissena* spp. are highlighted.

N O T E S

Preliminary Assessment of Protistan and Metazoan Symbionts of *Dreissena polymorpha* in the River Shannon, Ireland

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Obtaining information on parasites, commensals, and other symbionts of invasive species in their new geographic range may be important in deducing such things as the life-cycle stage at which an invasion occurred, since many symbionts occur only in specific stages of the host. Also important is the fact that invaders may introduce parasites into the new range, such as trematodes that are potentially infective to native wildlife. Conversely, both native and co-invasive parasites may exert some biological control over the invasive species, so that the invader's population dynamics can be understood only if its parasites are fully evaluated.

Ireland was invaded by zebra mussels, *Dreissena polymorpha*, within the last decade. In only a few years, this highly fecund species has spread throughout the island's Shannon navigation and into a number of other Irish lakes, and is now well established throughout the main inland navigation connected with the Shannon and Erne catchments. We initiated a preliminary survey of *D. polymorpha* at several sites along the River Shannon, to assess the presence and potential impact of metazoan and protistan symbionts on the mussels.

During early August 2003, samples of *D. polymorpha* were collected at several sites along most of the length of the River Shannon. The five primary sites included (from North to South, moving downriver) Lough Key, Jamestown Quay, Killinure on Lough Ree, Portumna Bridge north of Lough Derg, and Killaloe south of Lough Derg. The Lough Key site was further divided into four sub-sites, which included (in order of proximity to the nearby town water treatment plant), Boyle Harbour Quay, Stag Island, Rockingham Crannog Quay, and Clarendon Lock. Collection methods varied among the sites, depending on substrates available, but included scraping uniform surfaces (e.g., concrete walls) or hand picking from irregular surfaces (e.g., rocks, submergent plants, unonid shells). Measurements were made to determine mussel biomass and density at each site, and the mean shell length was determined for each sample. All mussels were fixed immediately in 75% ethanol, in which they were stored until examination.

In the laboratory, each fixed specimen was dissected under a stereoscopic microscope. The mantle cavity was thoroughly flushed with ethanol, and the gills were removed intact, then stained in acetocarmine and mounted whole in gum damar to examine for adhering and internal symbionts with a compound microscope. The remaining intact visceral mass, with foot attached, was placed in a vial of fresh ethanol for later histological examination. All sediment flushed from the mantle cavity, along with any residual sediment from the dissection, was examined under a compound light microscope using brightfield, phase contrast, and differential interference contrast optics.

A large number of mussels harbored the ciliate, *Conchophthirus acuminatus*. This ciliate is generally regarded as an obligate commensal, which is host-specific to *D. polymorpha.* It occurs widely and abundantly among European populations of *D. polymorpha*. Its occurrence in Ireland may indicate introduction of the mussels as adults (and is consistent with the most likely vector, an introduction as hull-fouling on imported leisure craft from Britain), since veliger larvae are not known to harbor ciliates. Following similar reasoning, it is possible that the North American invasion by *D. polymorpha* included only veligers, since *C. acuminatus* has not been found on that continent. Preliminary examination revealed no metazoan symbionts in any of the mussels. Trematodes, annelids, nematodes, and insects are known to occur in *D. polymorpha* elsewhere, and our future studies will continue to determine if they colonize the mussels in Ireland. However, the present results are generally consistent with other reports of *C. acuminatus* being the most widespread symbiont of *D. polymorpha*, often occurring where no other symbionts occur.

NOTES

Current Distribution and Abundance and Future Colonization Potential of *Dreissena polymorpha* in the Hudson River Estuary

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In May 1991, zebra mussels were first detected in the Hudson River. The presence of this species has been added to a large number of exotic species that have been introduced into the Hudson River. The occurrence of zebra mussels in the Hudson River has primarily been ascertained by the examination of navigation buoys that are removed from the river in November-December each year. Other methods such as SCUBA surveys and benthic grab samples are capable of locating zebra mussel colonies, but are extremely time intensive and have not been used to any great extent in the Hudson River. To date the farthest south that settled adult zebra mussels have colonized navigation buoys is upper West Haverstraw (D. Strayer, personal communication). Some of the factors that affect the distribution of zebra mussels include temperature, rainfall, flow rates and salinity. While the zebra mussel is widespread in estuaries and inland brackish waters of Europe, high salinity is believed to be the most critical limiting factor in brackish waters.

The focus of this study was the elucidation of the distribution and abundance of *Dreissena polymorpha* larvae (veligers) in the stretch of the Hudson River from Stuyvesant to Kingston. This is important because to understand the potential ecosystem and economic impacts of zebra mussels in the Hudson River, it is necessary to determine their current distribution and abundance and future colonization potential. The planktonic state is probably the most important life stage to study for obtaining a better understanding of dispersal, colonization, and prevention. However, because veligers and post-veligers are microscopic and relatively non-distinct morphologically, this life stage is arguably also the most difficult to study.

Water samples collected in June 2003 from more than 15 sites (from both the left and right banks) along the Hudson River were examined using polarized light microscopy to determine the densities of planktonic *Dreissena polymorpha*. Data was collected on the larval morphological forms of *Dreissena polymorpha*, as well as identifying general range in size and age. Densities ranged from 3-28 larvae/liter from the locations examined. The region along the Hudson River from Middle Ground Flats to Catskill contained the highest larvae densities, exceeding 20 larvae/liter for either the right or left bank sample. All larval forms were observed including velum forming, straight-hinged larvae, umbonal larvae and foot-forming, although the abundance of different morphological types at different sites varied. The majority of the larval forms were in the 80-110 µm size range, however larvae greater than 150 µm and less than 70 µm were observed at some sites. This information is being used to elucidate larvae densities at different locations and ultimately will be used to make predictions regarding a distribution map of adult zebra mussel colonies within a stretch along the Hudson River.

NOTES

Distribution and Impacts of *Dreissena polymorpha* and *Corbicula fluminae*, Two Freshwater Exotic Suspension Feeders

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Dreissena polymorpha and *Corbicula fluminea* are among the most aggressive aquatic invaders world wide and often dominate water bodies they invade. They occupy similar habitats; however, their tolerance of and preference for certain characteristics of freshwaters differ in important ways. In addition, they can have different impacts on freshwaters they invade. We identify similarities and contrast differences between these two species, and highlight important questions yet to be addressed, including: linking short-term laboratory findings to large scale and long-term effects, the consequences of simultaneous invasion versus considering each in isolation, and identification of local versus system-wide effects when these non-native bivalves invade.

N O T E S

Patterns of *Dreissena* spp. Biomass in Relation to Physical Environmental Variables in the St. Lawrence River

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The St. Lawrence is the first large North American river to be invaded by the zebra mussel (*Dreissena polymorpha*) and the quagga mussel (*D. bugensis*). As such, it may provide predictive information for other invaded river systems. Few statistical models exist for zebra mussel abundance, and none exist for quagga mussels. Furthermore, zebra mussel models may not be valid for quagga mussels, as there are significant differences in bioenergetics and physiological tolerances between the two species.

Using linear regression analysis, we related zebra and quagga mussel biomass (fresh weight per m^2) to sedimentary characteristics and water quality variables in the river. Calcium concentration was positively correlated with both zebra mussel biomass and quagga mussel biomass ($r^2 = 0.47$ and $r^2 = 0.75$ at $P < 0.001$, respectively) across sites. However, biomass was not predicted by the same combination of variables for both species. In stepwise regression models, zebra mussel biomass across quadrats was positively correlated with calcium but negatively correlated with depth, sediment particle size, and substrate richness (model $r^2 = 0.51$, $P < 0.037$). Quagga mussel biomass was positively correlated with calcium concentration, conductivity, and depth, and negatively correlated with sediment particle size (model $r^2 = 0.64$, $P < 0.02$). Given that the impact of an invader increases with its abundance, our results suggest that zebra and quagga mussel impacts vary predictably across environmental gradients.

NOTES

Human Waterborne Parasites in Zebra Mussels (*Dreissena polymorpha*) From the Shannon River Drainage, Ireland

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Zebra mussels (*Dreissena polymorpha*) from throughout the Shannon River drainage in Ireland were tested for anthropozoonotic waterborne parasites such as *Cryptosporidium parvum*, *Giardia lamblia*, *Encephalitozoon intestinalis*, *E. hellem,* and *Enterocytozoon bieneusi*, by multiplexed combined direct immunofluorescent antibody and fluorescent *in situ* hybridization method. Parasite transmissive stages were found at 75% sites with the highest mean concentration of 16, 9, and 8 *C. parvum oocysts, G. lamblia cysts*, and *E. intestinalis* spores/mussel, respectively. On average 8 *E. bieneusi* spores/mussel were recovered at one selected site. Approximately 80% of all parasites were viable, thus capable of initiating human infection. The Shannon River is polluted with serious emerging human waterborne pathogens including *C. parvum* against which no therapy exists. Zebra mussels can recover and concentrate environmentally-derived pathogens and can be used for sanitary assessment of water quality.

N O T E S

Effect of the Biotoxin Microcystin on the Feeding Behavior of the Zebra Mussel and Dynamics of the Toxins in the Mussel and in the Aquatic Environment

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Zebra mussels are known to have serious ecological impacts due to the high densities they can reach and by the filtering pressure they exert on aquatic ecosystems. Improved water clarity has been noticed in some areas affected by the mussels but little is known about the potential impacts of the mussels on the distribution and abundance of toxic cyanobacteria and the toxins they carry in their surrounding environment. Moreover, cyanotoxins are of growing interest for environmental management and human safety as they have been reported to cause cattle and human death. *Microcystis aeruginosa* has therefore been chosen for the experiments as they produce microcystins, a well-known freshwater and brackish water biotoxin. The goal of the study was then to evaluate the impact of those toxins on the feeding behavior of the mussels and the role of the mussels in the possible changes of abundance of those cyanobacteria in the environment. Feeding experiments were conducted in the laboratory in controlled conditions (temperature, light) with mussels collected in the Shannon water system and acclimated to the experimental conditions in the flow-through system. Several species of phytoplankton commonly found in Irish freshwaters and two strains of toxic *microcystis* were obtained from culture collections and cultured in sterile conditions. Preliminary test revealed that the two strains of cyanobacteria contained considerable amounts of microcystins whereas the other strains contained no toxin.

In order to have a energy balance budget for the mussels, clearance rate, filtration rate, ingestion and absorption rate were determined by monitoring the depletion of cells and by collecting faeces and pseudofaeces produced during a two hours feeding trial in the flow-through chambers. Single cell suspensions were used to feed the mussels in a first series of trials and several mixtures of algae were offered to the mussels in a second set of experiments. This was to investigate the possible selectivity processes operated by the mussels toward the toxins.

In a second approach, the study focused on the impact of the mussels on the biogeochemistry of the microcystins in the environment. The same experimental design was used to monitor the accumulation of the toxins in the mussel tissues and the release of toxins in the water, faeces and pseudofaeces.

The results of the study were then considered in terms of the possible use of the zebra mussel as a biofilter to clean water bodies heavily affected by cyanabacterial blooms.

NOTES

Alien Species in the Mediterranean Sea: Risks, Drivers and Vectors

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The Mediterranean's busy maritime traffic, the proliferation of fish and shell-fish farms, and the man-made Suez-Canal left the sea exceptionally susceptible to biological invasions. The rapid increase in human population density and urbanization along its shores has brought about coastal development, increased levels of agricultural run-offs and industrial wastes and some unsustainable fishing practices. These changes have caused widespread disruption of the littoral ecosystem and decimation of the biota, which may promote opportunities for the success of invasions.

The principal vectors of introduction into the Mediterranean are, in descending order of importance, passage through the Suez Canal, mariculture and shipping. Alien macrophytes, invertebrates and fish are found in most coastal habitats, and it is noteworthy that most of them are thermophilic, originating in the tropical Indo-Pacific or tropical Atlantic. Should global warming affect Mediterranean sea-water temperature, then thermophilic invasive species would gain a distinct advantage over the native biota. Some invasive species have already outcompeted or replaced native species locally, some are considered pests or cause nuisance, whereas other invaders are of commercial value.

The rate of marine bioinvasions has increased in recent decades; collectively they have significant ecological and economic impacts in the Mediterranean. However, little has been done to evaluate the risk posed by each vector, or to minimize the risk of introducing additional alien species: legislation on introduction and transfers of alien species exists only in few countries; the implementation of the IMO International Convention for the Control and Management of Ships' Ballast Water and Sediments may be a decade away, the TBT ban increases risk of invasion by ship fouling organisms; and the imminent deepening of the Suez Canal without installing a salinity barrier risks the entry of cohorts of new invaders.

One would expect that in an age of heightened environmental concern plans to deepen the Suez Canal, which had served as a conduit for over 80% of the known alien taxa in the Mediterranean, would raise a great deal of attention, controversy and a discussion on "environmental accountancy". Mediterranean countries have been expending funds and efforts to preserve their marine environment and protect the marine biota. However, unless a salinity barrier (such as a hypersaline lock) is installed in the Suez Canal, the Eastern Mediterranean countries would find the biota in their part of the sea fundamentally changed within a few decades.

NOTES

The Sicily Channel: A Crossroad Between Atlantic and Indo-Pacific Worlds

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In the last decade, a growing amount of evidence, incorporated by several authors as signals of global changes, defined a trend of expansion of thermophilic species in the Mediterranean. This phenomenon is markedly shown by the spread of some nonindigenous fish beyond their natural limits and by their success in the new colonized areas. The incoming of these species is historically linked to two main migratory fluxes, one from the Atlantic through the Strait of Gibraltar and the other from the Indo-pacific, through the Suez Canal. With a different timescale and in combination with climatic events, these two opposite routes of invasion progressively enriched this Sea and shaped the faunistic divergences between the western and the eastern Mediterranean. These two basins, characterized by a different hydrological, edaphic and faunistic identity, join each other in correspondence of the channel between Sicily and Tunis, known as the Sicily Strait. This part of the Mediterranean has been considered the western boundary to Lessepsian migration but, recently, new evidence revealed a "dread" weakening of this threshold. The recent spreading of some Indo-pacific fish species trough this area disclose the chance for these invaders to "jump to the west", opening a new scenario for the processes of colonization in the Mediterranean Sea.

This work gives an update of the status of Atlantic and Indo-pacific exotic fish in the area of Sicily Strait with special focus on the recent spread of two successful Erythrean species: *Fistularia commersonii* and *Siganus luridus*. Also the occurrence of some previously recorded Erythrean (*Siganus rivulatus, Stephanolepis diaspros, Leiognathus klunzingeri, Sphyraena chrysotaenia*) and Atlantic (*Seriola carpenteri, S. rivoliana, S. fasciata, Pisodonophis semicintus, Sphoeroides pachygaster, Chaunax suttkusi*) migrants is discussed. On the basis of this new evidence, the Sicily Strait could be considered an area of faunistic convergence between Atlantic and Indo-pacific faunistic worlds: a bridge on their way to the two basins, where acclimation to the new conditions could be thus foreseen. The presence of such alien species in this area strengthen the need to clarify the causes and the processes which lead their displacements and provide further evidences of a trend of "tropicalization" in the Mediterranean fish community, beyond its continuous enrichment.

N O T E S

Natural Dispersal Mechanisms and the Secondary Spread of Exotic Species

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Following the primary introduction of an exotic species both natural and anthropogenic vectors normally become involved in their changing distribution. The spread by natural means of species to an Atlantic Island from the Americas and Europe are considered in this account. The species retrieved have different biological characteristics and consist of some vagrants, such as tropical disseminules and mollusca, generally considered to be exotics. Although found to be living on arrival these subsequently perish; but some can become established over short periods of time. Some evidence has been gathered to show that on occasion conditions exist whereby floating materials from North America and northern Europe appear on Irish coasts. The information gathered provides some basis as to which exotics, according to their mode of life, are unlikely to be successfully managed. For example, species with floating seeds or with air bladders such as: *Lathyrus japonica, Colpomenia pergrina* and *Sargassum muticum* would at some time have become established in Ireland. Similar situations are likely to occur for many other islands elsewhere in the world.

N O T E S

Changes in Global Economy and Trade, and Potential Spread of Exotic Freshwater Bivalves

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Five freshwater bivalves, *Dreissena polymorpha, D. bugensis, Corbicula fluminea, C. fluminalis* and *Limnoperna fortunei* are known aggressive invaders, expanding their ranges and causing notable changes to habitats. It is likely these molluscs will continue to expand their ranges to include other world regions. All species have wide physiological tolerances and are prone to dispersal via specific pathways. Here we use the major modes of dispersal to predict possible means of future spread worldwide. Changing conditions in economies and trade can enable new pathways for spread, and, as distributions change, opportunities for transmission from an increasing number of sources. Once established in a new region, additional vectors are likely to be involved in local spread of these invaders.

NOTES

Vectors of Local Dispersal of Marine and Estuarine Invasive Species in the Southern Gulf of St. Lawrence, Canada

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In recent years the green crab (*Carcinus maenas*), the alga *Codium fragile* ssp. *tomentosoides*, the clubbed tunicate (*Styela clava*), and the amphipod *Caprella mutica* have become established in the southern Gulf of St. Lawrence (sGSL). All of these species have the ability to spread and cause major disturbances in the health and functioning of estuarine ecosystems in the gulf. These alien species could negatively affect estuarine fisheries as well as major bivalve aquaculture operations. To date, many studies have been conducted to determine the vectors used by marine organisms to spread around the world. However, there have been relatively few studies that examine how species spread locally once they have established a beachhead population.

This study examined the interaction between human behaviour and the spread of the green crab and clubbed tunicate in the sGSL. Interviews were conducted with both commercial and pleasure boaters in Prince Edward Island (PEI). The goal of these interviews was to determine the predominant movement patterns of boaters in the sGSL. Armed with this information, potential hotspots of future spread of invasive species can be identified. Pleasure boats were found to move between ports more frequently than commercial boats. For pleasure boats, 50% of the powerboats and 80% of the sailboats had come from another port to the interview location. Moreover, 63.9% and 100% of the powerboats and sailboats, respectively, were planning to dock at another port during their next trip. Since pleasure boats in the sGSL move from port to port quite frequently, it is important to determine if they are transporting invasive species with them. Samples of bilge water, entangled macrophytes, and hull scrapings were collected from interviewee's boats and these samples are being examined for the presence of invasives.

To examine the potential for the clubbed tunicate to be transported on boat hulls, settlement plates made of the most common types of boat hull materials found in PEI were used to collect tunicates. These 10cm x 10cm plates were made of fibreglass, wood, and aluminium. The aluminium plates were left untreated, while the fibreglass and wood plates were painted with either black or white anti-fouling paint, or black or white exterior paint. Tunicates settled mainly on the aluminium plates and plates painted with exterior paint; very few settled on the plates treated with anti-fouling paint. There also appeared to be no colour preference for either black or white plates. The sampling and experiments done during this project will allow for the relative importance of human activities on the dispersal of these new invaders in the sGSL to be quantified. This data can then be used to apply the Hazard Analysis and Critical Control Point (HACCP) method to identify where critical control points are needed to slow the spread of the invasive species examined in this project, as well as any future invaders in the sGSL, and to identify the range of transport likely from a point introduction.

N O T E S

Oyster Transports as a Vector for Exotic Species Introductions

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Several species of oysters have repeatedly been introduced to Northwest European coastal waters. Starting in the early 1870s, the American oyster, *Crassostrea virginica*, was introduced from the United States. American oyster imports were carried out until 1939. In 1964, the first shipment of Pacific oysters, *Crassostrea gigas*, arrived in France. Imports of Pacific oysters from British Columbia and Japan into Northwest Europe were carried out until 1980. Several European countries imported oysters. The largest quantities were imported by the British (American oyster), and the French and Dutch (Pacific oyster). Oysters were transported alive, sometimes packed in algae, and were relayed in receiving waters for culturing purposes. In the North Sea, oyster transports are the most important vector for alien species. In European coastal waters, oyster transports are responsible for the introduction of at least 36 species of the total number of 156 established exotic species of animals and algae.

We developed a simple conceptual model that takes one donor region, one vector and one recipient region into account. The invader has to overcome four important steps in the introduction pathway, being: 1) uptake by the vector; 2) transport; 3) introduction; and 4) establishment. Assuming that there are no changes in the recipient and donor region, other than the establishment of species from the donor region in the recipient region, we expect the introduction rate to decrease, being high shortly after contact has first been established, and thereafter decreasing in time. This expected pattern seems to contradict available data, since there is a worldwide (and local) trend of increasing numbers of invasive species. However, when trying to describe patterns in the introduction of exotic species, it is important to distinguish between vectors of introduction. Each vector has specific traits that influence the number of introduced species and their nature. We tested this model for oyster-associated exotic species introductions.

We present a detailed analysis of the introduction of Pacific oysters into the Oosterschelde estuary, in the southwest of the Netherlands. Timing and quantity of historical oyster imports were reconstructed, and the introduction of associated flora and fauna was correlated to these imports and analysed in time and space. The magnitude of this vector was estimated by taking monthly samples of Pacific oysters from culture plots in the Oosterschelde estuary. Through identification of surviving epiflora and epifauna, after mimicking transport conditions, the first two steps of the invasion pathway were quantified. Combined with historical data on introduction time and place of exotic species, and the magnitude of the oyster imports, the pathway for oyster-associated introductions can be fully described. This will contribute to our understanding of introduction processes.

NOTES

Invasion Corridors and Barriers to the Finnish Lake District, NE Baltic Sea

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The Finnish Lake District (62 °N, 29 °E) is a northward continuation of the Baltic Sea all the way (> 300 km) up to the interior of central Finland. Finnish inland lakes, naturally acidic and nutrient-poor, are geologically and ecologically young and do not host any endemic species. The naturally low biodiversity makes the lakes susceptible to introductions of alien species. The Lake District is connected to the Gulf of Finland (GoF) via the Saimaa Canal, a gateway for species introductions to > 10 inland harbours. Shipping from the Baltic and North Sea coasts to the eastern GoF and to the Lake District is increasing every year. The amount of cargo transported via the Canal has increased tenfold since the broadening of the Canal in 1968, being ca. 1,8 million tonnes in 2000. Also the recreational traffic via the Canal has increased steadily, especially during the last 10 years. New Russian oil terminals are under construction in the easternmost part of the GoF and old ones are expanding. An estimated fivefold increase in tanker traffic is followed by an increase in ballast water discharges and most probably by more alien species introductions to the GoF, a transit area for alien species to adjacent and remote areas.

During the last 100 years, > 20 species have been successfully introduced deliberately or unintentionally in the Finnish Lake District. Few species have had harmful ecological or economic impacts on the recipient area; most of them have occupied empty niches and have become part of the native flora and fauna. Especially certain alien fish species have been a valuable addition for recreational and professional fishing in the area. However, the Finnish inland lakes are unique and vulnerable ecosystems, where new species additions may cause imbalance in some way. To measure the threat from alien species for the Lake District, a deductive risk assessment based on literature studies mapped 29 known invasive freshwater species and their potential to be introduced in the area. By the environmental matching approach annexed with a vector analysis, six of these species (*Anguillicola crassus, Potamothrix heuscheri, Potamothrix vejdovskyi, Hemimysis anomala, Cercopagis pengoi* and *Gmelinoides fasciatus*) turned out to have high capacity to be established in the inland waters of Finland in the near future. In summer 2003, the North American amphipod Gammarus tigrinus was found in Hamina, NE GoF, increasing the risk of its introduction into the Lake District from intermediate to high.

The main vector for alien species transport to the Lake District is ballast water and hull fouling. The crucial factors for successful species introductions are the availability of vectors and invasion corridors and how well the species adapt to the prevailing environmental conditions. The barriers for alien species are the cornerstones of the biological integrity of Finnish inland lakes: low temperature, low nutrient level, and isolation.

N O T E S

A GIS Analysis of Water Bodies Potentially at Risk for Zebra Mussel Invasion by Trailered Boat Transport in Western North America

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Federal, regional, tribal and local agencies and organizations cooperate in the 100th Meridian Initiative to prevent the invasion of zebra mussels and other aquatic nuisance species into western North America. Since the initiative's inception in 1998, participants of the 100th Meridian Initiative have conducted boater interviews in almost all western states bisected by and west of the 100th Meridian, with the exception of California, New Mexico and Colorado. The University of Texas at Arlington maintains the 100th Meridian Initiative database that includes boater origins and destinations for over 8,000 trailered boats. A geographical information systems analysis of this database was performed to help identify which water bodies may be receiving trailered boats coming from potentially infested areas. Since zebra mussels can attach to boats and survive several days out of water under favorable conditions, any boat reported as visiting a water body within 40 km of known zebra mussel infestations was considered to be potentially contaminated. All other destinations visited by such boats, then, could be at risk for zebra-mussel invasion. The identified water bodies are well suited for targeted monitoring efforts and public outreach programs designed to educate boaters about aquatic nuisance species.

NOTES

Invasive Aquatic Species in Ontario: A Review and Analysis of Potential Pathways for Introductions.

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We review eight different pathways for invasion by aquatic nuisance species into Ontario. These include fish stocking programs, private aquaculture, the bait industry, the aquarium and ornamental pond trade, the live food fish industry, recreational boating, canals and diversions, and commercial shipping. These pathways have been responsible for the introduction of more than 160 exotic aquatic organisms into Ontario. Several gaps in policy and legislation are identified. We conclude that the greatest potential for the future introduction and spread of invasive species are with the commercial shipping industry, the live food fish industry, and the ornamental pond/aquarium trade. Recommendations are offered to reduce the potential for additional aquatic invasive species to become established in the future. New legislation is required and public awareness programs need to be expanded. Response protocols need to be developed which clearly define roles and responsibilities of different agencies. Finally, there needs to be a more coordinated effort between stakeholders and various levels of government with regard to invasive species.

NOTES

Invasive Freshwater Fish in the Iberian Peninsula: Introduction Pathways and Life-history Traits

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We have recently reviewed the introduction pathways and differential life-history traits of invasive freshwater fish at several scales: throughout Europe, within the Iberian Peninsula, and at the local scale of the smaller streams of Catalonia (NE Spain). Here, we summarise these results and focus on the results for the Iberian Peninsula. The Iberian peninsula and southern European countries, that are richer in fish endemisms, are unfortunately one of the main destinations of alien fish within Europe. About 25 alien freshwater fish species are established in Spain. In contrast to native fish, the number of alien fish species is not significantly related to basin area, latitude, longitude, or water runoff. We identified different introduction pathways within the Iberian peninsula, centroeuropean species (e.g., *Rutilus rutilus, Scardinius erythrophthalmus, Perca fluviatilis,*...) dominating northeastern Spain and North American species (*Lepomis gibbosus, Salvelinus fontinalis, Fundulus heteroclitus*) predominating in the rest of the Iberian peninsula.

A comparison of the life-history traits of native and alien fish shows little difference in mean features but significant differences in their variability. Invasive species are more variable in a suite of attributes such as fecundity, longevity, and temperature tolerance. This higher variability of life-history traits among invasive species seems related to the human use of invasive species, which is significantly higher from that of native species and ranges from mosquito control and aquarium use (small fish species) to aquaculture and sport fishing (larger species). As previously reported for other taxa, taxonomic affiliation is also significantly different between native and invasive fish species. Invasive species belong to only five taxonomic orders but to a wide spectrum of families without native species in the Iberian Peninsula. The application of a phylogenetic comparative method (independent contrasts) highlights that it is important to account for phylogeny in such comparisons between native and invasive species (since the significance of results change).

The management of alien freshwater fish in Spain is virtually absent and at present anglers are illegally spreading several species such as wels (*Silurus glanis*) or bleak (*Alburnus alburnus*) to new river basins with no prevention, education, or control from public administrations.

N O T E S

Pilot Project on the Linkages Between Development Assistance and Invasive Alien Species in Freshwater Systems in Southeast Asia: A Report to the US Agency for International Development

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For decades development projects have worked to improve the social, economic, and political reality of those in the developing world through agriculture, fisheries, and water security projects. Until recently, these projects have typically been conducted without much consideration for their impacts on the surrounding ecosystems that ultimately sustain local communities. At times, project managers and donor agencies have failed to recognize or acknowledge that cultured organisms can have significant impacts on ecosystems and human health when they are released or escape into natural systems (Msiska et al. 1991, Welcomme 1988). As a result, species originating in one part of world have been intentionally or unintentionally introduced into other regions of the world. In some cases, these alien species have proven invasive, causing harm to ecosystems, economies, or human health, and thus threatening the very development activities they were introduced to support. Collectively, these introductions have contributed to a long-term problem of global scale; invasive alien species (IAS) are now among the top drivers of biodiversity loss and environmental change globally (Sala et al. 2000).

As awareness of IAS has grown, efforts to safeguard against their spread have begun to emerge. Forward-looking development agencies, which may have in the past been responsible for IAS introductions, are now educating their officers and partners about the risks posed by IAS. Recognizing the significant impacts that IAS have on the environment, economy, and human health, the U.S. Agency for International Development (USAID), in cooperation with the Global Invasive Species Programme (GISP), sponsored a preliminary assessment to investigate the linkages between IAS and development assistance in the freshwater systems of Southeast Asia. This report details the findings of the assessment, which focused on three areas – (1) development assistance as pathway of introduction, (2) development assistance projects adversely impacted by IAS, and (3) development assistance projects working to address IAS.

The assessment findings indicate that some development agencies are engaged in aquaculture projects that use alien species in Southeast Asia's freshwater systems in order to further food security and economic development (WorldFish 2003c). On occasion, the cultivation of local species has been suppressed in order to use species that international experts better understood (Msiska et al. 1991). Traditional aquaculture species like carps and tilapias, which have been documented to be extremely invasive in some parts of the world, are still commonly used outside their native ranges. In Southeast Asia, these species are sometimes used in open water systems, often absent even a basic assessment of their potential impacts, and certainly without long-term monitoring programs in place. In recent years, a few development agencies have begun to evaluate the introduction, use, and distribution of alien species that have a significant potential for becoming invasive and thus undermine their projects (MRC 2002a). Some development agencies have begun to develop alternatives to alien species. For instance, there are efforts underway to establish an indigenous aquaculture program in the Mekong region of Southeast Asia. Increased financial and technical support is necessary, however, to expand these activities and make them sustainable throughout the region. Yet, there still remains a significant need for greater education on the risks of IAS within the development assistance sector, as well as further evaluation following the introduction of alien species.

For all programs involving alien species, regional governments need to increase their capacities to conduct adequate risk assessments and environmental impact assessments. Given the progression of regional and global trade integration, coupled with the increasing freshwater aquaculture production, the countries of Southeast Asia will undoubtedly face escalating risks from IAS. In order to ensure sustainable development, development agencies must continue to raise awareness of IAS, as well as provide means for the Association of Southeast Asian Nations (ASEAN) countries to protect both their economies and their ecosystems from the impacts of IAS. A summary of recommendations arising from this assessment is listed in the following section. The authors hope that these recommendations will help ensure that the sustainable development opportunities for Southeast Asia are not diminished by the economic and ecological impacts of IAS.

Summary of Recommendations

Based on the findings of this assessment, the authors recommend that USAID and other relevant donor agencies take the following actions to support responsible and sustainable development practices in Southeast Asia. In order to be effective, the specific means by which the recommendations are addressed will need to reflect the socio-economic and ecological contexts unique to each ASEAN country.

USAID Internal Action

Policy

- Improve coordination among USAID offices regarding species introduction and the implications of IAS.

USAID Interagency Action

Policy

- Use the findings of this assessment, to inform the revision of the U.S. National Management Plan on IAS, especially the international section.
- Coordinate between USAID and other development agencies on activities that are relevant to the prevention, management, control and eradication of IAS.

USAID External Action

Policy

- Promote acknowledgement and enforcement of existing instruments governing sustainable management of fisheries, including protection of biodiversity.
- Encourage and support a study to identify gaps in international and national policies that enable resource managers to introduce and propagate alien species without adequate consideration and prevention of potential ecological and socio-economic impacts. As a result of the study, projects should be developed to help countries design new policies to rectify these gaps.
- Identify and promote use of 1) incentives for resource managers to apply "best management practices" for native and alien species and 2) penalties for resource managers whose practices lead to the introduction and spread of IAS.
- Work with the Mekong River Commission (MRC), WorldFish Center, USAID Pond Dynamics/Aquaculture Collaborative Research Support Program (PD/A CRSP) and UN Food and Agriculture Organization (FAO) in addition to engaging managers, policy makers, industry and other stakeholders to help developing countries implement the Code of Conduct on Responsible Fisheries.

Management and Monitoring

- Assist governments, industries and local communities within the region to improve management and monitoring infrastructures, including the development of best management practices.
- Encourage the continued development and expansion of indigenous aquaculture programs coupled with sustainable capture fisheries management.
- Promote a holistic approach to the management that considers genetic diversity (especially with respect to indigenous aquaculture), pathogens and parasites associated with fisheries, as well as native biodiversity at all levels.

Research

- Encourage and support studies, such as the WorldFish Center's and the USAID PD/A CRSP's work to develop techniques for the management of alien aquatic species that significantly reduce the potential impact on native biodiversity (e.g., minimizes escapes, disease-transfer).
- Encourage and support research to identify environmentally-sound methods of eradicating and controlling aquatic IAS (including pathogens and parasites) within the region.
- Encourage and support programs, such as the MRC's Aquaculture of Indigenous Mekong Species program and the USAID PD/A CRSP program, to investigate and promote, where appropriate, the use of native fish species for aquaculture.

Information Sharing

- Strengthen technical capacity in risk assessment and environmental impact assessment by sharing relevant information from U.S. National Invasive Species Council and providing training and financial support where feasible.
- Provide governments with copies of relevant IAS publications (e.g., U.S. National Invasive Species Management Plan) as well as encourage the development of national and regional plans to prevent and manage aquatic IAS.
- Encourage the governments of the region to report the occurrence of aquatic IAS (including pathogens and parasites) through the Network of Aquaculture Centres of Asia-Pacific (NACA) and other relevant mechanisms and support them in the development of regional network of national databases on aquatic IAS.

Education & Training

- Further develop environmental education programs for industry, policy makers and local non-governmental organizations (NGOs) and communities about the importance of native biodiversity and the potential risks associated with alien species, like those PD/A CRSP has developed.
- Support the development of a field guide/website on aquatic IAS present in Southeast Asia, that includes information on emerging IAS, that is IAS that are already established in neighboring regions or the countries of trading partners with similar environments.
- Where necessary, provide training on the aforementioned issues using local/regional training centers and experts in conjunction with relevant U.S. agencies or multi-national organizations such as the World Conservation Union (IUCN) or CAB International (CABI).

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Ships' Sea-Chests – A Vector for the Dispersal of Aquatic Invasive Species

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The larvae of marine organisms may be inadvertently transported in ships' ballast water, and this mechanism has been proposed to explain the introduction of nonindigenous species into ecosystems around the world. However, many larvae are short lived and would not survive the long voyages involved in international shipping. They will metamorphose in the ballast tank, but the juveniles are unlikely to obtain sufficient dissolved oxygen and nutrition to survive. Since larval dispersal is unrealistic for these organisms, mature adults must have established the populations in the new environments. But how can the sufficient adult organisms to successfully establish a new population be transported long distances?

The ascidian *Styela clava* is a good model for the study of long distance dispersion of organisms with short larval life-stages. It is oviparous; the eggs hatch after 12 to 15 hours and the negatively geotactic larvae are active for approximately 12 hours. The larvae settle on a hard substratum and develop into sessile adults. *S. clava* is native to the northwest Pacific; it was first recorded in British waters in 1954, and has since spread along the UK coast and the west coast of Europe. In coastal waters, a sheltered, high salinity site appears to be necessary to establish the initial population in an area; however, once established it rarely spreads along exposed coast to neighbouring suitable habitats. The current patchy distribution of this sessile invertebrate is reviewed with reference to the dispersal methods available. The natural dispersal methods suggested for its spread involve larval drifting and the drifting of adults attached to flotsam; man-aided methods involve transport of juveniles and adults, either attached to oyster shells or to ships' hulls. The limitations of these proposed dispersal methods are examined.

The majority of the sites where *S. clava* has been recorded are commercial ports and harbours, many of which have neighbouring small fishing harbours and marinas where no specimens of *S. clava* could be found, e.g., Porto and Lisbon (Portugal) and Fenit (Ireland). This heterogeneous distribution cannot be explained by natural dispersal or the presence of oyster fisheries. The adults are rheophobic, so hull attachment is an unlikely mechanism for dispersal, particularly as the hull is treated with anti-fouling agent. Therefore, alternative methods of man-aided dispersal were examined, and pre-eminent amongst these was the transport of adults attached to the inside of ships' sea-chests. These seawater intake chambers, the source of the cooling water, fire-fighting water and ballast water pumped aboard, provide a relatively sheltered environment with a sufficient water flow for the organisms to grow to maturity. The number and size of the sea-chests is in proportion to the size of the ship. Typically, a 3500 ton displacement warship has eight large sea-chests and four smaller water intakes, which provide an internal surface area prior to the pump suction in excess of $50m^2$. Ships' sea-chests can therefore provide a mobile substratum for numerous reproductively mature adults, which may then spawn in any harbour visited with suitable water quality.

This paper reports the results of several examinations of ships' sea-chests and demonstrates that this is a suitable transport mechanism for sessile marine organisms. Furthermore, the ledges contained within the sea-chests would allow this dispersal method to apply equally well to any organisms that could survive in the sea-chest, so it is likely to be an important vector for many invasive species. Indeed, this dispersal mechanism could explain the heterogeneous distribution observed for many species.

A qualitative dispersal model is proposed to explain the arrival and establishment of a population of *S. clava* at a site. Consideration of the available dispersal methods enables the identification of likely colonisation sites and, consequently, more selective sampling to determine the limits of distribution of this invasive species.

Ballast Water as a Vector of Macroalgae: Experimental Studies in the Mediterranean Sea

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In the last decade a great increase in the number of introduced species has been observed in the Mediterranean Sea. In some cases these species have proven to have an invasive behaviour. In the Gulfs of Naples and Salerno (Italy, South Tyrrhenian Sea) since its first record in 1997, the presence of the green alga *Caulerpa racemosa* is becoming more and more conspicuous. It is able to grow at different depth and on every kind of substrata, creating new ecological niches on bare sand habitats. To understand how this species can be introduced in this area, maritime traffic has been considered, since Naples and Salerno are commercial harbours with intense and well established activities on world level. It is confirmed, in fact, that ballast water represents the largest single vector for the translocation of marine species across the globe and it is recognized that planktonic organisms can be successfully transported. On the contrary there are very few reports on benthic macroalgae and up to now there are no studies concerning the Mediterranean basin.

The present research was carried out at three different levels: 1) analysis of the shipping traffic in 2001, 2) sampling and culture of ballast water samples and 3) laboratory experiment simulating ballasting and deballasting of *C. racemosa*.

The yearly maritime traffic was derived from logbooks in the harbour offices. The water was sampled on board of ro/ro carriers and container ships, directly extracted from the ballast pump (in-line sampling) and stored in dark plastic bottles. The sampling strategy was done according to the different time of transit of the water (1, 2 and more than 3 weeks) and to the geographic sources (Mediterranean and ex-Mediterranean). Salinity, oxygen and temperature were recorded immediately after the sampling. In the laboratory the water was filtered by hand operated vacuum pump, in order to capture fragments, spores and other structures. Filters were checked under fluorescence and kept in culture at defined conditions for one month. Once the time in culture was completed, algae were identified at the lowest taxonomic level.

The survival of *C. racemosa* thallus fragments was tested in conditions of darkness for one, two and three weeks to simulate transport in a ballast tank. The recovery was tested by culturing fragments under local mean conditions of light and temperature.

In relation to shipping traffic in 2001, on a total of about 36 000 arrivals, 7000 were commercial, of which 95% were from the Mediterranean basin while only 5% from ex-Mediterranean harbours.

The environment inside the tank was never estimated to be restrictive for algal survival. Nevertheless macroscopic fragments were never observed in water samples during filtration. By culturing the filters, 15 taxa were identified, probably deriving from spores and/or other resistance forms. Their amount was not related to the time in the tank and to the geographic source. Most of the taxa belongs to Chlorophyta and are distributed worldwide. One allochtonous species, *Ulva ohnoi*, recorded as sp. nov. in Japan, was found in water coming from Port Said (Egypt). Since all ships, entering the Mediterranean from the Suez Channel sail through Port Said, this area can play a key role as a donor area for the introduction and dispersion of species all over the basin.

The simulation experiment demonstrates that, even after three weeks under difficult conditions the fitness of *C. racemosa* doesn't change, confirming its invasive behaviour. Although this species was not recorded in ballast water samples, the results suggest the possibility that it was introduced and dispersed in the Mediterranean through this vector.

The present contribution point out the relevant role played by ballast water as a vector for macroalgae introduction and dispersal.

Posters

Review of Sound Studies for Deterring River Herring Species

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From the beginning of advances of inland waterways, several species of river herring, notably alewife, blue back herring and various species of shad have shadowed those progressions, seeking new spawning territory. The novel marine based behavior of river herring, not characteristic of native freshwater fishes, has wreaked havoc at selected industrial sites located on waterways invaded by these alien species. The latest of these accidents have occurred at highly sensitive nuclear installations on Lake Michigan in the United States, where conventional screening structures have been disabled beyond repair, and industrial sites they serve shut down, resulting in tens of millions of dollars in lost revenue and damage.

Nearly forty years ago it was observed by submariners that certain herring species responded to high frequency sound generated by military equipment. Later studies confirmed that most river herring species do in fact respond dramatically to underwater sounds greater than 156 kHz. Unfortunately this promising knowledge has floundered in the intervening years leading many aquatic life experts to label it unreliable and unsubstantiated. Ironically, the basic finding of the fish behavior, relative to the sound, has never been discounted. What happened?

The only successful studies of river herring response to sound were documented in the early 1990s by fish biologists of the New York Power Authority in an effort to keep the alewife invaders out of the water intakes of the James Fitzpatrick Nuclear Power Plant located on the southern shore of Lake Ontario. Unlike their colleagues, capable as they were with observing and documenting behavior of aquatic species, these researchers combined their efforts with acoustic engineers having expertise in the design and manufacture of submarine sound equipment responsible for those earliest observations.

One cannot observe active high frequency sound in water; it cannot be seen, it cannot be heard, and it cannot be felt by any of the human senses. Is it any wonder that civil engineers, producing works that elicit response from all of the human senses, have pronounced sound technology for river herring deterrence as “unreliable and unsubstantiated”? In order to study and further develop sound technology as a means of diverting and managing invasive aquatic species, one must look for the responses of those species and not human observations. Being outside of the realm of human observation, high frequency sound must be verified by other technical means.

This poster session will make a brief synopsis of the basic high frequency sound and fish response concept (the one never disproved) and then highlight possible design flaws in other studies labeled as inconclusive. Corrective measures suggested for new study designs will focus on the nature of underwater sound propagation, available technology to produce adequate sound pressure levels, and the fundamental importance of sound field verification, the one item most frequently dispensed with in inconclusive studies.

N O T E S

Preliminary Study on the Diet of Two Invasive Gammarid Species *Dikerogammarus haemobaphes* (Eichwald 1841) and *Pontogammarus robustoides* (G.O. Sars 1894)

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Dikerogammarus haemobaphes and *Pontogammarus robustoides* are two of the most common ponto-caspian gammarid species occurring in Polish waters. Many invasive species have very wide spectrum of diet and some of them are known as very affective predators. The aim of this study was to estimate the food preferences of *D. haemobaphes* and *P. robustoides* by field and laboratory experiments. Animals used for my investigation were sampled from the lower Vistula River where the species co-occur. The analyses of digestive track contents and observations of the predatory behavior were done. Results of this study will be presented and discussed on the poster.

NOTES

Alien Crustacea in Poland: A State of Art for the New Century

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There are 793 species of Crustacea known to occur in Poland. However only 18 representatives of five orders of macrocrustaceans could be undoubtedly identified as alien species that invaded or were introduced to Polish waters in historical times. They are Decapoda – six species: *Pontastacus leptodactylus*, *Pacifastacus leniusculus*, *Orconectes limosus*, *Atyaephyra desmaresti*, *Rhithropanopeus harrisii*, *Eriocheir sinensis*; Amphipoda – nine species: *Chelicorophium curvispinum*, *Gammarus roeselii*, *G. tigrinus, Chaetogammarus ischnus, Dikerogammarus haemobaphes, D. villosus, Pontogammarus robustoides, Obesogammarus crassus, Talitroides alluaudi;* Mysidacea – *Hemimysis anomala*; an onychopod Cladocera – *Cercopagis pengoi* and a cirriped – *Balanus improvisus*. It is noticeable that nine of these species (*P. leptodactylus, C. curvispinum, C. ischnus, D. haemobaphes, D. villosus, P. robustoides, O. crassus, H. anomala, C. pengoi*) are of Ponto-Caspian origin, out of the rest – five (*P. leniusculus, O. limosus, R. harrisii, G. tigrinus, B. improvisus*) arrived from North America, and remaining four from East Asia (*E. sinensis*), islands of Indian Ocean (*T. alluaudi*), and from southern Europe (*A. desmaresti, G. roeselii*). The poster summarises biogeographical and historical data as well as ecological consequences of the crustacean invasions in Poland.

N O T E S

The Pacific Coast Estuarine Information System: Creating a Baseline for the Future

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Coastal researchers and managers have a growing need for ready access to a diversity of data types, including estuarine-specific lists of native and nonindigenous species and estuarine/landscape characteristics. These data are key components in ecological risk assessments in general and in "early detection & rapid response" strategies for invasives species in particular. However, this information is scattered in the peer-reviewed and gray literature as well as State and Federal databases. To address this problem, the US EPA and USGS are developing a database, *Pacific Coast Estuarine Information System (PCEIS)*, synthesizing biological and landscape characteristics for the estuaries of Oregon, Washington, and California, USA. Currently, *PCEIS* contains georeferenced information on 182 estuaries and more than 500 sub-estuaries/tributaries. *PCEIS* summarizes the occurrence of both native and nonindigenous species of benthos, fishes, and seagrasses for each estuary. Inclusion of the native species greatly enhances the database's utility such as allowing the ranking of estuaries by the relative percent invasion or generating baselines of native species to evaluate future impacts of invasive species on indigenous fauna. Presently *PCEIS* contains more than 2600 species. With growing recognition of the role of landscape attributes and loadings on estuarine structure and function, we are also summarizing key estuarine and landscape characteristics, such as areas of the estuary and associated watershed, percent intertidal area, land use patterns, and nutrient loadings to the watershed. This information is initially being captured in a user-friendly, stand-alone Microsoft Access™ database but will eventually be linked to the USGS's The National Map.

In addition to generating the baseline lists of native and nonindigenous species, outputs from PCEIS are used as inputs into "Genetic Algorithm for Rule-set Prediction" (GARP, a machine-learning algorithm). GARP is a spatially explicit ecological niche model used to predict the potential geographic distributions of invasive species based on matching of environmental requirements. GARP has been used successfully in predicting distributions of terrestrial and freshwater invaders. One of the challenges in applying GARP to estuarine invaders is obtaining environmental data layers (e.g., salinity) at a fine enough spatial scale. By synthesizing such environmental data for the Pacific Coast, *PCEIS* allows us to evaluate the utility of this model for estuarine ecosystems. Additionally, the standardized taxonomic species lists generated from *PCEIS* are being used to develop regional "master species lists". Such regional taxonomic lists are used to assess local deviations from the expected "average taxonomic distinctness", a recently proposed practical index of ecological condition.

NOTES

A Study on the Prevalence and Intensity of Parasitism in the Freshwater Mussel *Dreissena polymorpha* (Pallas, 1771) in Lough Derg, Ireland

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Dreissena polymorpha (Pallas, 1771) has recently been introduced in Ireland. According to boat owners and eye-witness accounts by fishermen, the zebra mussel probably arrived on the Dock of Limerick in the years 1994-1995. Several populations are now well established particularly in the Shannon water system. Numerous ecological and economical problems have arisen following this rapid invasion. A study on the reproductive cycle and population dynamics of the zebra mussel in Ireland has been conducted but little is known about the parasitology of this bivalve. This survey is therefore investigating the presence of parasites in the zebra mussel in Lough Derg, Co. Tipperary in the context of new pathogens introduction and environmental impacts. Monthly samples of *Dreissena* were collected from January to October 2001. By histological technique, 30 individuals per month were screened. Preliminary results revealed the presence of the ciliate, *Conchopthirus acuminatus,* situated primarily in the digestive gland of the mussels and in the digestive tract to a lesser extent. This suggests a possible link between the mode of colonization of the parasite and the feeding behavior of the mussels. Seasonality was observed in the infection, as the prevalence of parasitism was the highest in the summer months considering all the individuals. In the meantime intensity of infection did not seem to differ significantly all along the study period suggesting a possible mechanism of regulation of the burden of parasites in the mussels. Prevalence and intensity of infection have been evaluated in different mussel size classes and sex of the animal was determined for each of the individuals screened. The aim of the study was then to investigate the prevalence in different age groups and the relationship between prevalence of infection and reproductive state. No significant differences were noticed for the intensity and prevalence between males and females for all the months sampled whereas the larger animals seemed to be more infected than the smaller ones.

NOTES

Chemical Toxicity and Environmental Fate: An Evaluation of Aquatic Pesticide Use and Risk Assessment

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Aquatic herbicides have been registered for use in the United States for more than 45 years. During that time, herbicides have been effectively used to manage invasive aquatic plants including such key problem weeds as *Hydrilla verticillata, Myriophyllum* species, *Potamogeton* species, *Eichhornia crassipes*, *Egeria densa*, *Salvinia molesta*, and other species. There have been no reports of detrimental effects from the use of aquatic herbicides when used according to the Federally approved labels to native populations of plants or animals, including invertebrates and other microorganisms, even after many years of use. Registrants are required by US law to report any negative effects attributed to the use of their products, however, there are no requirements or consideration given to the reporting of the beneficial use of aquatic herbicides.

Requirements for registration in the United States include basic chemistry, toxicology, and environmental fate information, which are derived primarily from laboratory information. During the re-registration process of 1987 under the Federal Insecticide, Fungicide, and Rodenticide Act, registrants are required to resubmit registration packaged for herbicides including significantly more data requirements such as extensive fate information, use patterns, bioaccumulation, etc.

The new regulations under the Environmental Protection Agency now require a complete set of data in which to characterize and assess the risk and use of pesticides, including diquat in aquatic weed management. This information consists of the general properties of the pesticide such as molecular structure, mobility, predicted degradation pathway, etc. Complete analytical procedures for the parent compound plus major metabolites for regulatory authorities and the registrant are also required. The analytical package the definition and understanding to trace and locate the test material and evaluate and quantify residue levels in tissues, soil, water, and air (if applicable).

Environmental fate, distribution, and transformation effects of the parent and major metabolites must be well understood and verified. A clear pathway of degradation must be well constructed, qualified and quantified. Fate, half-life, aerobic and anaerobic degradation and transformation are evaluated. The kinetics and metabolism of the parent and major metabolites must be understood and quantified. The effects on man and animals must be thoroughly understood. Thorough understanding of these effects include an understanding of the test material with regard to gastrointestinal system and liver, the renal system, eyes and skin, respiratory system, and nervous system. Effects on reproduction, embryo toxicity, teratogenicity, mutagenicity, and carcinogenicity are also understood.

All of this information is then used to input a federal risk assessment for the registered or potentially registered use pattern of the herbicide. These risk assessments clearly support the notion of risk/benefit in their calculation with the proper tenet that all actions or inactions involve risk. Risk is inevitable in all management situations and it is up to the regulator to identify, quantify, and evaluate the risk level of any pesticide such as diquat.

Syngenta Crop Protection has completed and submitted several data packages on aquatic herbicidal use, which have been reviewed and approved by the USEPA. By understanding and characterizing the product and its use pattern, a complete risk assessment can be made and understood to allow regulators a thorough review for registration. In this way, necessary tools in aquatic weed management can be maintained or developed using reasonable risk assessments and evaluations.

Invasions of Ponto-Caspian Gobiidae in Poland

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Until recently the family *Gobiidae* was represented in Poland by four native species living in the Baltic Sea. Since the 1990s three alien gobiids of Ponto-Caspian origin appeared in Polish waters. In 1990 the first individuals of round goby, *Neogobius melanostomus*, were recorded in the Puck Bay (part of the Gulf of Gdansk). Within a few years the fish spread along the entire shore of the Gulf of Gdansk, established population in the Vistula Lagoon and entered the lower course of the Vistula River. The second species – racer goby, *Neogobius gymnotrachelus*, was found in 1995 in the Bug River (the left tributary of Vistula) and until now has colonised the downstream section of Vistula. The same expansion road was taken by monkey goby, *Neogobius fluviatilis*, noted in the Bug River in 1997, which after six years reached to the mouth of the Vistula. Considering the rapid expansion of gobiids in Polish waters, we assume that they may migrate further to the west through the Bydgoski Canal connecting the Vistula to the Oder drainages and further to the North Sea basin. However, studies conducted in autumn 2003 have not yet revealed the gobiid occurrence in the Bydgoski Canal or in the Notec River.

NOTES

Life History Traits of Ponto-Caspian Gobiids as Factors Promoting Their Expansion

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Since the 1990s a rapid expansion of several Ponto-Caspian gobiids has been observed in many European countries, as well as in the Great Lakes in North America. The phenomenon of their successful invasion may be related to the dynamic geological history of the Ponto-Caspian region, where environmental conditions were changing over time. As a result, organisms that have evolved in such unstable habitats possess a wide spectrum of tolerance toward various environmental factors and are characterised by biological features that may promote their invasiveness. Based on the case studies upon racer goby, *Neogobius gymnotrachelus*, from the Wloclawski Reservoir (the Vistula River, Central Poland) we suggest that opportunistic feeding strategy and reproductive behaviour can be among the most important life history traits promoting invasion of the species. The diet of racer goby differed between sites according to the zoobenthos structure. In a site dominated by molluscs, gobiids fed mainly on that group, while in a site where Amphipods and Chironomids larvae were most numerous; they also dominated in the fish alimentary canals contents. The fecundity of racer goby was relatively small (average 1000 oocytes per female), however we assumed that the spawning behaviour typical for all Gobiidae (eggs deposited in shelter and guarded by a male) increases the chance of successful reproduction. Moreover the spawning period was prolonged and lasted from April to August, what can be regarded as a feature enhancing invasiveness.

N O T E S

Harbor Water Quality – Origin and Settlement of Invasive Species

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Ballast water management regulations offer a wide spectrum of options to control the invasion and establishment of biological species. Article 8 (h) of the Convention on Biological Diversity states: "…Each Contracting Party shall, as far as possible and as appropriate: ...(h) Prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species." The option of biological mapping and information of diverse species of geological regions gives a prerequisite to choose the waters. The primary issue is the origin of "nature-selected, fit species" that successfully settle at alien lands. Control over origin and establishment of resistance-proof invading species will be of help in curbing the menace. The harbors/ports that are located at river mouths and estuaries, coupled with anthropologically influenced waters, offer fertile ground for the origin of resistant varieties of species. Studies indicate that the resistant varieties can thrive well in nutrient rich, low saline and anoxic/hypoxic waters. Improved water quality conditions leave less chance for survival of these species and they may disappear altogether. *Capitella capitata* and *Mytilopsis salleii* are found to be very few in numbers at stations characterized by thoroughly mixed, oxygen rich, saline waters in contrast to organically enriched, anoxic and stagnant waters of Visakhapatnam harbor in the aforesaid study. This prompts a thought pertaining to harbor water quality: a) to improve, understand and develop awareness; b) to strengthen the management aspect; c) to provide appropriate legal and institutional mechanisms and, d) to enhance knowledge and research efforts at first hand and install regulations at the global level.

The solutions include thorough water circulation patterns and avoidance of stagnation of nutrient rich waters in the enclosed, semi-enclosed harbors/ports. An overall development of conceptual model of influencing factors of water quality pertaining to specific regions will be of use to develop a long term strategy to achieve necessary changes.

NOTES

By Land and Water They Go: Aquatic Snails in the System. Are They Native, Exotic, Invasive or Just Great Bio-indicators?

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Zebra mussels (*Dreissena polymorpha*) have threatened the St. Croix National Scenic Riverway ever since they were discovered upstream of the confluence with the Mississippi in 1992. The Riverway is a unit of the National Park System and is recognized for its outstanding recreational and biological resources, particularly the nationally significant richness and abundance of freshwater mussels (~40 species). The diversity of unionids within the Riverway is the greatest in the Upper Mississippi watershed. There is little doubt that the assemblage of aquatic gastropods is of similar note. These faunal groups will be severely impacted by a zebra mussel infestation or other exotic invasions. Freshwater mollusks are a keystone faunal group of freshwater systems and while the unionid mussels in the St. Croix and Namekagon Rivers have been relatively well studied, little detailed information is available for aquatic snail species. Past surveys and sporadic collecting efforts over the past 110 years are sufficient to indicate that snails are indeed present in this system, and that snail diversity is typically lower than that of unionids, but with similar abundances in suitable habitats. However, no recent data is available to assess shifts and/or trends in patterns of snail distributions and abundance.

The problem and question is thus posed in the face of imminent threats. The St. Croix National Scenic Riverway has remarkable native mussel diversity, so one would expect similar snail diversity. Little or no current information on snails from the Riverway is known. Zebra mussels might spell the demise of species before river managers are aware of their presence. Black carp (*Mylopharyngodon piceus*) are certain to have a negative impact on all the Riverway's mollusks species. These animals are experiencing dramatic declines and unprecedented levels of extinction as a consequence of habitat degradation from agricultural and industrial pollution, damming, invasive species (e.g. New Zealand mud snails, Zebra mussels, etc.) and a number of other human mediated impacts. A thriving and diverse molluscan assemblage is an integral component and indicator of healthy aquatic/riparian ecosystems. Therefore, discovering what snail species are present and where, does the Riverway support exotic/invasive species, and what impacts other invasive/native species will have on this faunal group is a critical set questions to begin to answer.

The presentation will outline the results of a survey of aquatic snails on the St. Croix and Namekagon during the 2004 field season. Emphasis will be placed on those species which are rare or invasive and what strategies might be best to conserve or eliminate species based on this determination. Also discussed will be tools that might be used to protect desired species from the onslaught of threats, particularly aquatic invasive species.

NOTES

US Coast Guard Ballast Water Management Program: Prevention of Ship-mediated Invasions

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The US Coast Guard is the United States agency designated by Congress to develop a national regulatory program to reduce, and eventually prevent, introductions of nonindigenous aquatic organisms into US waters via the operations of vessels. At the direction of Congress, the Coast Guard has established mandatory ballast water management regimes for the Great Lakes and other regions of the US. The National Ballast Information Clearinghouse (NBIC), also established by congressional direction, collects the ballast water management (BWM) reports for vessels entering ports and places outside of the Great Lakes ecosystem and analyzes ballast data and patterns. Efforts are underway to maximize vessels' use of electronic means of submitting BWM reports. The database of information gleaned from the reports is available to the public at the NBIC web site, along with reports of analyses on the patterns of vessel entries and ballast water management practices. On the basis of the first biennial report of the NBIC, the Secretary of Transportation determined that compliance with the voluntary guidelines was insufficient, and directed that the program be made mandatory. The Coast Guard has subsequently initiated a series of regulations that implement penalty provisions for non-reporting and expands the reporting requirement to all ships operating in US waters, and converts the voluntary guidelines into a mandatory program. We have begun the process to establish ballast water discharge standards with an analysis of the environmental impacts of several alternative ballast water discharge standards as required by US law.

To support the development and implementation of this regulatory program, the Coast Guard has initiated a suite of Research and Development (R&D) projects. These projects include efforts to develop protocols for evaluating the effectiveness of treatment technologies, analytical methods for verifying BWE, and management practices that could be used to address the problem of NOBOB vessels, which cannot conduct BWE due to safety constraints. The Coast Guard and the Environmental Protection Agency (EPA) have established a formal engineering test program for ballast water treatment technologies within the EPA's Environmental Technology Verification (ETV) program. The ETV program is intended to accelerate the development and commercialization of ballast water treatment technologies through third party verification and reporting of performance. In support of development of our compliance and enforcement program, the Coast Guard R&D Center is coordinating the development of an improved method for verifying that ballast water in a vessel was in fact taken on in mid-ocean. The Coast Guard is also collaborating with academic and government researchers, and the shipping industry on studies that characterize the temporal and spatial patterns of NOBOB vessels, the amount and distribution of water and sediment carried in their ballast tanks, and the composition of the biological communities they carry. In addition, the Coast Guard has established a program to provide an incentive for ship owners to participate in the shipboard evaluation of prototype treatment systems. Under this Shipboard Technology Evaluation Program, ships operating an accepted experimental system would be considered to conditionally meet regulatory requirements for ballast water management for a specific period of time.

The Coast Guard leads US participation in negotiations at the International Maritime Organization for the Convention for the Management of Ships' Ballast Water and Sediments. The IMO Diplomatic Conference that took place earlier this year brought forth this international agreement and work continues on the development of guidelines that will support this Convention.

NOTES

Range Limits of *Limnoperma fortunei* (Dunker 1857) Due to pH Variation

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Limnoperna fortunei, the golden mussel, is a typical representative of invasive species introduced recently to Brazil. The biology and behaviour of this species have not been well documented in tropical waters. As there are some nationally significant habitats in Brazil where rapid pH fluctuation could prevent the establishment of *L. fortunei*, this study was designed to test the effect of the pH variation on the survivorship of adult golden mussels.

Beakers containing spring water were used under aeration and ambient temperature, each containing two adult mussels. Six treatments were tested in total, each treatment having four replicates. Three of the treatments used hydrochloric acid (HCl) to adjust pH down at varying rates, and three used sodium hydroxide (NaOH) to increase pH at varying rates. Every 48 hours the pH in the treatment beakers was adjusted by adding either the acid or base. The change in pH was either low, medium or high depending on the volume of chemical added. There were two control groups, each one with 4 replicates (two individuals/replicate). In one set of controls the mussels were fed and in the other they were not.

In the two control groups there was no mussel mortality in the 21 days of experiments. The total variation of the pH tested ranged from 2.6 to 9.2. There were some early deaths on the third day of the experiment, probably attributable to weak condition of the individuals tested. The first death (at NaOH) occurred at the 11th day of experiment, at pH = 8.82. After this day all the deaths occurred at pH>8.5. There were no organisms alive at pH>9.0. In the low pH experiment mortality begun at pH of 3.44. Most animals reached mortality at pH 2.7 – 2.6. There were no organisms alive at pH<2.6.

Limnoperna appears to be able to tolerate large changes in pH, at least for short periods of time. It is unclear if long term survival is possible at pH levels higher then those for which we found acute mortality. We observed definite variation in the filtering patterns of individuals kept at different pH levels. At the abruptly adjusted low pH, the mussels were observed to close the valves and stop filtering. This would compromise their long-term ability to survive. Chronic exposure to various pH levels below the threshold of acute lethality, using much larger experimental sample must be tested. We also plan to investigate the combination of pH and temperature conditions mimicking those found in Brazilian waters.

N O T E S

Design and Testing of Incubator-Emergence Traps (IETraps) for Use in Hatching Studies in Ballast Tanks

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Sediments that accumulate in ballast tanks of transoceanic vessels have been shown to contain varying concentrations of resting stages (eggs, cysts, spores) of invertebrates and phytoplankton. Hatching of resting stages collected from ballast tanks under well-controlled optimized laboratory conditions revealed the potential risk for new invasions via these dormant stages. However, it is much more difficult to assess the extent to which such hatching occurs within ballast tanks under regular operating conditions. To solve these problems, a simple and low-cost incubator-emergence trap (IETrap) was designed for *in situ* hatching experiments conducted in ballast tanks on operating commercial vessels. The trap is constructed of standard PVC plumbing components and allows ballast water to enter, while excluding organisms in the incoming water and retaining organisms that hatch within the trap. However, whether the conditions inside the trap match those in the surrounding ballast water, especially the oxygen concentration, is of concern. The presence of sediment inside the traps and restricted exchange of ballast water inside and outside of the trap could lead to hypoxia or even anoxia within the traps, thus confounding *in situ* hatching trials. To evaluate this, two experimental designs were used. In one, live animals were added to a separate trap incorporated into each of four *in situ* hatching experiments conducted on commercial ships, and their condition was evaluated at the end of each experiment. For the second test, the sensor end of an In-Situ Corp. MP Troll 9000 probe was sealed in a trap to continuously record temperature, conductivity and dissolved oxygen within the trap. A second MP Troll 9000 was mounted immediately adjacent to the instrumented trap to measure ambient conditions outside the trap. The instrumented trap package was moored in a ballast tank that was then filled with Great Lakes water for an *in situ* hatching experiment conducted over an 11-day period during October 2003. This experiment was supplemented with additional laboratory tests. The combined field and laboratory experimental results will be presented.

N O T E S

Elemental Fingerprinting of Zebra Mussel (*Dreissena polymorpha*) Shells Using Inductively Coupled Plasma Mass Spectrometry

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The zebra mussel (*Dreissena polymorpha*) first arrived in Ireland during the early 1990s and has spread rapidly through the Shannon River system. This poster will describe the design and application of a laboratory-based matrix removal/preconcentration system using an iminodiacetate chelating ion exchange reagent. The methodology is evaluated for the determination of trace elements in zebra mussel shells.

The chelating ion exchange reagent selectively isolates trace elements in solution from the shell of zebra mussels (which consists of macro levels of Ca, Mg, Na and various anions in solution). The trace elements are incorporated into the zebra mussel shell structure from the surrounding freshwater environment.

The use of a sample pretreatment technique leads to reduced matrix and spectral interferences with improved detection limits for atomic spectrometric determinations. The system is used in conjunction with a low-flow microconcentric nebuliser and Inductively Coupled Plasma Mass Spectrometer (ICP-MS).

Previously, an extensive baseline elemental fingerprint study of bivalve shells around Ireland's coastal area has been successfully carried out using the technique outlined in this poster[1-2]. Preliminary results will be presented profiling trace element constituents in zebra mussel shells in two Irish lakes (Lough Derg and Lough Key) on the River Shannon. Potentially the elemental fingerprint data obtained by this technique could be used to geographically monitor zebra mussel infestation on the Shannon River and also measure the impact of trace element pollutants on the freshwater environment.

NOTES

The National Aquatic Nuisance Species Clearinghouse and Searchable Electronic Database

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Stakeholders interested in the introduction, spread, potential impacts, and control of nonindigenous aquatic nuisance and invasive species require timely, reliable scientific information and fast, easy access to published research pertaining to such organisms. Since 1990, information relating to the zebra mussel has been available from Sea Grant's Zebra Mussel Information Clearinghouse. But, the Clearinghouse is no longer *just* a zebra mussel information source. Since mid-1997, the "National Aquatic Nuisance Species Clearinghouse" has had the mission to facilitate and coordinate aquatic nuisance, nonindigenous, and invasive species information (ANS/NIS) sharing among researchers worldwide; provide continuity to the timely dissemination of findings of ANS/NIS research projects; and facilitate ANS/NIS prevention and control technology transfer between researchers and stakeholder audiences. The Clearinghouse serves as a major link between the research community and a wide array of university, government agency, industrial, and special interest stakeholders, and plays a high-profile role as a primary nexus for identifying completed, current, and proposed ANS/NIS research activities and for linking researchers with similar interests.

Thirty-one North American marine and freshwater aquatic nuisance, nonindigenous, and invasive species are addressed in the Clearinghouse and it is continually updating its library and searchable database of over 6500 documents, which include specific collections on 28 organisms, as well as biological macrofouling, ballast water, aquatic exotic organism, and invasive species policy issues.

All Clearinghouse information is accessible to any researcher, agency, industry, utility, student, or other individual or group having need of the information via electronic mail, fax, toll- or toll-free telephone, written requests, or visits to the Clearinghouse. A new, keyword outline and full text searchable electronic database of the Clearinghouse's Technical Library Bibliography is now available on the Clearinghouse's revamped, user-friendly World Wide Web home page (www.aquaticivaders.org). Citations include: author(s), title, document source and date, an annotation, type of publication, document length, language in which the document is written, whether the document is available from the Clearinghouse or direct from some other source, and the copying/mailing fee from the Clearinghouse. Most documents are available directly from the Clearinghouse on interlibrary loan and can be ordered via a convenient on-line "shopping basket." The web site also contains a series of detailed maps charting the range expansion of the zebra mussel and the "quagga" mussel in North America since 1989, information on a number of other informational and educational materials available from the Clearinghouse as well as extensive "hot links" to other ANS/NIS web sites.

The Clearinghouse's quarterly publication, *Aquatic Invaders*, presents papers on a variety of ANS/NIS and related topics such as: research, policy, impacts, new introductions, ballast water, education and outreach, and control measures as well as highlighting library holdings, useful web sites, and meeting announcements.

The Federal Aquatic Nuisance Species Task Force and its various Regional Panels, the National Invasive Species Council, and numerous other state, federal, and international agencies and institutions utilize the Clearinghouse as a major channel for extending information on zebra mussel, aquatic nuisance, nonindigenous, and invasive species spread, research, and policy initiatives to all interested audiences.

NOTES

Biological Invaders in the Taranto Seas (Mediterranean Sea)

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Biological invaders have been identified as one of problems for the biodiversity conservation in marine habitats. In the Mediterranean Sea a large number of exotic species have been intentionally and accidentally introduced through ship traffic, ballast waters, aquaculture, trade of living bait, aquariology as well as scientific research. Moreover, the warming of seawater seems to represent a further cause of the spread of tropical species in this basin.

The Taranto seas are located on the coast of the northwestern Ionian Sea (Eastern-Central Mediterranean) and they consist of two basins named "Mar Grande" and "Mar Piccolo". Both the basins are subject to several anthropogenic impacts, including urban and industrial sewage outputs, intense naval traffic and aquaculture activities.

In this presentation the authors report the occurrence and settlement of exotic species (the opistobranchia *Bursatella leachi* and *Melibe viridis*, the bivalve *Musculista senhousia*, the polychaeta *Branchiomma luctuosum* and the ascidiacea *Microcosmus exasperatus* and *Polyandrocarpa zorritensis*) as well as the faunal assemblage changes in the marine ecosystem of the study area.

N O T E S

Effects of Natural and Artificial Filamentous Substrate on Settlement of Zebra Mussel Larvae

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The hydroid *Cordylophora caspia* and the zebra mussel *Dreissena polymorpha* are invasive fouling organisms co-occurring in freshwater ecosystems. Though a great deal of research focuses on the range expansion and presence of adult zebra mussels, there is still a need to understand processes of larval settlement and how that relates to adult populations. Further, little attention has been given to the colonial hydroid *Cordylophora caspia* and how it affects larvae and/or adult zebra mussels. The marine literature documents enhanced larval settlement in the presence of natural filamentous substrates such as hydroid colonies and algae. Similar studies are rare in freshwater systems, although freshwater literature suggests that *Cordylophora caspia* consumes zebra mussel larvae. A previous study by the authors showed that in river systems, artificial filaments enhanced zebra mussel settlement primarily by increasing the amount of surface area available for settlement.

We examined the effects of natural (hydroids) and artificial (polypropylene) filamentous substrates on settlement in zebra mussel (*Dreissena polymorpha*) larvae in Burnham Harbor Lake Michigan. Twelve frames, each containing 4 PVC treatment plates (live hydroids, dead hydroids, polypropylene filaments and no filaments or controls) were deployed for an 8-week period from late June through August 2003. Plates were retrieved and preserved every two weeks and replaced with a new set for the duration of the study. Larval supply was monitored weekly. Plates are currently being analyzed for abundance and sizes of settled zebra mussel larvae. Preliminary observations suggest that live and dead hydroid colonies, as well as artificial filaments enhanced settlement of zebra mussel larvae.

In addition to the plate experiment, laboratory experiments were conducted and field data collected to determine if *Cordylophora* colonies actually consume zebra mussel larvae. Laboratory results indicate that hydroid polyps do not eat smaller larvae and consumption of larger larvae is rare. Field data clearly demonstrate that *Cordylophora* polyps consume larvae. Sizes and the number of larvae within hydroid guts are still being analyzed at this time.

These results will enhance our understanding about the role of hydroid colonies and filamentous substrates in the process of enhancing and/or deterring settlement of zebra mussel larvae. Knowing how *Cordylophora caspia* and *Dreissena polymorpha* interact will clarify ecological dynamics between two invasive species and may add insight as to how each affects endemic species present in invaded habitats.

NOTES

Commercial Seaweed Farming of *Asparagopsis armata* at the West Coast of Ireland: Impact and Distribution

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Originally described from Australia, the red alga *Asparagopsis armata* is currently being commercially cultivated in Ireland for the cosmetics industry. The gametophytes of this species can now be found within a 75 km radius of the seaweed farm. This farm is probably the source pool for populations of *A. armata* on the Irish west coast. Fragmentation of the algae, to seed cultivation ropes maintains the population in Ard Bay and without this farm this alga would probably not flourish in nearby area. The population of *A. armata* that does exist in Ard Bay may have an epiphytic relationship with *Ulva* sp. The optimum growth conditions for the gametophyte stage were observed to be 15ϒC, 8:16 (l:d) at a light intensity of 10 µmol photons m^{-2} s^{-1}. The surface sea temperature of Irish waters is suitable for growth and survival of the tetrasporophyte and gametophyte; however, it may not be warm enough for sexual reproduction. This is probably the reason it is not present outside the radius of the farm. Although there is plenty of suitable habitat, and little, if any, herbivory, *A. armata* does not appear to be spreading beyond the immediate vicinity of the aquaculture operation.

NOTES

Sargassum muticum at the West and South Coast of Ireland: an Invasive Species on the Move?

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The alien invasive seaweed species *Sargassum muticum* was recorded from Kilmore Quay for the first time in Ireland by the Irish Seaweed Centre in 2001. After this record, it has been found at Rath strand Kenmare River (Co. Kerry), Cashel Bay (Co. Galway) and Drum Cliff Bay (Co. Sligo) in the following years. It is important to note that these specimens were attached, indicating the presence of established populations. As shown in other studies of the invasion of *S. muticum* in the UK, Denmark, and Portugal, this species may have an impact on tourism, biodiversity and the aquaculture industry.

In Ireland a study was carried out form April 2003 to November 2003 to map the geographical distribution and spread of the invasive brown macroalgae *S. muticum*. The overall objective of the study is to determine the present status, distribution and invasive capability of *S. muticum* at the west and south coast of Ireland. The areas where *S. muticum* were reordered for the first time in the past were surveyed in this study including neighbouring areas. Furthermore, bays and inlets in close proximity of the original survey area were also examined. The extent of the population and spreading ratio was measured if *S. muticum* was encountered. Detailed maps with distribution, spreading and extend of the beds are produced from the survey records.

This study showed that *S. muticum* most probably arrived in the mid-1990s and is spreading along the coast of Ireland. The results indicate that spreading is facilitated by Yachting and perhaps via oyster transport. Spreading rates are difficult to calculate due to the nature of the introduction and late discovery in Ireland, nevertheless, with some uncertainty a rate of spreading of 2-3 km year^{-1} has been calculated for two bays. Furthermore, this study showed that *S. muticum* has been found growing in Seagrass beds and in rock pools, which might have serious consequences for the biodiversity in rock pools and protective status of seagrass habitats.

NOTES

Impacts of the Zebra Mussel on Chlorophyll *a* and Nutrient Concentrations in Lough Erne, a Eutrophic Irish Lake

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Lough Erne (109 km^2) is the third largest lake In Ireland. Based on the OECD lake classification, lake phosphorus (P) concentrations of up to 90 µg P L^{-1} have been typical of a markedly eutrophic water-body but only in the shallow waters of the lake have the annual average chlorophyll *a* concentrations in excess of 15 µg L^{-1} corresponded to eutrophic conditions. While algal blooms occur in the deep-water regions of the lake, the paucity of phytoplankton here has been attributed to light limitation accentuated by the peat stain of the water and the deep thermocline (>30m). Since monitoring began in 1973, P concentrations in the lake and its inflowing rivers have been increasing at rates of 1.5 to 2 µg P L^{-1} $year^{-1}$. These increases have been most noticeable in the dissolved reactive P (DRP) fraction, and within the lake there has been no commensurate impact on chlorophyll concentrations, an indication that phytoplankton growth in the lake has been P saturated since the mid 1970s. The zebra mussel (*Dreissena polymorpha*) was introduced into the lake by 1996 but it was not until 2000 its numbers had increased to the extent that there was any noticeable reduction in chlorophyll a concentrations in the water column. By 2002 chlorophyll *a* concentrations in the shallow waters had been reduced from a summer averages to less that 4 µg L^{-1}. An analysis of P concentrations from 2000 to 2003 shows that the reduction in particulate P (PP) concentrations that has occurred since 2000 has been proportionate with the reduction of chlorophyll *a* with no evidence for an increase in non-algal PP. Similarly there was no increase in the dissolved unreactive P that could indicate an increase in dissolved organic P compounds. While DRP concentrations have increased since 2000, the cumulative increase of close to 8 µg P L^{-1} is in line with the historic trend increase from higher DRP concentrations in the inflowing rivers to the lake. Therefore, when compared with the reduction in chlorophyll a and PP in the water column, it appears that the zebra mussel has resulted in a decline in lake total P. This may reflect a continued uptake of P by phytoplankton, which is being rapidly incorporated into the zebra mussel population through grazing, and/or an increased uptake of P by benthic primary production, aided by the large increases in water transparency that have occurred since 2000. While the seasonal depletion of soluble silica and nitrate has lowered this change has been small in comparison to the large percentage reduction in phytoplankton. There was no evidence of a marked change in ammonium concentrations.

NOTES

Geographical Information System "INVADER" Online Version: Invasive Species of the Baltic Sea

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At present the Internet-based informational resources on invasive aquatic species are located in several national, regional and global databases and information systems. However, these resources generally do not include geo-referenced information on distribution of invasive species. This information is urgently needed for such management purposes as risk assessments, prevention of new introductions and control and eradication of the established invasive aquatic species. Future development of the Internet resources on invasive aquatic species should consider their integration in the developing global network of online interoperable databases and information systems. Priority should be given to development of the interlinked regional information hubs, which should provide comprehensive information on invasive alien species, including regional invasive species directories with species-specific entries, and online access to the datasets of geo-referenced monitoring data. One of these information hubs, the Regional Biological Invasions Centre web portal (RBIC), is hosted by web-server of the Zoological Institute of the Russian Academy of Sciences in St. Petersburg (http://www.zin.ru/rbic). Currently RBIC is serving as an important part of the European informational network on invasive species, recently recognized by the European Strategy on Invasive Alien Species. RBIC web portal can be considered one of the main informational resources, providing online access to the geo-referenced distribution data on invasive aquatic species. The first demonstration version of GIS "INVADER", with comprehensive geo-referenced information on distribution of Ponto-Caspian invasive cladoceran *Cercopagis pengoi* in Europe and North America, is available online beginning 1999. During 1999-2002, GIS "INVADER" was used for generation of geo-referenced distribution maps of invasive species for the online RBIC Illustrated Database of the Aquatic Invasive Species of Europe (http://www.zin.ru/projects/invasions/gaas/aa_idb.htm).

In 2003, the online searchable version of GIS "INVADER" was developed (http://www.zin.ru/rbic/projects/invader). This online GIS application includes some functions for online management of geo-referenced data on distribution of invasive aquatic species, available in databases of Zoological Institute and partner institutions. The present online version of GIS "INVADER" (Invasive Species of the Baltic Sea) covers the Baltic Sea region, and includes geo-referenced distribution data for such invasive aquatic species as the polychaete *Marenzelleria viridis*, zebra mussel *Dreissena polymorpha*, cladoceran crustaceans *Cercopagis pengoi* and *Bythotrephes longimanus*, amphipods *Pontogammarus robustoides* and *Gmelinoides fasciatus*, Chinese mitten crab *Eriocheir sinensis*, Amur sleeper fish *Perccottus glenii*. Currently online GIS "Invasive Species of the Baltic Sea" is part of the HELCOM project on development of open informational resources on invasive alien species for the Baltic Sea area, supported by the Baltic Sea Regional Project.

N O T E S

Nonindigenous Crustacean Species in the Coastal Zone of the Baltic Sea

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The Baltic Sea is the world's second largest brackish reservoir. Both the history of the Baltic Sea as well as its brackish water make it possible for the fresh water, brackish water, and marine organisms to live in the area. Due to low salinity, 3 to 20 psu, the biodiversity of the Baltic Sea is poorer in comparison to a full marine sea, such as the North Sea.

During the last fifty years the appearance of many species, which were not present in the Baltic Sea before, have been observed. A simple food web, common in the Baltic Sea, increases the chances of the successful territorial occupancy by the newcomers.

These are species from saline waters, such as *Rhitropanopeus harrisii tridentatus* (Maitland 1875), present in the coastal waters of the Baltic Sea since 1945, or *Cercopagis pengoi* (Ostroumov, 1891), for the first time recorded in the Gulf of Gdansk in 1999. First individuals of the invasive *Gammarus tigrinus* (Sexton,1939) were observed in the Gulf of Gdansk in 2000. *Orconectes limosus* (Rafinesque, 1871), species of the fresh water origin, is also present in high numbers in the Vistula Lagoon. Presence of the catadromous crab *Eriocheir sinensis* (Milne-Edwards, 1854) was recorded in the Polish zone of the Baltic Sea in 1940. Most of the invasive species of the Baltic Sea come from the North America, Ponto –Caspian region, Pacific Ocean and South East Asia. They are all highly tolerant towards environmental factors. Due to the invasive character the species were classified as invasive, alien, non-native or exotic, introducing xenodiversity and usually having a negative influence on the Baltic ecosystem. On the other hand the increase of the range of the species inhabiting neighbouring seas is observed.

Carcinus maenas is also common in the Polish zone of the Baltic Sea. From year 2002, *Palaemon elegans* is also abundant. Regarding the short history of the Baltic Sea (10.2 thousand years) we can assume that the reservoir is being occupied by species of various origin, coming from different directions, and by number of ways, highly tolerant towards environmental factors, usually euryhaline and omnivorous. Some of the crustacean species, although treated as alien, are now an integrated part of the macrozoobenthos (*Balanus improvisus*), others, such as *G. tigrinus* are in the invasive stage and force native species (genus *Gammarus*) to withdraw. Still others, such as *O. limosus* or *E. sinesis* influence the functioning of the trophic web and the energy flow in the environment.

Therefore the Baltic Sea species have a more significant impact on the functioning of this ecosystem. The low biological diversity of the Baltic Sea makes it more vulnerable to alien species.

NOTES

Analysis of Shipping Traffic Into US Waters by Vessel Service

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This poster presents an analysis of traffic patterns into US waters from ships traveling outside the US EEZ. Patterns are shown for numerous ship types and demonstrate the potential challenge we have in mitigating the spread on invasive species through ships' ballast water. As the poster shows, most ships transiting US waters do not have the opportunity to conduct ballast water exchange, which is the only economically feasible method of preventing ballast water discharges that are favorable to species proliferation. The poster also estimates the annual cost of a new US regulation requiring ballast water exchange for ships operating outside the US EEZ.

N O T E S

Development of the Fluorescent *in situ* Hybridization Assay (FISH) as a Species Specific Identifier of the Northern Pacific Seastar, *Asterias amurensis*

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The *in situ* FISH hybridisation assay protocol has been developed to detect a high profile marine pest in ships' ballast water, namely the seastar, *Asterias amurensis*, which has not been detected in New Zealand waters. The species specific probe construct, AM-2F with fluorescein tag, scored positive against *A. amurensis* larvae, as ascertained by strong green fluorescence signal. The probe was also tested against larvae of the starfish *Pateriella regularis* and *Coscinasterias muricata*. These starfish are predominant species in harbours and estuaries in Australasia and are present in Asterias-infected regions of Australia such as Port Phillip Bay and the Derwent Estuary where New Zealand has shipping contacts (eg Ports of Melbourne and Hobart). The signal given by the probe against these species was either absent or extremely weak indicating minimal or no cross reactivity. The assay method is different from other molecular methods used to identify this species in that the probe hybridises with 18S rRNA of the intact organism. The probe is currently being tested against closely related species of Asterias, namely *A. rubens* and *A. forbesii*. The advantages of the FISH method reside in using the same sample for species identification and viability whereas other methods detect only the presence of the species DNA. The new method could find application as in the defining of safe windows for ballasting in Asterias-infected ports or in inspection of ballast water for pests by quarantine and inspection agencies.

N O T E S

Ballast Water Exchange in Regional Seas

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In February 2004 the International Maritime Organisation adopted a Ballast Water Convention. The convention includes ballast water treatment standards that aim to reduce the risk of introducing non-native species via ballast water. These standards will provide a benchmark for the development of ballast water treatment methods, which has been hampered in recent years by the lack of a treatment standard to aim for. Therefore, there is a current scarcity of technologies that are able to prove they can achieve the standard. Owing to the lack of treatment standards and the associated effect on technology development, many countries, including the United Kingdom, have had to rely on ballast water exchange as the only readily available method to reduce the risk of introducing non-native species.

Ballast water exchange was originally developed for vessels on trans-oceanic voyages as a means of reducing the risk of introducing non-native species via ballast water. The method involves vessels exchanging ballast water taken on in ports for water loaded in deep oceans. The assumption behind this method is that coastal species will be unable to survive in oceanic waters and any oceanic species loaded into the tanks will be unable to survive in the coastal waters of the vessel's next port of call. The method also relies on the fact that plankton are less abundant in open oceanic waters and carrying out the exchange therefore reduces the abundance and diversity of the plankton present in the tanks. Ballast water exchange remains the only readily available technique for managing ballast water, and although the majority of European shipping is regional and vessels are therefore not passing through deep waters, this method may be utilised in these areas owing to a current lack of alternative technology. If in-transit exchange of ballast water in regional seas is to be undertaken then it is important that the effects of such an exchange are better understood. A previous study carried out by Fisheries Research Services Marine Laboratory, Aberdeen seemed to indicate that, in some cases, there might be an increase in diatoms and dinoflagellates after exchange in regional seas. A three year follow on project at the Fisheries Research Services Marine Laboratory carried out a detailed assessment of the efficiency of in-transit exchange in the North Sea and Irish Sea on planktonic organisms in ships' ballast tanks.

The preliminary results would seem to indicate that ballast water exchange in regional seas might not be as effective as mid-ocean exchange. For example:

- When the original port water is of low salinity the salinity of the water in the ballast tanks after exchange does not increase to the same extent as when the original water was of a higher salinity. This could indicate that the original port water might not always be completely removed during the exchange process. Any low salinity water remaining in the tank would then have a dilution effect on the water loaded into the ballast tanks.
- For zooplankton, ballast water exchange generally resulted in a decrease in abundance but an increase in the number of taxa and diversity. Further analysis of the changes in the taxa present before and after exchange is being carried out.
- For phytoplankton, the initial results are more variable. The number of taxa increased on some occasions after exchange and decreased on others. There was generally a decrease in abundance after exchange. Further analysis is underway to determine the differences between the species present in the samples before and after exchange.

Overall, the initial results would seem to indicate that ballast water exchange carried out in shallow waters close to the coast may not be as efficient as exchange carried out mid-ocean. Further analysis of these data is underway and multivariate statistical methods will be used to determine the efficiency of exchange at reducing the abundance and diversity of plankton.

Enemy Escapee or Trojan Horse? Parasite Burden of the Invasive Asian Portunid Crab, *Charybdis japonica* and a Native New Zealand Portunid, *Ovalipes catharus*

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One explanation for invasiveness in nonindigenous species (NIS) is that they arrive in a new range free from natural enemies, such as parasites and diseases, which control their abundance in their native region. However, not all NIS arrive unencumbered. Some bring with them parasites that are capable of infecting native species that have no natural defences against them. The Asian portunid crab, *Charybdis japonica* (Portunidae), was first discovered in Waitemata Harbour, Auckland, New Zealand in 2000. Since then its population size has fluctuated, but it still persists. This study compares the parasite fauna of the introduced population of *C. japonica* with a comparable native portunid, *Ovalipes catharus* (Portunidae) to determine whether it carries fewer parasites than the native species.

Samples of *C. japonica* (n = 118) and *O. catharus* (n = 114) were collected from Waitemata Harbour in April, August and October 2003 using baited traps. Sex, weight (g) and carapace width (mm) of each crab were measured prior to dissection and inspection for parasites. The identity, location and abundance of parasites found were recorded.

Size distributions of the two portunids overlapped significantly, but *O. catharus* reached the greater maximum size. Sex ratios of the trapped populations were skewed, with only 11.0% *C. japonica* and 17.5% *O. catharus* samples being female. There was no significant difference in sex ratio between the two species.

Although the incidence and prevalence of parasitic organisms were comparatively low in both species, *C. japonica* tended to have the greater parasite burden. Two forms of endoparasite were recovered from *C. japonica:* a juvenile ascaridoid nematode found in the mid-hind gut region (~6% of specimens) and unidentified brown nodules found throughout the body tissues. The nodules could not be formally identified by histopathology, but resembled fluke eggs. Given the location throughout the body tissues, it is unlikely they are fluke eggs but are potentially a part of, or are another type of parasite. Further work is to be carried out to gain positive identification for these endoparasites. Tube-worm casings were also repeatedly recovered from the exoskeleton of *C. japonica* (81% of individuals).

O. catharus harboured the ectosymbiotic bryozoan, *Triticella capsularis* (100% of individuals), but no endoparasites were recovered from the native species.

Literature on *C. japonica* in its native region has been scarce. Only one paper has reported any parasites, a rhizocephalan (Kim 2001). This parasite appears to be absent from the New Zealand population. Further samples from Japan are to be secured for future comparisons.

N O T E S

Modeling Saltative Spread of Established Marine Invaders and Their Management

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The spread of invasive species is often characterised by long distance dispersal events (‘saltational jumps’) that are mediated by human transport vectors and which exceed the distance of natural dispersal. The spread of marine non-indigenous species (NIS) by ship hull fouling generally occurs in this way. Commercial or private vessels arriving from overseas locations may introduce NIS. Movements of domestic vessels can subsequently facilitate the spread of established NIS along the country’s coastline. New Zealand is a popular destination for ocean-going private yachts, with 550–750 international arrivals per year. Approximately 15 % of these yachts arrive with fouling assemblages on their hulls, and during their stay most yachts visit a range of marinas or other coastal locations that are frequented by a large number of domestic vessels. We collected data on the movement and maintenance history of approximately 1000 private yachts in New Zealand over a 12-month period and developed stochastic epidemiological models to simulate: 1) the spatial pattern of spread by NIS on private yachts, 2) the relative influence of a range of input parameters (boat maintenance, growth and transmission rates of the target species) on the rate of spread, and 3) the usefulness and efficacy of a range of management strategies designed to control marine pest outbreaks in New Zealand ports and marinas. Sensitivity analysis for the models identified the frequency of boat maintenance (which determines the proportion of yachts that are susceptible to becoming colonised by fouling organisms) as the most important factor governing the rate of spread of a species by yacht movements. We compare our simulations with the observed pattern of spread of the invasive kelp, *Undaria pinnatifida*, around New Zealand and make recommendations for cost-effective management measures to prevent or control the spread of other non-indigenous fouling species that may become established in New Zealand in the future.

NOTES

Use of Biocontrol Insects to Reduce the Use of Herbicides to Control Invasive Aquatic Plants

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After an extensive research and quarantine process, three insects were introduced into the United States from South America in the 1960s to control alligatorweed (*Alternathera philoxeroides*). These insects, alligatorweed flea beetle (*Agasicles hygrophila*), the alligatorweed stem-borer (*Arcola malloi*), and the alligatorweed thrip (*Amynothrips andersoni*), have become established and successfully control alligatorweed in much of the southeastern United States. Sense their introduction, the Jacksonville District has eliminated the spraying of herbicides to control alligatorweed. Unfortunately the insects are not as tolerant to cold as alligatorweed. Through funding from the US Army Engineer Research and Development Center in Vicksburg Mississippi, the Jacksonville District's APCOSC field collects and ships flea beetles to public agencies where the insects do not over-winter. This biocontrol project started in the 1980's and continues today. The APCOSC provides this yearly service to participants in Alabama, Mississippi, Georgia, Louisiana, North and South Carolina, Texas, and Puerto Rico. The participants in the project reduce their reliance on herbicides to control this invasive plant. Permits from the US Department of Agriculture are required to ship biocontrol insects between states. Photographs of the insect species, collections and shipping methods, and results will be provided in the poster.

N O T E S

The Present Status of the Asian Invasive Fish Species Topmouth Gudgeon *Pseudorasbora parva* (Schlegel, 1842) in Flanders (Belgium)

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The Asiatic cyprinid *Pseudorasbora parva* (Schlegel, 1842) is an invasive fish species originating from Japan, China, Korea and the southeastern part of the former USSR. In 1961-62 the species got unintentionally introduced into fish farms in Romania, when it came as a stowaway with the transport of Chinese herbivorous carps towards Eastern Europe. In the next thirty years, *P. parva* has become widespread almost all over Europe.

Outside its natural distribution area, *P. parva* is often experienced as a nuisance species due to its high resistance to stressed environmental situations, its high reproductive capacity, its competitive nature towards other fish species (food and niche competition, predation on eggs and larvae) and its facultative parasitism.

The Institute for Forestry and Game Management has a fish monitoring programme which gathers data of fish occurrence in Flanders. This monitoring programme, conducted over the last 12 years, resulted in a profound knowledge of the fish fauna of rivers, canals and standing waters of Flanders. Among other things, the evolution of the invasion of the topmouth gudgeon in Flanders was followed.

In September 1992, the first 3 specimens of *Pseudorasbora parva* were found during a fish stock assessment in the river Kleine Gete (Demer basin, Flanders, Belgium). Prior surveys in the Demer basin and other river basins in Flanders did not report the presence of *P. parva*.

Since then the species has spread rapidly and became the 16th most widespread freshwater fish species in Flanders. The distribution area of *P. parva* comprises all major river basins. It frequently occurs in streaming as well as in standing waters, yet the highest densities are mostly found in the proximity of shallow ponds.

So far, the presence of *Pseudorasbora parva* has not been documented yet for the Walloon provinces in the southern part of Belgium.

An important factor in the fast dispersion of *P. parva* in Flanders consists of accidental introductions, associated with the annual restocking of cyprinid fishes, like roach (*Rutilus rutilus*), rudd (Scardinius *erythrophthalmus*), ide (*Leuciscus idus*) and European chub (*Leuciscus cephalus*). Each year, the Flemish government spends thousands of euros on restocking the rivers and canals. Local fish hatcheries, traditionally extensive fish farms, guarantee the fish supply. Yet, since the eighties, there is the trend among the fish breeders to import fry from the former Eastern bloc, and grow these foreign fishes for our local market. For several reasons (a.o. commercial), importing juvenile fishes has become more preferable than investing space, time and money in raising and managing domestic fish stocks. As with the opening of the borders and the free market with Eastern Europe, this traffic has received an important impetus. The overlap in time of the occurrence of *P. parva* in the Western European surface waters and the upcoming import of cyprinids from Eastern Europe, where *P. parva* was already present since the 1960s and 70s, is striking. Therefore, the hypothesis that *Pseudorasbora parva* has reached Western Europe (incl. Flanders) as a stowaway through commercial fish transports poses a most plausible explanation for its presence in our Flemish waters.

Besides this, the dispersion was enhanced by the use of P. Parva as live baitfish and by escapes from fish farms and fishing ponds.

Developing a National Monitoring Program for the Early Detection of Coastal Aquatic Invasive Species

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The first line of defense in decreasing the impacts from aquatic invasive species is preventing their introduction, however it is not practical to think that all introductions can be prevented. Therefore it becomes essential to implement a monitoring program for the early detection of newly introduced, non-native species. The United States Congress has recognized this approach in the reauthorization language of the National Aquatic Invasive Species Act (NAISA). NAISA mandates that an interagency team collaborate to develop a National Program that conducts ecological surveys for the early detection of aquatic invasive species.

Although NAISA has yet to be reauthorized, a small interagency task team has determined the initial steps required to develop and implement a national program of this magnitude. The interagency effort was strongly guided by provisions in NAISA. The Act, if passed as currently written, mandates that these surveys be carried out in cooperation with state, local, port, tribal authorities, and other non-federal entities and be based on a plan and set of standardized survey and sampling protocols that addresses a diversity of aquatic ecosystems. Additionally, the monitoring program should be structured in such a manner that the rates of, patterns of, and conditions surrounding introductions of non-native aquatic species in aquatic ecosystems can be assessed.

The National Oceanic and Atmospheric Administration has taken further steps towards implementing a national coastal and Great Lakes early detection and monitoring program by 1) beginning to develop an inventory of aquatic species know to reside in the US and Canada through which potential new species can be compared, 2) developing a reporting, species verification and warning system to alert resource managers, 3) developing an aquatic species information network with search and mapping capabilities, and 4) beginning the development of standardized survey protocols and sampling methods for the early detection and monitoring of aquatic invasive species.

N O T E S

The Louisiana State Aquatic Invasive Species Management Plan — Process and Product Update

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As was reported last year at these meetings, the natural landscape physiognomy of Louisiana, with its nearly subtropical climate, its several rivers and extensive man-made canal systems, its position of being one of the Nation's busiest ports-of-entry, and with a long-term resident multi-cultural human population, is especially vulnerable to bioinvasion. According to the US Geological Survey, Louisiana has the most invasive plant species (33) except for Florida (51), and almost twice the average number of introduced plants as other states particularly into the coastal wetlands I the southern half of the state. In recognition of both the environmental and economic threats of bioinvasion, and also because of him being an avid duck hunter, the previous governor, M.J. "Mike" Foster, by executive order MJF 02-11, in June 2002, established the Louisiana Aquatic Nonindigenous/Invasive Species Task Force (LAISTF) to devise a management plan to address the prevention, control, containment, and/or eradication of aquatic nuisance species in the State. The Louisiana Department of Wildlife and Fisheries, as designated as the lead agency, who, in turn, outsourced the writing of the plan and support of planning process to the Center for Bioenvironmental Research (CBR), an independent university-based research center shared by Tulane and Xavier universities in New Orleans.

This poster describes the creation, structure and function of the AIS Task Force and Louisiana's experience in producing the management plan. The plan has evolved through consensus building utilizing two novel techniques of information solicitation. Of most interest are the methods of how the information was collected (homework assignments and recorded discussions), the processing of that which was collected (consensus decision-making based on point-allocated voting), and the emphases (prioritization of: pathways vs. species; prevention via education or regulation) of the plan that resulted. It is felt that the procedures that the Task Force used to ultimately develop a consensus plan might be of interest to other states/groups doing the same. The completed plan will have been sent to the US Fish and Wildlife Service Aquatic Nuisance Species Task Force in Washington by the end of August and the Louisiana legislation that supports the LAISTF will have been acted upon favorable by that time also.

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Synbranchid Eels in the United States: History of Introduction and Current Status

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At least five introduced populations of swamp eels (Family: Synbranchidae) are established in the United States. The earliest known introduction occurred in Hawaii, before 1900. That population still survives on Oahu. Recent field samples suggest eel numbers are low, but these samples may not be providing accurate estimates of population size. Since the early 1990s, four separate populations of synbranchids have been discovered in the southeastern United States, one in northern Georgia and three in peninsular Florida. All four mainland populations are firmly established and some are relatively widespread. Preliminary genetic research comparing the four southeastern populations suggests that these introductions were independent. Based on the current high numbers and broad distribution of eels in Florida, it is likely that initial introductions in the state occurred long before biologists first collected the animals. Chinese immigrants reportedly brought eels to Hawaii. However, the introduction pathway of eels to the mainland is unclear, likely a result of their import as food and as ornamentals, followed by escape or release. Live synbranchids are common in certain US city fish markets. Although all introduced synbranchids previously were thought to be the Asian eel *Monopterus albus*, genetic evidence indicates involvement of several different species.

NOTES

Pulsed Low Power Laser Irradiation as a Ballast Water Treatment Technique: A Laboratory Study

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Ships with ballast water on board act as a vector of aquatic species invasion. Even though the ballast water exchange regulations that were implemented in 1993 target at reducing the problem of nonindigenous species introduction, efforts continue to find a more effective treatment technique. Elevation of the ballast water temperature to above 30°C, irradiation of water using UV light and treatment of ballast water with biocides are some of the techniques that are being tried.

In this report we present data on the laboratory studies of the impact of low power pulsed laser irradiation from a Nd:YAG laser on three marine phytoplankton species. The phytoplankton species used were *Skeletonema costatum*, *Chaetoceros gracilis* (centrale diatoms) and *Heterocapsa circularisquama* (dinoflagellate). Individual cultures of these species were exposed to laser irradiation in a flow-through irradiation assembly (a glass tube of 50cm long and 2.5cm diameter and irradiated from the top (beam diameter 2.1cm) with two flow speeds 9 lit/h and 4.6 lit/hr (retention time 42 and 85sec, respectively). The results showed that the laser irradiation of fluence 0.1J/cm^2 resulted in a significant mortality of diatoms and dinoflagellate. The mortality for 4.6 lit/h flow was >90% in *S. costatum* and *H. circularisquama* and >70% in *C. gracilis*. The survived cells showed a sluggish post-irradiation growth (observed for 10d in an illuminated incubator at 21°C) compared to the non-irradiated control. The cells upon irradiation were found broken. This result shows that laser irradiation has the potential as a ballast water treatment technique to reduce the problem of species invasion via ballast water.

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Tools Assessing Risks: Ongoing Efforts to Evaluate Potential Harm of Introduced Aquatic Organisms

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A number of relatively recent fish introductions into the United States have caused considerable concern among government agencies, resource managers, researchers, and the public. A few of the more notorious are the Asian or Chinese carps, snakeheads, and swamp eels. US Geological Survey (USGS) researchers have conducted or are finalizing risk assessments on these and other fishes following procedures developed by the former Risk Assessment and Management Committee of the Aquatic Nuisance Species Task Force. Based on past experience, there are a variety of risks associated with a species arrival into areas where it is not native. The risks are evaluated by estimating the probability of several factors such as whether the organism is present in a given pathway and capable of surviving the journey, and whether it can successfully colonize and subsequently expand its range. Other factors to evaluate include environmental and economic impacts, and social and political consequences. The intended use of these risk assessments is to provide government agencies with the necessary information to make informed decisions. Closely allied with these risk assessments are other USGS publications and products. Included is a soon-to-be completed guide to introduced cyprinid fishes as well as our long-established and continually updated database which houses geographically referenced data and information on aquatic introductions in the United States.

NOTES

War Against *Crassula helmsii*

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The antipodean stonecrop *Crassula helmsii* is an extremely invasive aquatic species that has rapidly colonised more than 650 ponds, ditches and wetlands across Great Britain since it first became naturalised in the early 1960s. *C. helmsii* out competes many other species and often results in almost total suppression of the native flora. Its presence in areas of high conservation value, such as the New Forest Special Area of Conservation is a grave cause for concern.

Hampshire Wildlife Trust, the leading conservation charity in the county of Hampshire in southeast England, has recently completed a three-year experimental control project on *C. helmsii*. By using a combination of chemical control, shade material and mechanical removal, the Trust has managed to reduce the extent of *C. helmsii* cover by 99% over a three hectare shallow water body (an ex-gravel working known as Holmsley Gravel Pit) in the New Forest.

The Trust found that chemical control using the aquatic herbicide Reglone (active ingredient diquat bromide) was the most effective on submerged plant material, whilst Roundup (active ingredient glyphosate) worked well on emergent bankside stands. Tank trials by the Centre for Ecology and Hydrology showed glyphosate to be 82% effective and diquat to be 100% effective). Other herbicides proved much less effective (e.g., dichlobenil 66% and terbutryne 48% effective on submerged plants). Shade material was effective in killing the plant due to light deprivation but was deemed an impractical technique. Mechanical control was ineffective due to fragments of the plant being left behind and subsequently regrowing.

During the same period as the Holmsley Gravel Pit trial management, the Trust undertook a comprehensive survey of 200 ponds across the New Forest – to see how widespread *C. helmsii* was in the area around Holmsley and beyond. The New Forest is the largest area of semi-natural habitat in southern England and a landscape of international importance, characterised by open heath, grassland, ancient woodland and wetland and maintained by extensive grazing. The survey provided some shocking results – the number of ponds invaded by *C. helmsii* had increased to 76, representing a four-fold increase in a decade. The presence of free-ranging ponies and cattle is undoubtedly a major factor in the spread of this alien species, as well as the links between the many linear water features and small temporary ponds, which provide ideal conditions for its colonisation.

The Trust has been instrumental in promoting the seriousness of the issue to other organisations, and is actively pursuing financial and political support to establish a New Forest-wide control programme for *C. helmsii* before it is too late.

NOTES

Classroom Technology For Learning and Decision Making About Invasive Species

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Sea Grant educators in the Great Lakes region of North America have collaborated to develop interactive internet sites through which students and their teachers can learn about aquatic nuisance species. For use by educators, the information in the sites must relate to pedagogy:

- Relationship to the school curriculum at different grade levels
- National curriculum standards addressed by the topics
- Innovative methods of teaching
- Creative and appropriate assessment of learning

The Internet sites will be introduced in an oral presentation entitled "Educators respond to invasive species: Interactive web-based activities for learning and decision making." The poster session venue will allow participants to discuss these educational resources in greater detail and interact with the web sites. The sites address education needs for two audiences, teachers and students.

For teachers we will portray some of the unique aspects of a process for making structured decisions and demonstrate their application in considering alien species questions. Lessons can be used directly on line or printed from files for hard-copy classroom use. We will also include excerpts from the Exotic Aquatics On the Move database and Alien Species short course to show how academic educators learn about and contribute to solutions to invading species problems.

For students we will demonstrate aspects of Nab the Aquatic Invaders! On this site, students assist five detectives in solving cases as they learn about 10 exotic aquatic species. The creative and engaging lessons provide memorable information and involve students in constructing their own learning about invading species.

NOTES

Ships' Sea-Chests — A Dispersal Mechanism for Nonindigenous Species

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The transport of larvae in ballast water has been proposed as a dispersal mechanism for non-indigenous species. However, the larvae of many species are short lived and would not survive the long voyages involved in international shipping. They will metamorphose in the ballast tank, but the juveniles are unlikely to obtain sufficient dissolved oxygen and nutrition to survive. Since larval dispersal is unrealistic for these organisms, mature adults must have established the populations in the new environments. But how can the adult organisms be transported long distances?

The ascidian *Styela clava* is a good model for the study of long distance dispersion of organisms with short larval life-stages. It is oviparous; the eggs hatch after 12 to 15 hours and the larvae are active for approximately 12 hours. The larvae settle on a hard substratum and develop into sessile adults. *S. clava* is native to the northwest Pacific; it was first recorded in British waters in 1954, and has since spread along the west coast of Europe. The natural dispersal methods suggested for its spread involve drifting of larvae and adults attached to flotsam; the man-aided methods involve transport of juveniles and adults, either attached to oyster shells or to ships' hulls. However, the observed distribution of *S. clava* is extremely patchy. This heterogeneous distribution cannot be explained by natural dispersal or the presence of oyster fisheries. The adults are rheophobic, so hull attachment is an unlikely mechanism for dispersal, but they could be transported attached to the inside of ships' sea-chests. These seawater intake chambers provide a relatively sheltered environment in which the organisms can grow to maturity then spawn in any harbour with suitable water quality.

The paper reports the results of several examinations of ships' sea-chests and demonstrates that this is a suitable dispersal mechanism for a variety of marine organisms.

NOTES

Changes in the Gulf of Gdansk Biocenosis by Round Goby (*Neogobius melanostomus*) – An Invasive Ponto-Caspian Fish

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Functioning of each ecosystem tends to stay in its specific dynamic equilibrium. Structure of the trophic net, its complicity and richness are governing factors in ecosystem stability. Changes in species content can influence the structure of the trophic net, flow of energy and circulation of matter. Invasion by the round goby (Neogobius melanostomus), the Ponto-Caspian fish, has been observed in the Gulf of Gdansk in 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 in the west part of the Gulf of Gdansk. The invasion process in this area involves a number of different species and a stable and complex ecosystem. This unusual situation provokes some important questions. How was such successful invasion possible? What changes in the ecosystem of shallow water of the Gulf of Gdansk were caused by the invader? We are trying to answer the second question by concentrating on the portion of the ecosystem where the biggest changes are likely to happen and document the scale of the change.

Round goby is a typical shallow water fish. Adult gobies feed primarily on bivalves. Filter feeders, primarily bivalves, are treated as dead end in the trophic net of shallow water zones of seas. This also applies to the Gulf of Gdansk. There are some fish species, mainly eelpout and flounder, feeding sporadically on bivalves but for none of the species do bivalves represent such an important source of food. Additionally general changes in the biocenosis during last thirty years resulted in increased bivalve quantity and areas covered by them. New invasive fish species removed part of this bottom deposit. A fraction of organic matter caught in bivalves is moved back to the trophic net. The average round goby has an energetic value of about 142 kJ. Colonies of bivalves do not only represent deposits of organic matter but also act as a sink for many toxic substances. Round goby feeding on bivalves returns toxic substances into the food web. From the heavy metals, the round goby accumulates mainly zinc and copper. In quantities higher than other Baltic fish – zinc up to 236 mg kg-1 ww in gonads, copper up to 325 [mg kg-1 ww in liver. Other heavy metals are accumulated in much smaller quantities. Accumulation of chlorinated hydrocarbons is lower in round goby than in other Baltic fish and even in the blue mussel. It is uncertain what impact the returned toxins might be on the ecosystem.

Up to now the round goby has been documented only in the west part of the Gulf of Gdansk. It inhabits the shallow water zone of an area of about 400 km^2. The quantity of round goby varies from less than one to 600 individuals on 100 m^2. Each year on average an adult round goby consumes about 0,4 kg of bivalves. Given the density of round gobies, thousands of tons of bivalves are consumed by this species each year. This is likely to be an important change to the Gulf of Gdansk food web. Tons of blue mussel (dominant bivalve in the Gulf of Gdansk) consumed represent a large quantity of copper being returned to the trophic net.

Due to degradation of ichthyofauna structure in the Gulf of Gdansk (lack of predators in shallow water zone) the round goby is not an important food source for other fish. Instead, the round goby is the main food supply for birds – black cormorants feeding in that area. The round goby constitutes from 60 to 90% of food of this birds. The round goby is also potentially a market fish.

Concluding, the invasion of round goby greatly changed the shallow water biocenosis of the Gulf of Gdansk.

Invasive Molluscs in the Mediterranean: State of the Art

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In recent years the number of alien mollusc species migrating to the Mediterranean Sea has been rapidly increasing. Many of these species migrate from the Red Sea through the Suez Canal. Immigration of Atlantic molluscs through the Strait of Gibraltar, the main connection between the Mediterranean Sea and the Atlantic Ocean, is also increasing. These migrations allow the settlement of allochthonous species, often competing with the autochthonous ones.

Within the framework of a research project dealing with the introduction of alien species in the Mediterranean, we have been carrying out an ongoing study articulated in different phases. We here report the results of the first of these, which focused on the updating of the invasive molluscs literature for the entire Mediterranean basin. Since 1865, 423 papers have been published on mollusc invasion in the Mediterranean, but the bulk is concentrated in the years 1975-2003, with 392 papers published. In total, 174 allochthonous species were signalled, 30 of which are needing confirmation. Of the total number of introduced species, 87% (90.7% of the confirmed invasive ones) come from the Indo-Pacific area, but they are mostly confined to the Levantin Basin where they have adapted well to the Mediterranean environment. Ten per cent (5.7% of the confirmed invasive ones), mainly represented by temperate species, come from the Atlantic Ocean and are mostly distributed in the western Mediterranean. These considerations suggest that some factors such as limiting hydrological features could restrain the penetration of invasive species into the central area of the Mediterranean, which counts about 20 invasive molluscs settled.

N O T E S

Authors

Francisca Aguiar

Francisca Aguiar graduated as Agronomic Engineer in 1992, at the Agronomy Institute, Technical University of Lisbon, and in 1996 she received her MSc degree in Integrated Pest Management, from the same institution where she specialized in aquatic nuisance vegetation of freshwater ecosystems. From 1993 onwards she is receiving support from the Portuguese Foundation for Science and Technology to develop research work on the characterization, ecology and management of aquatic and riparian vegetation. Currently, she is finishing her PhD thesis titled "Biodiversity and Exotic Vegetation in Mediterranean Fluvial Corridors: Influence of Adjacent Ecosystems", and she is working on the Project "Species Traits and Functional Attributes as Key Factors of Aquatic and Riparian Exotic Plant Invasibility."

Dr. David Aldridge

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 is Vice President of the Malacological Society, member of the IUCN Mollusc Specialist Group and advisor to many British conservation steering groups. He is joint author of the recently published 'Freshwater Bivalves of Britain and Ireland'. 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.

Dr. Franco Andaloro

Prof. Franco Andaloro is senior scientist at the Central Institute for Applied Marine Research (ICRAM) in charge of the Department of Sustainable Use of Resources. He is also the coordinator of the national research project on the identification and distribution of nonindigenous species in the Mediterranean, and of the project ALIEN (Atlantic and Lessepsian Immigrants Environmental Noises). Research fields are: ecosystem approach to fishery management, effect of global change on biodiversity, invasive species, impact of off-shore extraction platform and other anthropogenic impacts on biodiversity.

Dr. Lars Anderson

Lars Anderson has conducted research on the biology and management of aquatic weeds for 30 years. After receiving his graduate training at the University of California, Santa Barbara, he spent two years with the US Environmental Protection Agency in Washington, DC. He later joined the US Department of Agriculture-Agricultural Research Service and built research teams in Denver, Colorado and Davis, California, emphasizing research on reproductive biology, dispersal, herbicide efficacy and biological control with sterile grass carp, and host-specific insects. He is a past president of the Aquatic Plant Management Society and the California Weed Science Society. He is on the Steering Committee of the Southern California *Caulerpa* Action Team (SCCAT) that directs the eradication of *Caulerpa taxifolia* in California.

Charles E. Ashton

Charles Ashton is presently employed as a Biologist with the US Army Corps of Engineers, Jacksonville District, Aquatic Plant Control Section, at the Aquatic Plant Control Operations Support Center, Jacksonville, Florida. He Received a BS in Marine Science and MS in Biology from the University of West Florida, in Pensacola, Florida. Employment experience includes fishery biology with the US National Marine Fishery Service, aquatic toxicology at the University of West Florida with the US Environmental Protection Agency, field and district aquatic plant control operations with the Jacksonville and Mobile Districts, and Federal Section 10 and Section 404 regulatory programs.

Gail Ashton

Gail Ashton is a PhD student at the Scottish Association for Marine Science (SAMS) on the west coast of Scotland. Her first degree, in Marine Biology, was completed at the University of Wales, Swansea, where she developed a keen interest in marine ecology, in particular that of marine invertebrates. She is in the first year of her PhD studying the invasive caprellid, *C. mutica,* recently discovered on the west coast of Scotland. Her research interests include the future application of invasive research, cephalopod biology and ecology, and rocky shore ecology.

Iulian Astanei

Iulian Astanei is at present finishing his PhD research in the Molecular Ecology Research Group, GMIT under the supervision of Dr. Elizabeth Gosling. He is investigating the genetic structure of zebra mussel populations from Irish, European and North American locations using protein (allozyme) and microsatellite markers. His research topic provides a unique opportunity to study the genetics of an invasive species, just recently introduced into Ireland.

Karolina Bacela

Karolina Bacela is a first-year post-graduate student at the University of Lodz, Department of Invertebrate Zoology and Hydrobiology. The main area of her current research is an invasive amphipod's biology that contains their life cycles, site preferences and feeding strategies. She is also interested in the interaction between alien species and native ones as well as between co-occurring non-native amphipods.

Sarah Bailey

Sarah Bailey is a PhD candidate at the Great Lakes Institute for Environmental Research at the University of Windsor, Canada. She has been working with Dr. Hugh MacIsaac to assess the invasion risk posed by invertebrate diapausing eggs in residual ballast sediments. Sarah expects to complete her dissertation this December, and is currently looking for a post-doctoral research position.

Jason Baker

Jay Baker holds a BS in Biology from Gordon College and a Master of Environmental Management from Duke University. Jay has been an environmental analyst with the Massachusetts Office of Coastal Zone Management since 1999, where he manages water quality programs as well as the invasive species program. He has developed the Massachusetts Aquatic Invasive Species Management Plan, and is the Chair of the Science and Technology Committee of the Northeast Aquatic Nuisance Species Panel.

Nic Bax

Nic Bax leads the invasive species research group at CSIRO Marine Research in Tasmania, Australia. Current research areas are the design of effective management strategies for marine invasive species and the development of genetic approaches for biological control of invasive species. Long-term research interests include the functioning of marine ecosystems, especially habitat use, trophic interactions and fisheries.

Kathleen Beyer

Kathleen Beyer has been a PhD Student since February 2003, working on the effect of non-native freshwater fishes on fish community structure and their role introducing non-native fish diseases'. This is a collaboration between the University of Hull, Department for Environment & Rural Affairs (Defra), the Centre for Environment, Fisheries & Aquaculture Science (CEFAS) and the Centre for Ecology & Hydrology (CEH).

Her research interests include: impact of non-native fish species on native communities, spread and dispersal of smallbodied fish, incidence of exotic parasites in non-native fishes, native fish predation on non-native fishes, niche overlap between non-native and native fishes, and ecology and reproductive biology of marine turtles.

Dr. Charles W. Boylen

Charles (Chuck) Boylen is Professor of Biology at Rensselaer Polytechnic Institute in Troy, NY and Associate Director of RPI's Darrin Fresh Water Institute. Chuck received his PhD from the University of Wisconsin-Madison in 1969 and came to RPI in 1972. He has served on the Executive Boards of the Invasive Plant Council of NY and the Hudson River Environmental Society. Chuck began an extensive research program on aquatic vegetation in Adirondack lakes in 1973 and became involved in exotic vegetation in 1987 when Eurasian watermilfoil was discovered in Lake George.

Dr. Anthony B. Brennan

Professor Anthony Brennan earned a PhD from Virginia Polytechnic Institute in Materials Engineering Science. His research is focused on biomaterials with emphasis on the design, fabrication and characterization of biointerfaces, which mimic natural occurring surfaces. These materials, which include a variety of bioneutral and bioactive materials, are chemically modified to facilitate the study of the interactive nature of both physical and chemical stimulation by substrates on celllular function. He has published over 80 refereed articles, book chapters and abstracts and eight US Patents.

E. Shippen "Ship" Bright

Ship Bright is the Executive Director and Founder of the Maine Lakes Conservancy Institute [MLCI]. Ship served as Deputy Commissioner for the Maine Department of Conservation where he managed the legislative program. He has worked at Harvard University as a Senior Development Officer and, after serving in the United States Navy, he owned and operated a real estate company. He has a BA from Bates College, an MBA from Southern New Hampshire University and an MPA from Harvard's John F. Kennedy School of Government. He presently serves on the US Federal Invasive Species Advisory Committee. He is a registered Maine Guide.

David Britton

David Britton is a PhD candidate at the University of Texas at Arlington (USA) and a student trainee for the US Fish and Wildlife Service. He is an actively contributing member of the 100th Meridian Initiative, an international effort to stop the westward spread of zebra mussels in North America. He is interested in the physiological ecology of invasive species and has research experience with zebra mussels, channeled apple-snails, mosquitofish, physid pond-snails, and freshwater Asian clams. David's research has been primarily focused on physiological and evolutionary responses of aquatic animals to artificially elevated temperatures. He plans to complete his PhD this year.

Dr. Robert Brock

Robert Brock is a Fishery Biologist with the US National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service. Robert received his MSc degree in Marine Biology from the Nova University Oceanographic Center in Dania, Florida, where his research focused on direct and indirect competition of invasive fish species on native fish communities. Robert received his PhD in Aquatic Ecology from the University of Florida's Center for Wetlands, where his research assessed the trophic level effects of an invasive filter-feeding mollusc and planktivorous fish in Florida waters.

Robert is a member of NOAA's Invasive Species Working Group and recently was a member of an interagency study team that completed a report for the US National Invasive Species Council evaluating the importance of various pathways.

Dr. Lyubov E. Burlakova

Lyubov Burlakova received her BA, Biophysics from the Belarussian State University in 1985 and in 1998 her PhD from the Hydrobiology Institute of Zoology at the Belarussian Academy of Science. Her research interests and areas of expertise include aquatic invasive species ecology, spread and role in ecosystems; biodiversity and conservation of freshwater ecosystems; ecology of freshwater benthic communities; ecology of the zebra mussel and its role in aquatic ecosystems; growth, reproduction, parasitology and spread of the zebra mussel.

Dr. Fabio Bulleri

Fabio Bulleri completed a BSc. (Hons) at the University of Pisa, Italy in 1996, and his PhD at the Centre for Research on Ecological Impacts of Coastal Cities, University of Sydney in 2003, supported by IPRS/IPA Scholarships. During his PhD, Fabio investigated the effects of the introduction of artificial structures (e.g., seawalls, breakwaters) on intertidal rocky assemblages.He studied the effects of marine herbivores on algal assemblages and the mechanisms determining the distribution of canopy-forming algae within the framework of the EU project EUROROCK. He investigated the effects of transformation of coastal landscapes on biodiversity and on the spreading of invasive species within the framework of the EU funded project DELOS.

Dr. Marnie Campbell

Marnie Campbell is a Principal Risk Analyst in Marine Biosecurity at the Ministry of Fisheries, New Zealand. Marnie has a background in both marine community restoration and bioinvasions (research and policy), with her experience extending over multiple countries (Australia, Brazil, China, India, Iran, New Zealand, Seychelles, South Africa, Ukraine and the USA) over a period of 12 years. She has worked in the field of bioinvasions for CSIRO – Centre for Research on Introduced Marine Pests (CRIMP), the IMO GloBallast Port Surveys (port survey coordinator), IUCN Global Marine Program (port surveys), and for Corporate Process Management (Australian port surveys).

Natalie Carroll

Dr. Natalie Carroll is responsible for the development of curriculum and programs to teach youth about natural resources and the environment. She has taught middle and high school math and science (formally and informally) and a variety of college classes, including graduate-level courses via video and Internet formats.

Dr. Carroll has provides training for both youth and adults through workshops, seminars, clinics, and other informal venues. She has authored or co-authored numerous publications: print, CD-ROM *(Monitoring the Great Lakes with the Lake Guardian),* and websites *(Introduction to Agricultural Biotechnology,* www.agriculture.purdue.edu/teachers, and Onsite Wastewater Disposal, www.ces.purdue.edu/onsite/).

Maria Cassidy

Maria Cassidy holds a MSc (distinction) in Zoology from the University of Otago, New Zealand. After completing her Masters degree she worked in fisheries management for the New Zealand Ministry of Fisheries, including time as a Private Secretary for the Minister of Fisheries handling policy issues at Cabinet level. In 2000 Maria joined the Marine Biosecurity Unit in the Ministry and has been heavily involved in investigating and implementing post-border management programmes in New Zealand. She has also played a role in championing the importance of marine biosecurity across a broad range of domestic policy and legislation development programmes, including New Zealand's Oceans Policy and aquaculture reforms.

John Christmas

John Christmas is a PhD student 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 both terrestrial and aquatic invasive species.

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Jayaprada Chunduri is a Professor in the Department of Biological Sciences at the R.D. National College in Mumbai, India. Her past work experience has included being a Senior Research Fellow with the Council of Scientific and Industrial Research in India, a professor at St. Xavier College in the Department of Zoology, and professor at Tolani Martime Institute. Jayaprada is also a memberof the Marine Biological Association of India.

Dr. Alfred F. Cofrancesco

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Dr. Bruce Conn

Bruce Conn is Professor of Biology and Dean of the School of Mathematical and Natural Sciences at Berry College in Mount Berry, Georgia. Bruce also serves as Associate in Invertebrate Zoology at the Museum of Comparative Zoology of Harvard University in Cambridge, Massachusetts. His research centers on the biology of various invertebrate groups, and includes primarily work on parasites and reproduction. He has conducted research on dreissenids, Corbicula fluminea, Daphnia lumholtzi, and other invasive species over the past 20 years, along with his wife and collaborator, Denise A. Conn.

Liz Cook

Liz Cook is a research associate at the Scottish Association for Marine Science (SAMS) on the west coast of Scotland. Her main research interests are the role of biodiversity in determining the susceptibility of native communities to invasion; the biological mitigation of the environmental impacts of aquaculture; and the development of new species for aquaculture (e.g., sea urchins, scallops and abalone). Liz currently leads a new UK marine invasive species initiative, known as 'Marine Aliens' and funded by Esmée Fairbairn. This initiative is the first collaborative program of its kind, studying the distribution and impact on native marine biodiversity of seven invasive species in the UK.

Dr. John M. Cooley

John Cooley holds a PhD from Dalhousie University, Nova Scotia, Canada as well as BSc and MSc degrees from the University of Toronto, Ontario, Canada. He joined the Canadian federal Department of Fisheries and Oceans (DFO) in 1973 as a Research Scientist at the Canada Centre for Inland Waters in Burlington, Ontario following a post-doctoral appointment at the University of Florida in Gainesville. During his career, John has held a number of progressively more responsible managerial positions with the Department including National Acid Rain Program Manager and Director of the Great Lakes Laboratory for Fisheries and Aquatic Sciences at the Canada Centre for Inland Waters in Burlington, Ontario. In 1993 he assumed the position of Regional Director of Science for DFO's Central and Arctic Region. Presently he is serving as the Regional Director General for the Central and Arctic Region of the Department of Fisheries and Oceans. He has worked with the (Canada/US) International Joint Commission and the (Canada/US) Great Lakes Fishery Commission on a number of aquatic invasive species projects and more recently was part of the Canadian delegation to proceedings leading to the International Maritime Organization's Convention on Ballast Water.

Dr. David A. Culver

David Culver received his Bachelor's degree in Zoology from Cornell University, Ithaca, NY, in 1967. His master's and PhD degrees were earned in Zoology at the University of Washington, Seattle, WA. His professional appointments have been at the Biology Department, Queen's University, Kingston, Ontario, Canada (1973-1975), and at the Department of Zoology, The Ohio State University (1975-present), where he is now a professor in the Department of Evolution, Ecology, and Organismal Biology and in the university's interdisciplinary Environmental Science Graduate Program.

His research at these institutions has focused on eutrophication, planktonic productivity, fish recruitment, non-indigenous species, environmental pollution, harmful algal blooms, and modeling the interactions among physics, chemistry, and biology of large lakes, especially Lake Erie.

He and his students have published over 50 scientific papers on research supported by the National Science Foundation, US Fish and Wildlife Service, Ohio Department of Natural Resources, Ohio Sea Grant College Program, North Central Regional Aquaculture Center (USDA), Ohio Lake Erie Protection Fund, US Environmental Protection Agency, and the Howard Hughes Medical Institute. He is also currently involved as a consultant performing environmental research on the thermal and chemical impacts of coal-fired power plants on receiving waters for Dominion Power, American Electric Power, and the Electric Power Research Institute (EPRI).

Emily Darbyson

Emily Darbyson grew up in Montreal, Quebec and completed her undergraduate degree at McGill University. She co-investigated the diel feeding patterns of herring and mackerel in the southern Gulf of St. Lawrence, Canada during an internship with Fisheries and Oceans Canada. As a master's student at Dalhousie University in Halifax, Nova Scotia, Emily is currently examining the vectors and control points of marine and estuarine invasive species in the southern Gulf of St. Lawrence. In her spare time she enjoys cooking, skiing and rock climbing.

Dr. Martin H. Davis

Martin Davis BA (Hons), MTech, PhD, CSci, CChem, MRSC, CBiol, MIBiol, CMarSci, MIMarEST, MIEEM, AIL joined the Central Electricity Research Laboratories in 1970 as a marine analytical chemist studying the environmental effects of power generation, particularly biofouling control. He developed an interest in fouling organisms that led to a degree in applied biology and a doctorate in ascidian larval physiology. Following privatisation, he became a director of Fawley Aquatic Research Laboratories Ltd. with responsibility for ecotoxicology and biofouling research. He now teaches estuarine sciences and mathematics to nuclear engineers at HMS SULTAN. His present interest is in modeling the distribution of Styela clava Herdman and has recorded over forty new European populations.

Mary E. Davis

Mary Davis co-founded Fawley Biofouling Services, and is now senior partner of the fouling and environmental consultancy. She is responsible for coordinating biofouling monitoring programs and developing site-specific biofouling control protocols. She has a particular interest in the distribution of marine nonindigenous species in relation to biodiversity.

Jaimie Dick

Jaimie Dick is a Lecturer in Behaviour and Ecology, and Director of the new 'Quercus' Biodiversity and Conservation Biology Centre, a partnership between Queen's University Belfast and Environment and Heritage Service. His particular area of research is the behavioural attributes of invasive species and their community impacts.

Susanne Diederich

Susanne Diederich studied biology (zoology, microbiology, organic chemistry) at the University of Göttingen (Germany) and at Trinity College Dublin (Ireland). She completed her Diploma thesis on "Distribution and survivability of introduced Pacific oysters (*Crassostrea gigas*) in the German Wadden Sea".

Since 2001, she has been a PhD student at the Alfred Wegener Institute for Polar and Marine Research (Germany). Her focus is on ecological studies of the spread of *Crassostrea gigas* and its influence on native ecosystems, especially competition with indigenous mussels. Anticipated end of her PhD is the fall of 2004. Job offers welcome.

Márcia Divina de Oliveira

Márcia Divina is a biologist with a Master's in Limnology from the University of São Paulo, Brazil. She has been a researcher at the Center of Agricultural Research of Pantanal since 1995, where she has been working with limnology of rivers and their associated floodplains in the Pantanal wetland. Since 2002 she has studied the exotic species "golden mussel" in the Paraguay River floodplain, emphasizing the reproductive dynamic and limiting factors for its development. Márcia has been developing a lot of activities to prevent and stop the dispersion of the golden mussel in Pantanal and other river basins of Brazil in cooperation with the Brazilian Ministry of Environment.

Dr. Mohamed.M. Dorgham

Mohamed Dorgham is a professor of Biological Oceanography and Marine Ecology. He has also been the Head of the Oceanography Department, Faculty of Science at Alexandria University, and a Consultant in the sector of environmental quality to the Egyptian Environmental Affairs Authority (EEAA). Mohamed has participated in several scientific projects and is the Vice-Chairman of the scientific committee for Egyptian universities for promotion to associate professors in Oceanography. He has also attended about 40 international, regional and national conferences in Egypt and in several European and Asian countries. Mohamed has supervised three PhD and five MSc theses and has more than 50 scientific publications on phytoplankton and zooplankton, macroalgae and the effect of pollution.

Doug Duncan

Doug Duncan received a bachelor's and master's from the University of Arizona in Wildlife Management. He has worked for state and federal agencies, mostly on "nongame" fish and wildlife. He has worked for the University of Arizona, Arizona Game and Fish Department, US National Park Service, US Bureau of Land Management, and the US Fish and Wildlife Service with big game, small game, rodents, raptors and other birds, desert tortoises, plants and vegetation, and native fish. His work has involved all four North American deserts, some grasslands, scrublands, and woodlands, and he has always had a great interest in riparian and aquatic ecosystems. Though he has been employed by many agencies, he works for the resources.Concha Durán Lalaguna

Concha Durán has been working for the past eight years in the Ebro Hydrographic Confederation of the Environmental Ministry of Spain. She is a biologist responsible for Biological Water Quality. Her primary aim is the correct implementation of the Water Framework Directive in the Ebro basin. Up to now her work has never been in relation to exotic species, but the recent zebra mussel invasion has been her first contact.

Alain Dutarte

Alain Dutartre is a Research Engineer in the Water Quality Research Unit of Cemagref, a French scientific and technological public research institute, and leader in environmental science and expertise for the sustainable management of land and water. For 20 years he has been working on native and exotic aquatic macrophytes in several water body types, he is the coordinator of a research program on biology, ecology and management of the water primrose (Ludwigia spp) in France, and tries to participate in the improvement of macrophytes management.

Paul Elliott

Paul Elliott is a final-year doctoral student at Cambridge University. A member of two departments, Chemical Engineering and Zoology, his research centres on the ecology, industrial effects and control of the invasive zebra mussel in Britain.

Dr. Aschwin Engelen

Aschwin Engelen is a recent post-doctorate researcher, working in the Marine Plant Ecology Research Group (ALGAE) at CCMAR. During his Ph.D. he studied the population biology of a tropical brown *Sargassum* seaweed. With the combination of molecular tools, demographic fieldwork and population matrix modeling the life history of *Sargassum* was studied on coral reefs. This work directed him towards the invasive biology of *Sargassum* species. He currently works in the European ALIENS project. He is interested in the processes and features that play a key role in determining the invasive character of *Sargassum muticum* and the invasibility of marine communities.

Richard Everett

Rich Everett, a marine biologist by training, coordinates the United States Coast Guard's research activities on the prevention of biological invasions via the operations of ships, and provides technical expertise in developing and implementing regulatory and policy programs. He holds a BA degree in Biology from the University of California, Santa Cruz and a PhD degree in Zoology from the University of California, Berkeley. Following completion of his dissertation, he conducted post-doctoral research in marine and estuarine ecology at the Oregon Institute of Marine Biology and the Smithsonian Environmental Research Center. From 1992 to 1999, he was a Senior Staff Biologist with the US Fish and Wildlife Service's Chesapeake Bay Estuary Program, where he worked on estuarine shallow water habitat, non-point source pollution, and nonindigenous species issues. He has been in his current position with the US Coast Guard since 1999.

Dr. Jeremy Firestone

Jeremy Firestone is an Assistant Professor of Marine Policy in the College of Marine Studies, University of Delaware. He teaches US and international ocean and coastal law and policy. He conducts research in the areas of ocean governance and fish and wildlife management. He is presently examining offshore wind power regulation, indigenous rights and resource management, and the interaction between commercial vessels and marine mammals in addition to ballast water policy. Prior to obtaining his PhD in Public Policy Analysis, Firestone was an environmental and natural resources enforcement lawyer for US EPA and the State of Michigan.

John Fitzsimons

John Fitzsimons obtained his BSc in Marine Biology from the University of Guelph, Ontario, Canada. He is a research scientist with Fisheries and Oceans Canada at the Bayfield Institute in Burlington, Ontario. My areas of interest include restoration of native species, effects of aquatic invasive species, ecoepidemiology, contaminant dynamics and reproductive physiology. He has authored or co-authored over 35 peer reviewed papers.

Dr. Maria Monia Flagella

Maria Flagella graduated in Natural Science and her graduation thesis was on "*Posidonia oceanica* Meadows of the Ligurian Sea, epiphytes and associated fauna". In May 2001 she began collaborating with the Stazione Zoologica "Anton Dohrn" of Naples, Italy within the project "Mapping of the *Posidonia oceanica* Meadows Along the Coasts of Sardinia and the Surrounding Small Islands" at the Benthic Ecology Laboratory of Ischia.

In March 2002 she obtained a PhD in Biology of algae with the University of Messina, Sicily, Italy, working at the Stazione Zoologica "Anton Dohrn" of Naples, Italy and studying the ecophyisiology of invasive species and the introductions of allocthonous seaweeds in the Mediterranean sea via ships'ballast water. Within the PhD Maria collaborated with Stazione Zoologica 'A. Dohrn' on the European project ALIENS (ALgal Introduction to European Shores). She attended national and international conferences on algology and marine biology.

Francisco Sylvester Fleming

Francisco Sylvester graduated in Biological Sciences from the Universidad Autónoma de Madrid, Spain in 1998. Between 1999 and 2002 he worked at the Argentine National Environmental Agency on the control and management of natural protected areas and national parks in connection with the World Heritage (UNESCO) office. Since April 2002 he has held a postgraduate fellowship from the University of Buenos Aires, Argentina working on his PhD dissertation on aspects of feeding and ecological interactions of the invasive pest bivalve *Limnoperna fortunei*.

Oliver Floerl

In 1998 Oliver completed a BSc in marine biology at the University of North Wales in Bangor (UK). He went on to do a PhD at James Cook University in Townsville , Australia, where he assessed the potential of private yachts to transport fouling organisms between locations on Australia's East Coast. During 2002–2004 he was a post-doctoral fellow at the National Institute for Water and Atmospheric Research (NIWA) in Christchurch, New Zealand, where he developed the model presented in this poster, as well as predictive tools to prevent non-indigenous species introductions to New Zealand by private yachts. He is now a research scientist at NIWA and mainly involved in "biosecurity" research, i.e., attempts to prevent the introduction or control the distribution of nonindigenous species in New Zealand.

Dr. Nadine Folino-Rorem

Nadine Folino-Rorem is an invertebrate zoologist with training in both freshwater and marine systems. She obtained her MSC and PhD degrees in zoology from the University of New Hampshire, Durham, New Hampshire with an emphasis on marine invertebrate ecology. She is currently an associate professor at a liberal arts school, Wheaton College, in Wheaton Illinois. Her recent research has focused on the ecology and taxonomy of the euryhaline hydroid Cordylophora and its interactions with zebra mussels in freshwater rivers and lakes.

Barrie Forrest

Barrie Forrest is senior scientist at the Cawthron Institute in Nelson, New Zealand. He has managed a range of consultancy and research programmes in relation to coastal and estuarine ecology, anthropogenic impacts, and marine bioinvasion issues. Earlier work in the latter field included fundamental studies of dispersal characteristics, establishment processes, and ecological impacts of the invasive Asian kelp *Undaria pinnatifida*. More recent work has targeted the development of management tools. These have included a risk-based decision support framework for marine biosecurity stakeholders, and ongoing research into vector management methods for the aquaculture industry.

Pam Fuller

Pam Fuller obtained her masters degree from the University of Florida while working concurrently at what was then the US Fish and Wildlife Service Laboratory in Gainesville, Florida. She is now the program leader for the US Geological Survey's Nonindigenous Aquatic Species Program, which maintains a nationwide database and a Web site of aquatic invaders. She is author of the summary book "Nonindigenous 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.

Marc Gaden

Marc Gaden serves as Communications Officer and Legislative Liaison for the Great Lakes Fishery Commission, a US/Canadian agency established by treaty to improve and perpetuate the Great Lakes fishery resources. He has held this position since 1995. Mr. Gaden is responsible for communicating the commission's program to a wide variety of stakeholders and interested parties including commissioners; the media; legislators and their staff; officials from federal, state, provincial, and tribal fishery management agencies; advisors to the commission; officials from other resource management institutions; specialized groups; and stakeholders. Among his duties, Mr. Gaden conducts strategic planning, serves as a liaison with elected officials, and produces a periodic newsletter, informational fact sheets, news releases, and other items. Mr. Gaden is also responsible for overseeing the commission's internet site, which he developed and placed online in May, 1996.

Prior to joining the Great Lakes Fishery Commission secretariat, Mr. Gaden worked as a Legislative Assistant for the US House of Representatives' Great Lakes Task Force, researching, proposing, and advocating legislation of benefit to the Great Lakes region. Mr. Gaden also worked as a Legislative Assistant and Caseworker for US Congressman Dennis M. Hertel (D-MI), specializing in Great Lakes, environment, transportation, immigration, and Social Security issues. He received a BA degree in History and Political Science from the University of Michigan in 1991 and a MA degree in Unites States Foreign Policy from The American University in 1993. Currently, he is a doctoral candidate at the University of Michigan's School of Natural Resources and Environment.

Dr. Bella S. Galil

Bella Galil is a Senior Scientist with the National Institute of Oceanography in Haifa, Israel. She obtained her MSc in1978 and PhD marine biology in1983 from Tel Aviv University. She has written over 100 papers focusing on the anthropogenic changes along the Mediterranean coast of Israel and decapod taxonomy and is the lead author of the CIESM Atlas on Exotic Crustaceans, and coordinator of the new CIESM PORTAL Project surveying ship-transported alien organisms in Mediterranean ports. Bella has participated and led research cruises to study macrobenthic diversity in coastal and deep waters of the Mediterranean.

Dr. Francesca Gherardi

Francesca Gherardi teaches Zoology and Conservation Biology at the University of Florence, Italy. Francesca is the author of more than 120 articles in international journals. She was the co-editor of *Crayfish in Europe as Alien Species* (Balkema, 1999), the theme editor of *Biodiversity Conservation and Habitat Management* in the Encyclopedia of Life Support Systems (UNESCO, 2002), and is part of the editorial board for *Biological Invasions* (Kluwer). She is a member of the Invasive Species Specialist Group (IUCN), the President of the International Association of Astacology (IAA), and a Research Fellow at the Marine Biological Laboratory, USA. Francesca is a partner of Craynet: European crayfish as keystone species, linking science, management and economics with sustainable environmental quality (European Union, 2003-2005).

Emili García-Berthou

Dr. Emili García-Berthou is Associate Professor at the Department of Environmental Sciences (University of Girona) and leads several projects on invasive freshwater fish in the Iberian peninsula. His team has been investigating the ecology of invasive freshwater fish particularly in wetlands, lakes and reservoirs and has published several international papers on that topic. They are currently focusing mainly on mosquitofish (*Gambusia holbrooki*) and wels (*Silurus glanis*). Further information and PDF files of reprints are available at http://ciencies.udg.es/w3/EGarcia/

Kurt D. Getsinger

Dr. Getsinger has been studying the biology, ecology, and management of aquatic plants since 1973, and has been stationed at the US Army Engineer Research and Development Center since 1982. He is past-president of the Aquatic Plant Management Society (1995-96) and has served as a director for the Council for Agricultural Science and Technology. He serves as technical advisor to Federal, state, and international agencies, including the USEPA Office of Pesticide Programs, and holds adjunct faculty appointments at several universities. Dr. Getsinger has authored over 100 scholarly articles on the management of aquatic and wetland vegetation using herbicides.

Tim Glasby

Tim Glasby is an experimental marine ecologist who has studied anthropogenic impacts on marine invertebrates for the last 10 years. Since 2003 he has been part of a team researching the impacts and potential control of *Caulerpa taxifolia* in New South Wales, Australia. Most recently Tim has begun examining the role that artificial structures play in spreading subtidal marine invertebrates, particularly exotic species.

Stephan Gollasch

Dr. S. Gollasch was involved in the first European ship sampling programme on ballast water, tank sediments and ship hull fouling (1992-1996). His PhD is world-wide the first thesis based on ship sampling. He prepared, together with colleagues from 5 countries, the first risk assessment study for species invasions in the Baltic Sea, carried out for the Nordic Council of Ministers, Copenhagen.

Due to the international aspect of biological invasions Dr. Gollasch became a member of several international working groups: International Council for the Exploration of the Sea (ICES) Working Group on Introductions and Transfers of Marine Organisms (WGITMO), Working Group on Ballast and Other Ship Vectors (WGBOSV); International Maritime Organization (IMO), Marine Environment Protection Committee (MEPC) and the Baltic Marine Biologists (BMB) Working Group on Non-Indigenous Estuarine and Marine Organisms (NEMO). Since 2001 he has been the chairman of the WGITMO and WGBOSV. He was involved in the EU Concerted Action "Introductions with Ships" as co-chairman (study completed in January 2000).

Until the summer of 2001 Dr. Gollasch coordinated a bilateral research initiative together with a Canadian colleague to assess the survival of species in ballast water en-route. In addition to laboratory and desk studies he spent more than 100 days at sea during several ballast water sampling programmes.

He is currently involved in ballast water related research projects (e.g., ballast water treatment, ship sampling, risk assessment) as an independent consultant (www.gollaschconsulting.de). Recent contracts include the German and Dutch Ministry of Transport, German Ministry of the Environment, International Maritime Organization, European Commission, Nordic Council of Ministers and various research projects.

Derek Gray

Derek Gray is an undergraduate student at the University of Windsor, Ontario, Canada. He conducted his undergraduate thesis research on saltwater barriers to the introduction of nonindigenous species in the Laurentian Great Lakes. He is currently involved in a project that will perform an *in-situ* test of the effectiveness of open-ocean ballast water exchange to reduce nonindigenous species introductions via invertebrate resting stages.

Dr. Michal Grabowski

Michal Grabowski obtained his BSc from the University of Wolverhampton, UK in 1994, MSc in 1996 and PhD in 2000, both from the University of Lodz, Poland.

He is currently in the Department of Invertebrate Zoology and Hydrobiology at the University Lodz. His research interests are biogeography and ecology of invasions in aquatic environments, phylogeography of aquatic biota, and Amphipoda, Mysidacea, Decapoda, gobiid fishes.

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 of 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 based on the Boundary Waters Treaty between Canada and the United States dealing with their transboundary issues concerning water and air.

He graduated from the School of Commerce of McGill University, Montreal, Canada and Osgoode Hall Law School, Toronto, Canada. He is a member of the Ontario Bar. Mr. Gray worked extensively as Deputy Prime Minister, as a Minister, and as a Member of Parliament in the fields of parliamentary affairs; economic and industrial development; foreign investment; finance; consumer protection; competition; international trade; federal law enforcement; the environment and climate change; and Canada-US border issues.

In 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.

Charles Griffiths

Prof. Charles Griffiths is Director of the Marine Biology Research Institute at the University of Cape Town, South Africa and a core team member of the South African Centre of Excellence for Invasion Biology. He is author of over 100 research papers and of four books, including best-selling field guides to both the marine life and the insects of South Africa. His current research focused on marine biodiversity and the threats posed by marine alien species in Africa. His co-author in this presentation is Prof. Jenny Day, who is head of the Zoology Department and Director of the Freshwater Research Unit at UCT.

Edward Guida

Edward Guida received his Bachelor's Degree in Mathematics from Brandeis University in 1979 and earned his Masters Degree in Electrical Engineering from the University of Massachusetts Dartmouth in 1992. He has over 20 years experience in acoustic system design and development. He is presently Senior Member of the Technical Staff at Ocean Systems, which is the world's leading producer of underwater acoustic countermeasures and has been providing the US and Allied Navies with reliable underwater acoustic systems for 50 years. Over the past 10 years, Mr. Guida has applied his expertise in underwater acoustics to the area of acoustic fish deterrence.

Alexis Gutierrez

Alexis Gutierrez is the National Marine Fisheries Services' International Coordinator for the Office of Protected Resources. Recently, as a Fellow of the Smithsonian Institution's National Museum of Natural History, she completed an assessment of the linkages between development assistance and biological invasion into freshwater systems in Southeast Asia. She has worked as a Project Manager for the Global Invasive Species Programme and a staffer at the US National Invasive Species Council. She received a BA in International Studies, with a minor in Environmental Studies, from the Johns Hopkins University. She subsequently completed her MA in International Relations/International Economics at the Johns Hopkins University School of Advanced International Studies. She is interested in building the capacity of developing countries to address conservation issues at the interface of ecology, economics, and international policy.

Mark Hammond

Mark Hammond is with the Environment and Heritage Service, Northern Ireland. He has studied the ecology of *Spartina anglica*, an invasive non-native estuarine plant, for over five years. His work has included research into the effectiveness of *S. anglica* eradication and control treatments and the effects of these treatments on native estuarine flora and fauna. He has also investigated the impact of waves on the niche of *S. anglica* and the over-wintering survival of *S. anglica* seedlings. Mark currently assists with the strategic management of *S. anglica* in Northern Ireland.

Michelle R. Harmon

Michelle Harmon is with the US National Oceanic and Atmospheric Administration (NOAA) as a National Ocean Service representative for NOAA's Invasive Species Program. The Program is tasked with developing a comprehensive NOAA approach to meeting Congressional mandates related to aquatic invasive species, including strategies for prevention, early detection and monitoring, control, restoration, rapid response and education. Michelle also is working with US interagency and international teams to develop prevention and monitoring strategies for aquatic invasive species. Past experience includes accessing coastal chemical contaminant concentrations in sediment and biological tissues and determining the ecosystem impacts of those contaminants.

Deniz Haydar

Deniz Haydar graduated from the University of Groningen, The Netherlands in 1999 with a degree in marine biology. After graduation Deniz prepared a government-sponsored position paper on the Wadden Sea harbor seal population relative to various conservation proposals. His graduate project focuses on exotic species in northwest European waters and tests the hypothesis that once a corridor has been established between two regions, invasion rate initially is high, then decreases, assuming no changes in vector intensity or donor/recipient regions. The model uses three regional data-sets and the vectors of shipping, canals, and oyster transport. His graduate training also includes teaching and supervising undergraduate research projects.

Brian Hayden

Brian Hayden completed an honours degree in Environmental Biology, at the University College Dublin, in June 2003. He works in the Coarse Fish Unit of the Central Fisheries Board, where he has been employed since graduation. He has worked with zebra mussels and invasive cyprinid fish, such as roach and dace.

Keith Hayes

On completing his Master's Degree in Marine Resource Management, Keith Hayes joined the Institute of Offshore Engineering helping to develop quantitative risk assessment techniques for demersal trawl interactions with subsea well heads and pipelines in the North Sea. He joined CSIRO in 1997 and completed his PhD in Quantitative Ecological Risk Assessment in 2000. He is the principal architect of the risk assessment that underpins the Australian Ballast Water Decision Support System and continues to develop quantitative methods for ecological risk assessment of biological stressors such as invasive species and genetically modified organisms.

Leif Matthias Herborg

Leif Herborg recently completed his PhD on the Ecology of the Chinese mitten crab at the School of Marine Science and Technology at the University of Newcastle Upon Tyne, England. He analyzed the spreading behaviour as well as trying to elucidate some of the many unknown life cycle parameters of this species during a historic spread in Continental Europe. Leif then used these data to develop a GIS-based population model for one of the worst invaded rivers. Parallel he used DNA-microsatellites to establish the population genetics of the European populations. Further he ran behavioural experiments in order to determine mating rhythmicity and the presence of pheromones.

Hans Herrmann

Hans Herrmann is a marine ecologist with over 20 years experience in the field of biodiversity conservation, protected areas and natural resource policy. Before joining the North American Commission for Environmental Cooperation as the Head of the Biodiversity Conservation Program he was Executive Director of Pronatura, a Mexican non-governmental organization devoted to the conservation of biodiversity. Prior to that, Mr. Herrmann was the Science Director and phytoplankton ecologist at the Scientific Research Center of Quintana Roo (CIQRO). It was also his responsibility for the coordination of scientific research at the Sian Ka'an Biosphere Reserve.

In Mexico, Mr. Herrmann served at the National Advisory Councils of Protected Areas, Sustainable Development, and Forestry. At the National Forestry Council he served as the Chairman of International Affairs. At the international level, Hans was very active as head of the Mesoamerican Delegation at IUCN, and was the Mesoamerican representative of the GEF Focal Points Network.

He is currently a member of the Board of Directors of the conservation group Sea Watch; an Academic Board member of the Monterrey Tec *"Catedra Andres Marcelo Sada: Conservación y Desarrollo Sostenible"*; and Senior Fellow of the Eco Systems Institute.

Dr. Chad Hewitt

Chad Hewitt is the Chief Technical Officer - Marine Biosecurity for the New Zealand Government. In this statutory role, he is responsible for the management of marine incursions within the New Zealand EEZ and developing and managing the marine invasive species research portfolio. Prior to joining the New Zealand Ministry of Fisheries in 2003, Chad led the Invasion Processes Program at the CSIRO Marine Research Centre for Research on Introduced Marine Pests (CRIMP) in Hobart a position that he held since1995.

Gregory Hunter

Greg Hunter Hunter received his Bachelor's Degree in Oceanographic Technology from the Florida Institute of Technology in 1976 and completed various graduate level courses in Ocean Engineering at the University of Rhode Island, Mechanical Engineering at Northeastern University, Underwater Acoustics at Catholic University of America and Advanced Mathematics at Harvard University. He has over 27 years experience in underwater system design and development. He is presently a Program Business Development Manager at Ocean Systems, which is the world's leading producer of underwater acoustic countermeasures and has been providing the US and Allied Navies with reliable underwater acoustic systems for 50 years.

Mo Husain

Mo Husain is the developer of the American Underpressure System for oil tankers – an advanced oil spill prevention system for tankers. Mr. Husain provides the overall direction of the research and development of the ballast water treatment (BWT) program, involving infusion of inert gas in the ballast water. A graduate of the University of Michigan in Naval Architecture and Marine Engineering, Mr. Husain has over 30 years experience in ship systems engineering, specifically in the field of hydrodynamics of ships and oil spill prevention from tankers. He has more than 15 years experience as the president of companies conducting Department of Defence research and development projects.

Graeme Inglis

Graeme Inglis is currently Science Leader in Marine Biosecurity within the National Centre for Aquatic Biodiversity and Biosecurity, NIWA, New Zealand. He is currently project leader for a national programme of baseline surveys of New Zealand's ports and high risk entry points for introduced marine species and for a national series of targeted surveillance for 7 notifiable marine pests. Graeme has a PhD in experimental ecology from Sydney University and was formerly a Senior Lecturer in Environmental Studies at James Cook University. His research interests are in invasive species biology, human impacts on marine environments, and seagrass ecology.

Jacinta Innes

Jacinta Innes is a Senior Policy Officer within the Invasive Marine Species Program at the Australian Government Department of Agriculture, Fisheries and Forestry and has worked in the Program for a year and a half. Jacinta has been heavily involved in the development of Australia's National System for the Prevention and Management of Marine Pest Incursions, particularly in the biofouling work for the prevention element, as well as coordinating the research requirements for the Program. She also played a large role in developing Australia's position for the International Treaty on the Control and Management of Ships' Ballast Water and Sediments. She holds a Bachelor of Science, with First Class Honours in Marine Ecology.

Henk A. Jenner

Henk Jenner has a PhD in Biology/Toxicology and has spent more than 25 years as a researcher, manager and consultant at KEMA Nederland BV. He is now senior consultant at the Business Unit KEMA Power Generation and Sustainables' product team for Process and Cooling Water (PCW). He is co-editor of three books on macrofouling problems in Europe and wrote as author or co-author seven book chapters. In addition to 21 conference contributions he is author or co-author of 50 publications in the open literature. A few highlights in his career so far are R&D and implementation of antifouling methods like heat treatment ("thermoshock"); chlorination techniques as Pulse-Chlorination®; biomonitoring tools as KEMA Biofouling Monitor® for detection of settlement and growth of macrofouling. Recent developments are monitoring of biofilms by bacteria in relation with heat transfer resistance, microbial influenced corrosion (MIC) and human pathogens.

Doug Jensen

Doug Jensen has been the Coordinator for the Aquatic Invasive Species Information Center at the University of Minnesota Sea Grant Extension Program in Duluth, Minnesota for over 10 years. He is considered an expert on aquatic invasive species outreach and research and is frequently sought as a speaker at conferences across the US. There, he serves on state, regional and national multi-agency task forces working to address AIS issues. Doug has published several award-winning public education resources including a national education videotape, *Stop Exotics, Clean Your Boat*, featuring John Ratzenberger, a.k.a, the popular postman Cliff Clavin from the TV show Cheers. This video is being used in nearly every U.S. state and Canadian province to promote AIS awareness among boaters and anglers.

Other outreach materials he has published include aquatic invasive species WATCH ID cards, fact sheets, youth education curricula, CDs, and news releases. Results of his research have been published in peer review journals concerning aquatic invasive species in Lake Superior, zebra mussels and rusty crayfish, and Eurasian ruffe. In 1999, he co-hosted the 9th International Conference on Aquatic Invasive Species.

Before joining Minnesota Sea Grant, Doug was a researcher at the US Environmental Protection Agency laboratory in Duluth. He has a BS in Biology from the University of Minnesota Duluth and is pursuing a Masters of Education, with an emphasis on program evaluation.

Dr. Ladd Johnson

Ladd Johnson is an ecologist examining the structure and function of freshwater and marine communities, especially benthic assemblages of macrophytes and invertebrates. His work on invasive species has focused primarily on the ecology and dispersal of the zebra mussel, especially in inland lakes and waterways. He received his PhD from the University of Washington (USA) in 1989 and has been an associate professor at Laval University (Québec City, Canada) since 1995.

Lisa Jones

Lisa Jones is presently finishing her MSc research in Dr. Anthony Ricciardi's lab at McGill University in Montreal. Her thesis examines the physico-chemical factors affecting the distribution and abundance of zebra and quagga mussels in a large river system. The heterogeneous environment of the St. Lawrence River provides a unique opportunity to identify and test these factors. Her research is funded by a Natural Sciences and Engineering Council of Canada (NSERC) postgraduate scholarship.

Andrew Johnson

Andrew Johnson is the Manager of the Invasive Marine Species Program for the Australian Government Department of Agriculture, Fisheries and Forestry. The key focus of the Program is leading development and implementation of Australia's National System for the Prevention and Management of Marine Pest Incursions. Andrew has 10 years experience in the development and implementation of government policies relating to natural resource management and has worked on marine pest management activities since March 2003.

Dr. Ravindra C. Joshi

Ravindra Joshi is currently a Senior Research Fellow at the Crop Protection Division of the Philippine Rice Research Institute (PhilRice) — an agency attached to the Department of Agriculture, Philippines. He has been working on rice pest management for more than two decades. His research includes rice gall midges in Asia and Africa; invasive alien species of earthworms, rodents, leaf miner flies and golden apple snails in the Philippines. His interests are mainly to develop ecologically sustainable pest management methods that are environment-friendly, and socially acceptable to resource-poor-farmers.

Guillaume Juhel

Guillaume Juhel did his undergraduate studies in the field of Oceanography and Limnology at universities in Paris, France and the Laval University, Quebec, Canada. He is currently a PhD student in the Department of Zoology, Ecology and Plant Science, University College Cork, Ireland. Guillaume is primarily interested in the influence of toxic cyanobacterial blooms on the feeding behaviour of the zebra mussel and secondly on the ecotoxicology of the toxins, which involves studying the impact of toxic cyanobacteria on the physiology of the mussels.

Samuel Kahng

Samuel Kahng is currently working on his PhD at the University of Hawaii in the Department of Oceanography. He also works for the university as a Graduate Research Assistant. Samuel has volunteered since 1999 to such organizations as the Center for Whale Research, Friday Harbor, Washington: Orca Photo Identification Survey; Gerace Field Station, San Salvador, Bahamas: Coral Reef Monitoring; and Okavango Crocodile Project, Maun, Botswana: Tagging Nile Crocodiles.

Leena Karjala

Leena Karjala, MSc is a scientist in the Finnish Institute of Marine Research, Department of Biological Oceanography in Helsinki, Finland.

She is a marine biologist with a special interest in respiration studies on biomaterial and sediments. Leena has publications on community respiration and respiration and nutrient cycling in sediments. She is a member of the research group in the project of ecology and physiology of marine invasive species in the Baltic Sea, specifically *Cercopagis pengoi*.

Dr. Alexander Y. Karatayev

Alexander Karatayev completed his BA in Biology from the Belarussian State University in Minsk in 1976. He went on to his PhD in Hydrobiology from the Institute of Zoology, Belarussian Academy of Science in 1983. He completed his Doctor of Sciences in Hydrobiology from the Institute of Zoology, Belarussian Academy of Science in 1992. His research interests and 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; and ecology of cooling water reservoirs.

Byron Karns

Byron Karns received his undergraduate degree in history and masters of biological science from the University of Minnesota. Byron has worked for the National Park Service since 1991, all of that time with the St. Croix National Scenic Riverway. He began his work with the Park as a naturalist, and then the volunteer coordinator of citizens providing zebra mussel information to boaters at launches on the St. Croix River. For the past several years, he has been the zebra mussel prevention plan coordinator for the Riverway. In addition to working intimately with all aspects of the zebra mussel prevention plan, Byron does field monitoring and inventories of other exotic/native species on the Riverway. His Master's focus was on aquatic insects and water quality — these themes are of continued interest and study. During the past several field seasons, he has also assisted with the endangered Wing Mapleleaf (*Quadrula fragosa*) life history studies on the St. Croix, and has coauthored (Hove, et al., 2000) a portion of the results.

Timothy Keeney

Timothy Keeney is the Deputy Assistant Secretary for Oceans and Atmosphere at the National Oceanic and Atmospheric Administration in Washington, DC. His 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

Dr. David W. Kelly

David Kelly graduate with a PhD at Queens University Belfast in 2001. His research examined functional roles of native and invasive freshwater amphipods. In particular, he was interested in the predatory role of this putatively herbivorous/detritivorous group and their interactions with native invertebrate and fish communities. Currently, David works as a post-doctorate fellow at the Great Lakes Institute in Windsor, Ontario, Canada in Dr. Hugh MacIsaac's bioinvasion laboratory. David is using molecular tools to test invasion theory and to elucidate origins and pathways of a native North American brackish water species that has established and spread in both fresh and oligo-haline habitats in Europe.

Steven J.Kerr

Steven Kerr graduated from the University of Guelph, Ontario, Canada. He has been an employee with the Ontario Ministry of Natural Resources since 1976. His employment history includes: Fisheries Management Officer in Wawa; District Biologist in Owen Sound; Regional Fisheries Biologist, Eastern Region; and Fisheries Specialist, Southcentral Sciences Section. He has an excellent working experience on four of the Great Lakes. Steven is currently the Senior Fisheries Biologist with the Fisheries Section, Fish and Wildlife Branch, at the Ministry in Peterborough. He has authored over 100 technical reports and published papers.

Dr. Daniel Kluza

Daniel Kluza is a postdoctoral ecologist with the United States Environmental Protection Agency's National Center for Environmental Assessment. His work on nonindigenous 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.

Dr. Alicja Konopacka

Alicja Konopacka has received an MSc in biochemistry in 1970 and in Zoology in 1973 from the University of Lodz, Poland, and a PhD in 1981 from the same university. She is with the Department of Invertebrate Zoology and Hydrobiology at the University of Lodz and her research interests are biology, ecology and taxonomy of freshwater and marine amphipods (Crustacea, Amphipoda); alien species in fresh, brackish and marine waters; biogeography and ecology of invasions in aquatic environments.

Dr. Joanna Kostrzewa

Joanna Kostrzewa received her MSc in 1995 and PhD in 2000 from the University of Lodz, Poland. She is currently with the Department of Ecology and Vertebrate Zoology at the University of Lodz. Her research interests are biogeography and ecology of fishes, fish assemblages in freshwater systems, recolonization in rivers and ecology of Gobiidae

Stefan Kraan

Dr Stefan Kraan started a study Marine Biology at University of Groningen, The Netherlands. He moved to Ireland in 1996 to start a PhD in 1998 on molecular phylogeny and aquaculture of edible seaweeds at the National University of Ireland, Galway. Finished his PhD in 2001 and became manager of the Irish Seaweed Industry Organisation which later evolved into the Irish Seaweed Centre, a centre for seaweed research and development (http://www.irishseaweed.com). During a fieldwork trip he discovered the invasive species *Sargassum muticum* for the first time in the Republic of Ireland. This resulted in the development of an interest in the geographical distribution and rate of spreading of invasive macroalgae in Ireland.

Dr. Christopher Krzysztof

Christopher Krzystof, PhD, DSc, is a professor of zoology at the University of Lodz. He is the head of the Laboratory of Polar Biology and Oceanobiology, President of the Committee of Zoology, Polish Academy of Science (PAS), and Vice-President of the Committee on Polar Research, PAS. His interests and expertise include marine (mainly polar) and freshwater Crustacea (mainly Amphipoda) their taxonomy, biology, ecology, biogeography, invasion corridors. He has authored 100 scientific papers, and over 100 grey literature articles.

Dr. Eila Lahdes

Eila Lahdes, PhD is a scientist in the Finnish Institute of Marine Research, Department of Biological Oceanography, Helsinki, Finland She is a marine biologist with a special interest in ecophysiology and biochemistry. Publications on phytoplankton biochemistry, temperature adaptation of the cold sea crustaceans, membrane lipids and membrane bound enzymes. Recent years studies on ecophysiology and occurrence of the invader cladoceran, *Cercopagis pengoi* in the Baltic Sea.

Ari Laine

Ari Laine is a marine biologist (MSc, PhD-student) who works at the Finnish Institute of Marine Research. He has specialized in the ecology of macrozoobenthos, with special interest in long-term changes in the Baltic Sea ecosystem, including biological communities and interactions with the physico-chemical environment. Much of his work has been related to monitoring studies, which have offered material for long-term analysis. Recently, in an ongoing three-year project funded by the Academy of Finland, he has focused on the ecology and invasion history of the invasive polychaete *Marenzelleria viridis* in the northern Baltic Sea.

Dr. Brian E. Lapointe

Brian E. Lapointe is a marine ecologist who received his BS from Boston University in 1973, MS from the University of Florida in 1979, and PhD from the University of South Florida in 1982. He became a full-time employee with Harbor Branch Oceanographic Institution in January 1983. Brian's research involves the physiology, ecology, and biochemistry of macroalgae (seaweeds). His early work in the 1980s centered on the ecology of pelagic *Sargassum*, the floating brown seaweed for which the Sargasso Sea was named. More recently, his research has assessed biogeochemical linkages between land-based nutrient pollution, harmful algal blooms, and invasive species outbreaks in tropical seagrass and coral reef ecosystems.

Dr. Henry Lee II

Henry Lee II has worked for the US Environmental Protection Agency in Newport, Oregon, USA since 1980. One research focus is the assessment of the estuaries in Oregon, Washington, and California through EPA's EMAP program. The fish and benthic survey data from EMAP are being used to evaluate regional patterns of invasion on the Pacific Coast. Another focus is the development of a Pacific Coast database of native and nonindigenous estuarine species and the application of the database to predicting species distributions using a niche model, GARP. Henry is the chairperson of the EPA's Nonindigenous Species Working Group.

C.E. Bud Leffler

Bud Leffler is Marine Environmental Partners, Inc. (MEP's) founder and serves as its Chairman and Chief Technical Officer. His previous experience includes 17 years in various engineering and management positions with General Electric Co., Vice President of Siemens Energy and Automation Services Co., President of Allen Medical Systems, and President of Zaxis, Inc. a publicly-held biotech firm engaged in, among other specialties, the production of pharmaceutical grade water. Mr. Leffler holds patents and has patents pending related to his work at Zaxis, Inc. and MEP. Mr. Leffler is a member of the Society of Naval Architects and Marine Engineers, and he is a licensed 100 ton master pilot.

Tony Leigh

Tony Leigh is currently Technical Director of ATG Willand, a specialised manufacturer of UV disinfection systems. He has worked for ATG Willand for almost 20 years, over the last decade in a product and technical development role.

He has been instrumental in the development of UV for marine environments, particularly the application of UV treatment for disinfection of well injection water for offshore oil fields. He has primary responsibility, in conjunction with the University of Strathclyde, for applying computational fluid dynamics (CFD) modelling techniques to the development of a new generation of UV disinfection systems specifically designed for use in ballast water treatment.

Dr. Erkki Leppäkoski

Erkki Leppäkoski was born in 1941 in Helsinki, Finland. He received his MSc in 1965 and his PhD in Zoology in 1975 from the University of Turku. During 1966-72 he worked as marine biologist at Kristineberg Marine Research Station in Sweden. Currently, he is Professor of Ecology and Environmental Research at Åbo Akademi University in Finland. He has held this position since 1988. Erkki was also Director at the Archipelago Research Institute, University of Turku from 1972-1974.

John Lucey

John Lucey (MSc., CBiol, MIBiol, MPhil) is Senior Scientific Officer in the Environmental Protection Agency (EPA) based at Kilkenny in the southeast of Ireland. He previously worked for the Ministry of Agriculture, Fisheries and Food in Britain and for the Shannon Regional Fisheries Board in Ireland. His more than 20 year's working experience on Irish rivers has equipped him with a considerable knowledge of aquatic plant and animal communities. He provides advice within the Agency on nature conservation matters and has published papers on aquatic alien invasive plant species.

Frances Lucy

Frances Lucy is a lecturer at the Institute of Technology, Sligo, where she co-ordinates a Fisheries Management Certificate for the Irish Regional Fishery Boards. She is actively involved in zebra mussel research and has carried out surveys for the EPA and Marine Institute since 1998. She also runs an ecological consultancy, Environmental Services Ireland, in partnership with Dr. Monica Sullivan.

Thomas P. Mackey

Thomas Mackey is President and CEO of Hyde Marine, Inc., Cleveland, Ohio. He received BSE and MSE degrees in Naval Architecture and Marine Engineering from the University of Michigan. He is a Life Fellow of the Society of Naval Architects and Marine Engineers (SNAME), a Fellow of the Institute of Marine Engineering, Science and Technology (IMarEST), and a member of several other marine professional societies.

Mr. Mackey has presented several papers on ballast water management at various symposia, including the International Maritime Organization's 2nd International Ballast Water Treatment R&D Symposium in 2003. His company, Hyde Marine, has been actively involved with ballast water management procedures and equipment since 1996 and with treating of ballast water tanks to prevent and remove mud accumulations since the 1960s.

Mr. Mackey has been active in the marine business for the past 35 years and has been President of Hyde since 1973.

Dr. Hugh MacIssac

Hugh MacIsaac has his BSc (Hon.) from the University of Windsor, MSc from the University of Toronto, PhD from Dartmouth College, and a postdoctoral fellowship at the University of Toronto. He has been an assistant and associate professor at the University of Windsor. He is currently a professor and Department of Fisheries and Oceans Invasive Species Research Chair at the Great Lakes Institute for Environmental Research at the University of Windsor. His research interests are invasion biology, including theory, genetics, population modeling, and ecological and economic impacts. He teaches courses in conservation biology, Great Lakes science, and invasion biology.

Dr. Cathy Maguire

Cathy Maguire is a Research Fellow at Queens University in Belfast. Her research interests include lake ecosystems and food webs, and the impacts, ecology and control of aquatic invasive species. She has a BSc (Hons) in Environmental Biology, MSc in Applied Environmental Sciences and a PhD in Freshwater Ecology. Current research includes management of the impacts of zebra mussels in Northern Ireland and determination of their effects on fish populations in the Erne system through alterations of the food web.

Brian T. Maybruck

In 1994, Brian received his BA from the Ohio State University in Zoology. In 2001, he received his MS from NOVA Southeastern University in Marine Biology. In 2000, he was accepted into the University of Wisconsin-Milwaukee PhD program in biology. He received the UWM Chancellor's Graduate Student Fellowship Awards in 2002 and 2003, in the amounts of $1250 and $2500, respectively. He had an article accepted for publication in Protistology: Maybruck, B.T. and Rogerson, A. "Protozoan Epibionts on the Prop Roots of the Red Mangrove Tree, *Rhizophora mangle*".

Brian presented his research during the summer of 2003 at a seminar that was sponsored by the UWM Great Lakes Water Institute, and during a poster session at an open house given by the UWM Great Lakes Water Institute. He has also developed a novel method for the isolation of natural populations of protozoa for stable isotope analysis.

Declan McCabe

Declan McCabe is a community ecologist at St. Michael's College in Colchester, Vermont, USA. His research interests include factors controlling diversity of river insect communities. Factors investigated to date include, disturbance, caddisfly aggregations, and distance from a constant-temperature spring source. More recently Declan has investigated various aspects of zebra mussel biology including movement of adult mussels, and the impacts of mussels on soft-sediment communities in lakes. Laboratory work in collaboration with Mark Beekey and Ellen Marsden at the University of Vermont has focused on the influence of zebra mussels on habitat choice and foraging success of benthic insectivores.

Tracy McCollin

Currently employed at FRS Marine Laboratory in Aberdeen as a phytoplankton biologist working specifically on ballast water issues. Recent contracts and projects include an investigation of the efficiency of ballast water exchange in regional seas and participation in a European Union funded project (MARTOB) testing ballast water treatment methods. Other aspects of this post include advisory work on issues relating to ballast water and the introduction of non-native species and participation in the ICES/IMO/IOC Working Group on Ballast Water and Other Ship Vectors and the International Maritime Organisation (IMO) Marine Environment Protection Committee.

Mary Ann McGarry

Mary Ann McGarry has been involved in science/environmental education since graduating with a self-designed major from Dartmouth College, New Hampshire in 1981. She has worked in higher education with prospective teachers since 1989, primarily within the University of Maine System. She has served as the Director of Education for Maine Lakes Conservancy Institute since it's inception in 2000. Mary Ann has received state, regional, and international awards for her creative education focusing on watersheds.

Paul McLoone

Paul McLoone received his BSc (Zoology) in 1997 from the Queens University of Belfast and in 2000 his MSc (Fisheries Management Development and Conservation) from the University College Cork.

Since completing his degree, Paul has pursued a career in fisheries management, starting with a year working on his 'home' River Faughan, near Derry. While studying for his masters, Paul spent a summer with Centre Interniversitaire de Recherche sur le Saumon Atlantique (CIRSA) in Quebec, Canada. His thesis investigating marine growth variation in Atlantic salmon was conducted in conjunction with The Marine Institute's research facility in Newport, Ireland. Since 2000, Paul's work with the Central Fisheries Board has focused on recreational fisheries in Ireland's Navigable Waterways, a project funded by Waterways Ireland.

Dr. Robert F. McMahon

Robert McMahon has been at the University of Texas at Arlington since 1972, where he is now Professor of Biology and Dean of the Honors College. He received his BA in Zoology from Cornell University in 1966, and his PhD in Zoology from Syracuse University in 1972. His research expertise is in aquatic biology, marine biology, and the biology and control of introduced nonindigenous aquatic species, particularly freshwater and marine bivalve molluscs.

Kris McNyset

Kris McNyset has a BS from the Evergreen State College, a MS in Aquatic Ecosystems from the University of Michigan, and anticipates completing a PhD in Ecology and Evolutionary Biology from the University of Kansas in September 2004. Her dissertation research includes using ecological niche modeling in analyses of evolution of the ecological niche, niche conservatism, large-scale biodiversity patterns in aquatic ecosystems and invasive species threat assessment.

Aroha Miller

Aroha Miller is a Tuapapa Putaiao Maori Fellow within the National Centre for Aquatic Biodiversity and Biosecurity. She completed a BSc (Hons.) in Zoology at Otago University, New Zealand in 2000 on the parasitism, movement and distribution of the snail *Diloma subrostrata* (Trochidae), in a soft-sediment intertidal zone. The work presented at this conference represents part of Aroha's MSc thesis on the parasite fauna of the invasive Asian portunid crab, Charybdis japonica, and the New Zealand portunid, *Ovalipes catharus*. Her thesis tested the hypotheses that the invasive species carries fewer parasites than in its native range and than comparable native New Zealand crabs. Aroha is currently applying to extend this work into a PhD dissertation.

Dr. Brian K. Miller

Brian. Miller is a Wildlife Biologist and Natural Resource Sociologist and serves as the Associate Director of the Illinois-Indiana Sea Grant College Program. He coordinates Sea Grant field and campus staff outreach activities in Indiana and Illinois and works with outreach staff to design programs that achieve impact. Brian's research focuses on factors influencing local land-use decisions and on program impact evaluation.

Brian Miller worked with Allen Miller of Wisconsin Sea Grant to conceive the SGNIS project in 1995. He works closely with project collaborators to ensure that SGNIS is a valuable resource for users around the world.

Dr. Edward L. Mills

Ed Mills is currently Director of the Cornell Biological Field Station and professor in the Department of Natural Resources, College of Agriculture and Life Sciences, Cornell University. He is also Co-Director of Research for the Great Lakes Research Consortium, has recently been appointed as a member of the United States Section of the Council of Great Lakes Managers, and is currently a member of governor Pataki's New York task force on invasive species. His research interests are in areas of limnology, freshwater food webs, ecology of large lakes including the Great Lakes, and biological impacts of aquatic invasive species. He and his colleagues have published 100+ peer-reviewed articles on a wide range of topics including predator-prey interactions, exotic species invasions, and food web interactions in freshwater lakes. Ed has served on the Great Lakes Fishery Commission Board of Technical Experts focus area on Great Lakes exotics and currently has several funded research studies examining the impacts of exotic species in New York's freshwater lakes. He recently completed a comprehensive review of Great Lakes shipping since the opening of the St. Lawrence Seaway in 1959 that will appear in the October issue of BioScience.

Frédéric Mineur

Frédéric Mineur has a BSc in Biology and MSc in Oceanology from the University of Liège in Belgium. Currently he is doing a PhD funded by the European program Algal Invasions on European Shores (ALIENS) at the Queen's University of Belfast, Northern Ireland. He works on different aspects of seaweed introductions in Europe, including study of potential vectors such as transport by boat hulls and by association with oyster transfers.

Daniel P. Molloy

Dan is an aquatic biologist with the New York State Museum. His interests include the biology, ecology, and systematics of parasites of aquatic invertebrates and the development of environmentally-safe, biocontrol agents for the management of aquatic pest species.

James Adiel Morris, Jr.

James Morris Jr. is an employee of the National Oceanic and Atmospheric Administration's National Ocean Service, Center for Coastal Fisheries and Habitat Research, Beaufort, North Carolina. He received his BSc and MSc in Biology from East Carolina University, and he is a current PhD student in Zoology at North Carolina State University. James' research background includes various aspects of striped bass life history, migration, and population discrimination using otolith microchemistry. James has extensive experience in shellfish and finfish mariculture and has spawned reared various marine fishes such as *Centropristis striata*, black sea bass, *Leiostomus xanthurus*, spot, and *Orthopristis chrysoptera*, pigfish.

Recently, James' work has included the investigation of Hg uptake effects on juvenile pinfish *Lagodon rhomboides*; the use of laboratory reared spot *Leiostomus xanthurus* to validate otolith back-calculation methods; the use of polyculture as a viable method for the stock enhancement of reef fishes; age validation or red porgy, *Pagrus pagrus*, and the correlations of fish lesions with water mold (*Aphanomyces*). James' current primary research involves studying the recent introduction of the Indo-Pacific lionfish in the western Atlantic. James has also served as President (2001-2002) of the Tidewater Chapter of the American Fisheries Society.

Jim Muirhead

Jim Muirhead is a graduate student at the Great Lakes Institute for Environmental Research, University of Windsor, Ontario, Canada. His dissertation involves modeling dispersal of aquatic and terrestrial nonindigenous species at regional scales, and relating mechanisms of dispersal to observed invasion patterns.

Wing Ng

Wing Ng is a Senior Technical Engineer at Darlington Nuclear Generating Station, Ontario, Canada. He is responsible for the control of zebra mussels and aquatic species in the cooling water supply to the reactors as well as corrosion mitigation of the service water system piping. He has over 23 years of experience in the electric power industry. His other areas of expertise include air pollution control and flue gas desulphurization. He holds graduate degrees in Chemical Engineering and Chemistry.

Dr. Leo Nico

Leo Nico is a research biologist with the US Geological Survey in Gainesville, Florida. He received his Masters degree in Biology from Southern Illinois University and a PhD in Zoology from the University of Florida. His earlier work focused on South American fishes, including studies on piranhas and annual killifishes. As a government scientist, Leo researches nonindigenous fishes. In addition to black carp, Leo is investigating introduced Asian swamp eels and South American catfishes, and he is particularly interested in identifying the ecological effects associated with fish introductions.

Hideki Obika

Hideki Obika is a scientist at the National Institute of Advanced Industrial Science and Technology (AIST), Shikoku, Japan. He is a microbiologist. He works on oil degradation by bacteria, use of low power pulsed laser irradiation as a tool to dislodge biofilm from surfaces and effectiveness of laser as a tool to reduce the problem of bioinvasion via ships' ballast water. In addition, he also works on biological evaluation of new antibacterial/antifouling surfaces being made at the Institute and biodiversity of marine aquatic habitats in and around the Shikoku Island, Japan.

Martin T. O'Connell

Martin O'Connell has been studying fishes for 20 years and has worked in aquatic systems in New York, Virginia, Mississippi, Louisiana, and Trinidad. Although he has focused mostly on ecological and behavioural aspects of fishes, it has become more apparent to him over time that the conservation of native fishes depends greatly on studying and controlling invasive fish species. He is currently Director of the Nekton Research Laboratory at the Pontchartrain Institute for Environmental Sciences, University of New Orleans (Louisiana, USA). Some of his research interests beyond invasive fishes include estuarine fish assemblage dynamics, the conservation of rare fishes, and floodplain ecology.

Charles R. O'Neill, Jr.

Chuck O'Neill is a Cornell University/NY Sea Grant Senior Extension Associate, and Director of the National Aquatic Nuisance Species Clearinghouse, where he is responsible for development and implementation of extension education programs in aquatic nuisance, nonindigenous, and invasive species introduction, spread, impact, control, management and policy. Chuck chairs the Communications, Education and Outreach Sub-committee of the US National Invasive Species Advisory Committee. He serves on the National Aquatic Nuisance Species Task Force Communications, Education and Outreach Committee, and co-chairs the Northeast Panel on Aquatic Nuisance Species Communications, Education and Outreach Committee. Chuck teaches graduate seminars on Great Lakes Issues and Invasive Species at the State University of NY.

Dr. Dianna Padilla

Dianna Padilla studies invasion biology in aquatic systems including the role of human activities in influencing the spread of both freshwater and marine exotics, such as recreational boating, trade in aquarium and ornamental species and aquaculture. She also studies the population dynamics and impacts of exotic species on native ecosystems. She is conducting collaborative work with scientists who have studied the Eastern European invasion of zebra mussels for more than 20 years to test predictive models of the spread and ecological impacts of zebra mussels as well as summarizing decades of research that have not been previously available to non-Russian scientists.

Dr. Antoni Palau

Antoni Palau is a biologist who received his PhD in limnology of reservoirs in 1987. He has been an assistant professor on limnology and water quality since 1992 in the University of Lleida, Spain.

Since 1998 he has also worked as Environmental Manager of hydroelectric power plants for the Department of Environment and Sustainable Development (ENDESA), working on environmental reservoir management of water (instream flow needs) and sediments. He is Scientific Director of the Research Program on zebra mussel control.

Dr. Vadim Panov

Vadim Panov is a Senior Research Scientist at the Zoological Institute of the Russian Academy of Sciences in St. Petersburg, Russia. His current primary research interests include biology and ecosystem impacts of aquatic invasive species, and information technologies in biodiversity research. He is Coordinator of the Regional Biological Invasions Centre Information System (http://www.zin.ru/rbic/). Currently he is actively involved in several international working groups and networks, focusing on invasive species, including the SIL Working Group on Aquatic Invasive Species (Chairperson since 2001), and European Research Network on Aquatic Invasive Species (initiator and coordinator since 2001, together with Dr. Stephan Gollasch).

Nick Pasiecznik

Nick Pasiecznick is a representative of the compendium program of CABI. CABI is an international, non-profit organization. It provides information and scientific services in agriculture, forestry, health and the environment, in support of research, teaching, extension, business, policy and development. Through its many programmes in knowledge management and in science-based research and development, CABI is concerned with the needs of industrial and developing countries. The Compendium Programme, managed by CABI, plays a coordinating role in compiling expert inputs on chosen topics into global knowledge bases ("Compendia"), and presenting these through innovative and friendly technology (the "Compendium Technology").

Bivan Patnaik

Since 2002, I have been the Regulatory Coordinator for the Coast Guard's Aquatic Nuisance Species (ANS) Program. My responsibilities include:

- Managing a regulatory team of attorneys, environmental analysts, economists and technical writers;
- Coordinating with Federal Agencies, State agencies, and other stakeholders; and
- Reviewing draft or proposed ANS legislation

Prior to becoming part of the Coast Guard, I was a consultant to the Coast Guard. Where I assisted in the development of several environmental protection regulations. These include regulations for: the protection of endangered species; cleaning up of oil spills, and the disposal of commercial waste.

I also worked as a consultant to the Environmental Protection Agency (EPA), where I assisted in the development of guidance documents for EPA decision-makers on the cleanup of Superfund sites, and the clean up oil spills. I also wrote several articles for EPA newsletters. I have a B.S. in Biology from Virginia Commonwealth University, and an M.S. in Environmental Policy from Johns Hopkins University.

Dr. Judith Pederson

Judith Pederson received her PhD from Clark University in marine ecology. She directs the MITSG Center for Coastal Resources at the Massachusetts Institute of Technology Sea Grant College Program that facilitates access to scientific and technical information for policy makers, students, and the public. Judith's research interests are in marine bioinvasions and coastal pollution. She is a member of two ICES Working Groups, is coordinating a Canadian-Northeastern US regional ballast water management approach, organized rapid assessment surveys for New England, convened International Marine Bioinvasions Conferences and Workshops, and edited several conference proceedings, including a Special Issue of Biological Invasions.

Tom Perlich

Tom Perlich is currently the President of Ecochlor, a company he founded in 1999. Mr. Perlich has over 20 years of progressive management experience in the field of specialty water treatment. Prior to founding Ecochlor, Mr. Perlich was the Corporate Sales Manager for Vulcan Performance Chemicals. Mr. Perlich was also a Regional Sales Manager for Exxon Chemicals and an Account Manager for Nalco Chemical. He has experience in all forms of water treatment, including microbiological control in industrial and municipal water sources. Mr. Perlich holds an Industrial Engineering degree from Rochester Institute of Technology.

Jim Petta

Jim Petta received his BSc degree from Texas A&M University and his MSC from California State University. He has worked for Syngenta for the past 20 years in various technical and commercial roles, including an overseas term in Indonesia. Mr. Petta has worked directly as the technical director for Syngenta's aquatics and vegetation management group since 1993, primarily involved with habitat renovation and invasive plant management.

Stephen Phillips

Stephen Phillips is a program manager at the Pacific States Marine Fisheries Commission (PSMFC) and oversees the Aquatic Nuisance Species Project. Mr. Phillips has worked for the PSMFC for over 12 years. Mr. Phillips received his Bachelor's in Biology from Baldwin Wallace College in 1979 and a Master's of Fisheries Science from Oregon State University in 1987.

Marjo Pienimäki

Marjo Pienimäki, MSc is a PhD student at Åbo Akademi University, Environmental and marine biology. Her research topic is the transfer of aquatic nonindigenous species, their vectors and impacts on biodiversity, ecological risk assessment for port areas along the north coast of the Gulf of Finland and assessment of the role of selected ports in southern Finland as recipient and donor areas for non-native species introductions from/to other ports and seas with matching climate and salinity.

Dirk Platvoet

I am currently keeper of the crustacean collection of the Zoological Museum of the University of Amsterdam. I do research on invasive amphipod species. My background as taxonomist allows me to combine several disciplines like morphology, functional morphology and behaviour. I am preparing a dissertation on the ponto caspian species Dikerogammarus villosus and its impact on western European aquatic systems. I also use the species for more general purposes, like collecting information on the mechanism of feeding, grooming etcetera. This includes filming and SEM work on microstructures.

Steve Raaymakers

Steve Raaymakers studied marine biology and natural resource management at James Cook University, Australia in the1980s. Over the last 14 years he has worked in integrated coastal and oceans management and in the development and implementation of local, national, regional and global programs to manage human use of coastal and marine resources, with a special focus on shipping and port activities and marine pollution.

He has worked with the Great Barrier Reef tourism industry, the Great Barrier Reef Marine Park Authority and the Queensland Ports Corporation in Australia, with the South Pacific Regional Environment Programme in the Pacific Islands region an as an independent consultant in Australia, New Zealand and Europe. He is currently Chief Technical Adviser in the Marine Environment Division at the International Maritime Organization in London, responsible for the GEF/UNDP/IMO Global Ballast Water Management Programme.

Dr. Russell Rader

Russell Rader is an evolutionary ecologist interested in understanding the processes that produce patterns at the community level. He studies freshwater communities (invertebrates and fish), particularly streams and wetlands. He received a Bachelors of Science degree in Zoology from Brigham Young University (BYU) in 1977, a Masters degree in freshwater ecology from BYU in 1982, and a PhD in freshwater ecology from Colorado State University in 1987. Since 2000 he has been an associate professor in the Department of Integrative Biology at BYU. Prior to his current appointment, he filled a post-doctoral position at the Savannah River Ecology Laboratory (University of Georgia) where he worked on blackwater streams of the southeastern United States, a non-tenure track faculty position with Duke University where he worked in the Everglades, and he was a research scientists with the US Forest Service where he worked on invertebrate-trout interactions in Rocky Mountain streams, and processes that determine community structure in Rocky Mountain fens. Russell has been interested in invasive species since 1989 after becoming aware of the detrimental impact they had on the Everglades ecosystem.

Dr. David Raikow

David Raikow is a Research Aquatic Biologist at the National Oceanic and Atmospheric Administration (NOAA) Great Lakes Environmental Research Laboratory (GLERL) in Ann Arbor, Michigan USA. He studies the prevention, control, and impacts of biological invasions as part of the NOAA National Center for Research on Aquatic Invasive Species (NCRAIS). He earned his PhD from Michigan State University in 2002 by studying the impacts of the zebra mussel on food webs, nutrient cycling, and phytoplankton community structure in Michigan’s inland lakes. He also examines stream ecology and stable isotopes.

Debbie Reusser

Debbie Reusser has worked for the Geography Discipline of the US Geological Survey since 1991. She is the senior technology researcher for The National Atlas of the United States™. Her research focus is the development of a Pacific Coast database of native and nonindigenous estuarine species and the application of this information system to model current as well as potential future species distributions.

Dr. David F. Reid

David Reid received a PhD in chemical oceanography from Texas A&M University in 1979. He was a research oceanographer for 15 years and in 1985 became Assistant to the Director of the National Oceanic and Atmospheric Administration’s (NOAA) Great Lakes Environmental Research Laboratory (GLERL). In 2000 he moved back into full-time research and is presently lead investigator for several projects related to nonindigenous species and the ballast tank vector. He also serves as Director of the recently established NOAA National Center for Research on Aquatic Invasive Species, is Task Leader for the Aquatic Invasive Species Research Program at GLERL, and serves on the NOAA Invasive Species Program Management Team.

Dr. Anthony Ricciardi

Anthony Ricciardi is a professor of environmental science at McGill University (http://www.redpath-staff.mcgill.ca/ricciardi/). For the past 14 years, his research has examined the impacts of biological invasions on freshwater fauna.

Georges H. Robichon

Georges Robichon, BA, LLB, LLM, joined Fednav Limited, a major Canadian shipowner/operator, in 1984 and is currently Senior Vice-President and General Counsel and a member of Fednav's Board of Directors.

Since February, 2000, Mr. Robichon has been actively involved in the ANS/ballast water issue in the Great Lakes, including facilitating the adoption into law of ballast water legislation in the State of Michigan and the testing of two prototype ballast water treatment systems on a Fednav bulk carrier in 2001. Mr. Robichon was a member of the Canadian delegation to the IMO Conference in February, 2004, that adopted the *International Convention for the Control and Management of Ships' Ballast Water and Sediments.*

Maria Edith Rolla

Maria Rolla is a biologist who graduated in 1974 from the Brazilian public university (UFMG) in Belo Horizonte, Minas Gerais, Brazil. She made a one-year post-graduation course in IHE, Delft, Netherlands in 1985-1986.

From 1977-1989 she worked in an institute of research on limnology. Since 1989 she has worked in a hydro-electric company and has been working with reservoirs for the past 23 years, on water quality monitoring, which included the study of organism indicators. Since 2000, the industry has been suffering with invasive organisms and her main concern is on those issues.

Maria has also worked for 5 years as a teacher at the university, and has published 42 documents and 14 scientific works as well as attending many conferences discussing these subjects.

Dr. Robert Rosell

Robert Rosell is a freshwater fisheries scientist specializing in fish/environment interactions. Following a BSc and PhD in Marine Biology at Liverpool University he joined the Department of Agriculture for Northern Ireland as a marine biologist in 1986. He has specialized in freshwater since 1990. Since then he has been engaged in research and providing advice on freshwater fisheries and related environmental issues. Current research areas include restoration of a formerly extinct salmon population, ecological changes in lake fish populations in lakes affected by eutrophication and introduction of non-native species, and the commercial eel fishery of Lough Neagh.

Matthias Rothe

Matthias Rothe studied chemistry at the University of Heidelberg. He has 9 years experience as a Technical Manager in a company for water treatment in swimming pools. He completed two years work experience as a Technical Consultant for ProMinent in Heidelberg. Since 2002 he has been the Product Manager for Disinfection- and Oxidation-Systems for ProMinent in 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 electrolyses and membrane technology. More than 1500 employees in almost 100 countries deliver worldwide fast and reliable components and complete solutions.

Dave Rowe

Dave Rowe has 25 years experience with freshwater fish in New Zealand and is currently the group manager of the freshwater fisheries team in the North Island of New Zealand. His research on invasive species has involved impact assessment for introduced fish such as trout, rudd, tench, perch and gambusia in lakes. In 1980, he restored a small lake by using grass carp (to first remove exotic weed species) and then rotenone (to eliminate rudd and tench). Recent work has involved trials of piscicide impregnated pellets to reduce pest fish abundance.

Elena Ryan

Ms. Ryan earned her BA in Economics in 1996 from Reed College. She received a Masters in Public Policy, with an emphasis on transportation, from George Mason University in 2004. She worked for almost 4 years as a senior economist with the US Coast Guard and conducted cost-benefit analysis for US regulations addressing marine safety, security, and environmental protection. She has accepted a position with the US Department of Homeland Security, where she will work with members of the private sector to explore more cost-effective methods to achieve security against a host of threats.

Jean-Claude Sainlos

Jean-Claude Sainlos has a legal background in International Law, Law of the Sea, Maritime Law and Environmental Law. In January 2004 he was appointed Director for the Marine Environment Division of the International Maritime Organizations. Some of his past duties included Senior Deputy Director – Sub-Division for Pollution Response, and Technical Co-operation Coordinator for the Marine Environment Division of IMO.

Íñigo Sánchez

Íñigo Sánchez's research is focused on experimental ecology of seaweeds in intertidal communities on northern Spain. He works on the invasive seaweed *Sargassum muticum* as a model system to check some controversial aspects on invasion ecology, like how some communities resist invasion.

He is also deeply interested on the effects of *S. muticum* on intertidal macroalgal assemblages and which mechanisms are involved in these interactions.

Dr. Dario Savini

Dario Savini graduated in Biology from the University of Pavia, Italy in 1997. In 1999 he obtained his MSc in Marine Environmental Protection at the School of Ocean Sciences at the University of Wales-Bangor. In 2000-2003 he obtained his PhD at the Laboratory of Ecology, Department of Genetics and Microbiology at the University of Pavia, studying the ecology of the invasive Asian Purple Shell *Rapana venosa* in the Northern Adriatic Sea. At the moment he is a Post Doctoral fellow at the University of Pavia. His research interests fall broadly within the fields of benthic ecology and marine alien species biology.

Dr. Raymond B. Schaefer

Raymond Schaefer is President of Phoenix Science & Technology, Inc. (PS&T), which he founded in 1994. PS&T is a research and development company specializing in innovative light and sound sources for various environmental applications including zebra mussel control and water treatment.

He has expertise in a broad range of technology areas, including incoherent light sources, impulsive acoustic sources, and the interaction of light and sound with materials and systems.

He received his PhD and MA in Physics from Boston University, and BA in Physics from Cornell University.

Andreas Schmidt

Andreas Schmidt started his basic studies of biology at the Johannes-Gutenberg-University in Mainz, Germany in 1995. In 1997 he changed to the Carl-v.-Ossietzky- University Oldenburg for his main studies. His emphases are on marine ecology, zoology and microbiology. In 2003 he finished his studies with the diploma thesis "Mechanisms of Cold Acclimatisation on Boreal Fish: Investigations on Gene Expression from Mitochondrial Enzymes" as part of the working group of Prof. Dr. H.-O. Pörtner at the Alfred-Wegener-Institut, Bremerhaven.

Since March 2003 Andreas has been working on his doctors thesis on the bioinvasion of the pacific oyster into the East Frisian Wadden Sea as a project collaborator.

Dennis L. Schornack

Dennis Schornack was appointed to Chair the US Section of the International Joint Commission by President George W. Bush and was confirmed by the US Senate. During his tenure at the IJC, he has focused on the problem of aquatic invasive species and has testified on the subject before both the US Congress and the Canadian Parliament.

Mr. Schornack's leadership of the IJC caps a 25-year career at the top levels of state government, including 11 years in senior positions for Michigan Governor John Engler. Most notably, he co-led the development of Annex 2001, an agreement among the eight Great Lakes states and two Canadian provinces to manage Great Lakes water uses and diversions.

Mr. Schornack earned BA, BS and MA degrees from Michigan State University as well as an MA in public health from the University of Michigan.

Dr. Judy F. Shearer

Judy Shearer received a PhD in Botany (major Mycology) from Iowa State University, Ames, Iowa in 1988. She is presently employed as a research plant pathologist for the US Army Corps of Engineers Research and Development Center, Waterways Experiment Station (ERDC-WES), Vicksburg, Mississippi. Her research interests include biological control of aquatic weeds using plant pathogens, integrated aquatic plant management, and endophytic fungi of aquatic macrophytes. Current research emphasis is on the development of a bioherbicide for management of hydrilla as a cooperative project with the United States Department of Agriculture/National Center for Agriculture Utilization Research (USDA/NCAUR) and a private company, SePRO Inc.

Greg Sherley

Dr. Greg Sherley is a New Zealander and has worked for various Government Departments responsible for land management over his career. Most of the time he has been a research scientist working on conservation issues (for the New Zealand Department of Conservation, DOC) including the conservation of threatened terrestrial species (birds, herpetofauna and invertebrates) and the control of the invasive alien species, which threaten these species. Otherwise he has worked for inter-governmental organizations including the South Pacific Regional Environment Programme (SPREP based in Apia, Samoa) establishing an invasive species programme in the Pacific and most recently leading the Global Invasive Species Programme during its establishment in Cape Town, South Africa. Now back in New Zealand working for the Department of Conservation as one of their Principal Scientists, Greg is still spending about a quarter of his time advising and assisting the SPREP, Invasive Species Specialist Group (IUCN) and GISP IAS programmes.

Dr. Tamara Shiganova

Tamara Shiganova completed her MSc in 1970 at the Technical Institute for Fisheries in the Department of Ichthyology. In 1976 she completed her PhD in Biology at the Institute of Oceanology in Moscow. Currently Tamara is a Senior Scientist with the Laboratory of pelagic ecosystem. She is the functioning leader of research group in the P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences. Her research interests consist of aquatic invaders, impact of gelatinous invaders on the pelagic ecosystem, including trophic zooplankton, fish, their eggs and larvae, and fishery.

Sarah Simpson

Sarah Simpson earned her BS degree in Biology from Berry College in Mount Berry, Georgia. As a student at Berry, she spent a semester studying at the University of Limerick, Ireland, where she developed an interest in biotic aspects of the Shannon River while working with Dr. Bruce Conn on parasites of zebra mussels. She currently works in the United States as an Environmental Health Specialist for the Department of Health of the State of Georgia.

Dr. Michael Slimak

Michael Slimak is the Associate Director for Ecology in the National Center for Environmental Assessment of the US Environmental Protection Agency where he is responsible for research programs in ecological risk, global change, and invasive species. He began his EPA career in 1978 and has been involved with invasive species for over 15 years and currently represents EPA on the National Invasive Species Council.

Michael is a recognized authority on ecological risk assessments, has authored numerous government-sponsored reports, has published in peer-reviewed journals, and has received numerous awards for distinctive service. He holds a PhD in Environmental Science.

Dr. Jennifer Smith

Jennifer Smith recently completed her doctorate from the University of Hawaii in Botany, Ecology, Evolution and Conservation Biology. Much of her dissertation work focused on the impacts of invasive macroalgae on coral reefs. Most recently she has shown that several species of macroalgae that are cultivated for aquaculture throughout the tropics can have significant negative impacts on coral cover and diversity. Jennifer currently holds a faculty position at the University of Hawaii where she is continuing research from her PhD. She has been recognized both nationally and internationally for her studies on invasive marine species on tropical reefs.

A. Garry Smythe

Garry Smythe is a Senior Scientist and Project Manager at Stantec Consulting Services in Buffalo, New York.

Garry received a Bachelors degree in Biology, and a Masters degree in Natural Science and Mathematics from the State University of New York at Buffalo. For over 25 years he has conducted environmental studies related to Fish, Plankton Benthos and Water Quality. He has studied several Aquatic Invasive Species related to:

- Industrial and Municipal Facility-Fouling Risk Assessments;
- Control Technology R&D;
- Physiology Studies; and
- Monitoring Program Design and Evaluation.

Fred L. Snyder

Fred Snyder is an associate professor with Ohio State University Extension. He has served as a Sea Grant extension specialist on western Lake Erie since 1978 and is an extension program leader with Ohio Sea Grant. His marine advisory efforts have focused on fishing industry development, exotic species in the Great Lakes, water quality improvement, tourism and coastal business development. He currently is working with lake levels issues, watershed protection and exotic species movement.

Dr. Salius Stakenas

Salius Stakenas has 10 years experience in the environmental biology of freshwater fishes. Salius was awarded an MSc in Biology in 1995, elected as the young scientists representative on the Institute of Ecology Scientific Council (Vilnius) in 1999, and awarded a PhD in (Fish) Ecology and Environmental Sciences in 2002 on the species–habitat relationships of 0+ fishes in Lithuania rivers. Salius is currently undertaking an EC Marie Curie post-doctoral fellowship with Dr. Gordon H. Copp at CEFAS-Lowestoft (UK) on the behaviour and movements of non-native freshwater fishes (pumpkinseed *Lepomis gibbosus*, pikeperch *Sander lucioperca*, Wels catfish *Silurus glanis*).

Dr. Michael Stevenson

Michael M. Stevenson earned BS, MA and PhD degrees in zoology at three institutions. His current position is at the University of New Orleans as Associate Professor of Biological Sciences and Associate Dean of the College of Sciences, having been here for 28 years. His research has been primarily with pupfishes dealing with their systematics, behavior, and ecology in isolated or extreme environments. Being mostly desert-type fish in restricted habitats, exotic introductions have been noted and analyzed with the occurrence of hybridization and competition negatively affecting the indigenous populations. Michael was appointed as the replacement representative for the previous chancellor of UNO to the Louisiana Aquatic Invasive Species Task Force, meeting over the past two years. The information he received there was the bases for this report.

Dr. Daniel R. Sutherland

Daniel Sutherland has a PhD in fish parasitology from Iowa State University; postdoctoral training in fish parasite ecology at the University of Wisconsin-Madison; 30 years of research experience dealing with parasites of aquatic vertebrates in large rivers (Mississippi and Missouri rivers in North America and Essequibo River in South America) and large lakes (Lacustrine Great Lakes) systems; other exotic species research projects have dealt with *Myxobolus cerebralis* (salmonid whirling disease) and *Bothriocephalus acheilognathi* (Asian tapeworm).

Kristin TePas

Kristin TePas is employed by Illinois Natural History Survey and Illinois-Indiana Sea Grant. She works out of the Lake Michigan Biological Station in Zion, Illinois. Kristin has been assisting with the implementation of the Illinois ANS Management Plan since 2001 as the Assistant ANS Coordinator. She started in this position after graduating from Duke University where she received a Masters in Environmental Management.

Pamela Thibodeaux

Pamela Thibodeaux has worked for the US Fish and Wildlife Service for the past eight years. From 1996 to 2002, she worked in the Service's International Affairs Program on a variety of issues, including invasive species. Since then she has worked for the Service's Fisheries and Habitat Conservation Program on aquatic invasive species issues. She holds a BS in Botany from Miami University, Oxford, Ohio and an MS in Wildlife Management from Louisiana State University.

Dr. Donna Turgeon

Donna Turgeon is a Marine Ecologist with the National Ocean and Atmospheric Administration's (NOAA), National Ocean Service (NOS). She has many titles — professor, consultant, federal scientist and manager, fisheries regulations chief, NOAA working diver, artist, and grandmother. For NOS, she managed programs and led multi-agency teams that have monitored and assessed toxic contaminants, harmful algal blooms (red tides, shellfish poisoning), South Florida marine ecosystem's response to 'replumbing' the Everglades, coral reefs, and alien species. For 25 years, she has chaired an American Fisheries Society Standing Committee that publishes volumes on the names of aquatic invertebrates of the USA and Canada.

Dr. Gerard van der Velde

Gerard van der Velde studied biology and geology at the University of Leiden, The Netherlands after military service. He received his doctor's title in Aquatic Ecology at the University of Nijmegen in 1980. Hhe is currently associate professor at the same university. He is author or coauthor of more than 200 papers published in international journals. His first paper on invasions was in 1975. He was in the editorial board of the journal Aquatic Botany and is on the boards of Biological Invasions, Aquatic Ecology, Crustaceana and Chemistry & Ecology. Subjects of research were aquatic macrophytes, macroinvertebrates and fish, especially in rivers, estuaries and coastal environments. He was involved in projects all over the world including Kenya, Tanzania, India, Indonesia, Caribbean, and The Netherlands.

Mariëlle van Riel

Mariëlle studied Biology at the University of Nijmegen, The Netherlands specializing in aquatic ecology and animal ecology. She is currently a PhD student at the same university, working in the Department of Animal Ecology and Ecophysiology.

Dr. Emma Verling

Emma Verling completed her BSc degree in Zoology in the Department of Zoology, Ecology and Plant Science, University College Cork, Ireland in 1999. After a brief stint as a curatorial assistant at Oxford University Museum, she began a PhD in Marine Ecology, also at University College Cork. The main theme of her research was *echinoderm* behavioural plasticity and population dynamics. Since she completed my dissertation in January 2003, she has been working as a Post Doctoral Researcher in the Marine Invasions Research Laboratory at The Smithsonian Environmental Research Center.

Hugo Verreycken

Hugo Verreycken studied Biology at the University of Louvain, Belgium. He graduated in 1986 and started research on ecology of freshwater fishes in the Laboratory of Ecology and Aquaculture. In 1992 he became a fisheries biologist at the Institute for Forestry and Game Management where he was responsible for the Aquaculture Division from 1992 to 2000. Research was carried out on the optimization of the culture of indigenous fish for reintroduction and stocking purposes. Currently Hugo is responsible for the ‘fish and fisheries’ database management. These databases, which include data on nonindigenous species, will be made available through the Internet from 2005 onwards.

Stephan Verosto

Stephan has a BS in Mechanical Engineering from Pennsylvania State University; (1991) and a MEng Environmental Engineering (1997) from the University of Maryland. He is currently a Senior Engineer and the Ballast Water Program Manager at the Naval Surface Warfare Center – Carderock Division (NSWCCD) in West Bethesda, Maryland. Mr. Verosto’s field of expertise includes research, development, and test and evaluation of Navy shipboard environmental systems and equipment. Mr. Verosto has also had extensive in-service ship systems engineering experience with Navy combat support systems including low and high pressure air, seawater and freshwater cooling, 400 Hz power generation, and integrated logistics. His experiences have provided the opportunity to work onboard nearly 75% of the USNavy Fleet with a cumulative at-sea time of greater than one-year.

Annick Verween

Annick Verween studied biology at the University of Ghent, Belgium and graduated in 1999. Because she felt that her practical knowledge was still unsatisfied, she received a masters degree of Science in Environmental Technologies in 2001 and a Teaching degree in 2003. Since 2001 she has worked at the Marine Biology Department of the University of Ghent (http://www.marinebiology.ugent.be) and conducted her PhD-research entitled “Ecology of Fouling-organisms: A Detailed Study on *Mytilopsis leucophaeata* (Bivalvia, Dreissenidae)”. Since her research is linked with the industry, she also cooperates with BASF, Belgium and Ondeo-Nalco, Europe.

Dr. Barnaby Watten

Barnaby Watten is Chief of the Restoration Technologies Branch of the USGS Leetown Science Center, Kearneysville, West Virginia. He has worked for the Center for 17 years conducting research in gas transfer, mitigation of acid mine drainage, hydropower technologies and control of invasive species primarily in support of the US Fish and Wildlife Service, Office of Surface Mining and National Park Service. He holds a Bachelors degree in Aquatic Biology, a Masters degree in Agricultural Engineering and a PhD in Fisheries and Allied Aquacultures. He is a past President of the American Fisheries Society's Bioengineering Section and is a past President of the Aquacultural Engineering Society.

Dr. Robert Wilkes

Robert Wilkes became interested in marine algae while studying for his degree at National University of Ireland, Galway. Following this he worked in the US at the University of Connecticut on the commercial exploitation of seaweeds. He returned to NUI, Galway to begin a PhD in molecular phylogenetics of a variety of marine algae. After completing his doctorate he joined the Irish Seaweed Centre, working on a number of projects including monitoring the impacts of commercial seaweed farming, assessing the effects of 'green-tides' in Ireland and looking at the role of seaweeds as potential biofilters.

Everett F. Wilson

Everett Wilson completed a BSc from Oregon State University in 1971, with a Major in Fisheries. He continued with a MSc from the same university in 1973 with a Major in Toxicology and a Minor in Civil Engineering. Everett has worked for over 25 years in the area of aquatic toxicology and resource protection. This work has included research on the impact of pesticides on the ecology of aquatic mesocosms, and the impact of metals on estuarine and marine ecosystems. He has extensive experience on the impact of oil on marine ecosystems and the impact of cleanup of oil and other contaminants on aquatic and terrestrial ecosystems. His current position offers the opportunity to apply what he has learned to the area of aquatic invasive species and to gain additional knowledge through this work.

John Wimbush

John Wimbush was educated at Nottingham University and later received his Bachelor's degree from Rensselaer Polytechnic Institute in Communication, focusing on environmental writing. While he was Assistant Director of the Environmental Science Program at RPI, he taught their First Year Environmental Seminar. Since 1998 he has been Program Assistant at the Darrin Fresh Water Institute – RPI's field station on Lake George, New York, where he has concentrated on zebra mussel research, control and management issues, as well as education and outreach.

Dennis Wright

Dennis Wright completed his MSc in Aquatic Science from the University of Guelph in 1976. He has been working for the Department of Fisheries and Oceans since 1975. Currently he works in the Environmental Science Section as the Coordinator for Environmental Affairs. His major responsibilities include serving as the area coordinator for Aquatic Invasive Species issues for the Central and Arctic Region of the Department of Fisheries and Oceans, providing Secretariat services to the Canadian Council of Fisheries and Aquaculture Ministers Aquatic Invasive Species Task Group. The Task Group is in the midst of developing and implementing a "National Action Plan to Address the Threat of Aquatic Invasive Species." Dennis also serves as Senior DFO member to a number of multi-disciplinary committees and working groups composed of Canadian and United States agencies to review the impacts to Canadian fish and fish habitat on all aspects of the completion of a major water diversion project, the Garrison Diversion, in North Dakota and all of its associated sub-projects including the proposed diversion of Devils Lake.

Alicia M. Zoeller

Alicia M. Zoeller is currently employed as the Conservation Director for the City of Holyoke, Massachusetts. Her responsibilities include administration of wetlands protection laws and management of natural resources. Prior to re-locating to Western Mass., Ms. Zoeller was employed by the Commonwealth of Massachusetts as an aquatic biologist specializing in the shellfish industry and taught SCUBA diving along the New England coast. She holds a Bachelor of Science in Marine Biology from Salem State College, a Juris Doctorate from Western New England College School of Law and is admitted to the Massachusetts Bar. Ms. Zoeller is active in land protection, neighborhood revitalization and historic preservation in Western Massachusetts.

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Great Lakes Fishery Commission

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US Fish and Wildlife Service

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