8th International Conference on

Marine Bioinvasions

Abstract Book

August 20-22, Vancouver, Canada

Program and Abstracts for the 8th International Conference on Marine Bioinvasions (20-22 August 2013, Vancouver, Canada)

Cover photography & design: Kimberley Seaward, NIWA

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8th International Conference on Marine Bioinvasions

Dear Conference Participant

On behalf of the Scientific Steering Committee (SSC) and our sponsors, we would like to welcome you to Vancouver for the 8th International Conference on Marine Bioinvasions. Vancouver is a culturally diverse metropolitan city serving as the western gateway to Canada. We hope you will spend some time to explore all this city has to offer.

We are grateful for all of the efforts of the SSC and the local organizing committee as well as for the generous support of our sponsors: the Biodiversity Research Centre at the University of British Columbia for hosting the event; the Canadian Aquatic Invasive Species Network (CAISN), for providing additional funding by sponsoring one of the plenary presentations; The North Pacific Marine Science Organization (PICES), for providing travel awards to early career scientists; and the National Oceanographic and Atmospheric Administration (NOAA), for donating additional funds. Above all else, we are grateful for your participation and willingness to discuss your ideas, latest research results, and vision. Among the papers, posters, and plenary presentations that comprise the conference, we hope you will find many opportunities for discussion and new collaborations. Finally, we hope this summation of the state of the field will provide solutions to the problem of marine invasive species as well as generate new research directions.

Once again, welcome to the 8th International Conference on Marine Bioinvasions, and we look forward to a thought-provoking and rewarding experience!

Conference Co-Chairs:
Thomas Therriault
Fisheries and Oceans, Canada
Lisa Drake
Naval Research Laboratory, USA

Head of the Local Organizing Committee:
Cathryn Clarke Murray
WWF, Canada

Biological Invasions in Changing Waters: Envelopes, Estuaries, and Evolution

Eighth International Conference on Marine Bioinvasions

August 20-22nd, 2013

University of British Columbia, Vancouver, Canada

Abstract Book

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Sponsors and Contributing Organizations

The Scientific Steering Committee for the 8th International Conference on Marine Bioinvasions gratefully acknowledges the support of the following sponsors and contributing organizations:

Biodiversity Research Centre at the University of British Columbia

The North Pacific Marine Science Organization (PICES)

The Canadian Aquatic Invasive Species Network (CAISN)

The National Oceanographic and Atmospheric Administration (NOAA)

Scientific Steering Committee

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Jeff Crooks, Tijuana River National Estuarine Research Reserve, USA

Lisa Drake, Naval Research Laboratory, USA (meeting co-chair)

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Gemma Quilez-Badia, World Wide Fund for Nature (WWF) Mediterranean Programme Office, Spain

Gil Rilov, National Institute of Oceanography - Israel Oceanographic and Limnological Research

Thomas Therriault, Fisheries and Oceans Canada (meeting co-chair)

Chela Zabin, Smithsonian Institution and University of California-Davis, USA

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Judith Pederson, Massachusetts Institute of Technology Sea Grant Program, USA

Local Organizing Committee Members:

Cathryn Clarke Murray, WWF Canada

Christopher Harley, Department of Zoology, University of British Columbia, Canada

Thomas Therriault, Fisheries & Oceans Canada (meeting co-chair)

Programme

Day 1: Tuesday, 20 August 2013

8:00 to 8:45	Registration				
8:45 to 9:00	Welcome, Introductions and Announcements				
9:00 to 9:45	**Plenary**	**EMMA JOHNSTON**			
	Session 1:	**Management of Invaders**		**Session 2:**	**Factors Affecting Invasion Success**
		Chair: Andrea Locke			**Chair: Whitman Miller**
10:00 to 10:20	Andrea Locke	Developing a strategic plan for rapid response to Aquatic Invasive Species in the Gulf Region of Fisheries and Oceans Canada	**10:00 to 10:20**	Kedong Yin	Invasion of phytoplankton species in Pearl River estuarine and coastal waters, China
10:20 to 10:40	Jennie Brunton	Joint-agency response to *Undaria pinnatifida* in Fiordland, New Zealand	**10:20 to 10:40**	Fabio Bulleri	The ecological impacts of exotic seaweeds: variation between trophic levels and across environmental conditions
10:40 to 11:00	David Drolet	User-friendly and evidence-based tool to predict the probability of eradication of aquatic non-indigenous species	**10:40 to 11:00**	Graeme F. Clark	Here comes the sun: imminent algal invasions at high latitudes
11:00 to 11:20	Graeme Inglis	Optimising surveillance for multiple marine pests using stochastic scenario tree models	**11:00 to 11:20**	Judith Pederson	Changing weather, changing climate, changing distributions: native and non-native species in New England
11:20 to 11:40	**Break**		**11:20 to 11:40**		
	Session 1:	**Management of Invaders**		**Session 2:**	**Factors Affecting Invasion Success**
		Chair: Andrea Locke			**Chair: Whitman Miller**
11:40 to 12:00	Marnie Campbell	Biosecurity and food security: wicked problems that exacerbate each other?	**11:40 to 12:00**	Pamela Ward	Defining environmental cues of the red alga *Prionitis* that induce larval settlement of the invasive bryozoan *Watersipora* spp.
12:00 to 12:20	Kimberley Seaward	Marine Biosecurity Porthole: over 10 years of marine biosecurity data on the web	**12:00 to 12:20**	Haizea Jimenez	Quantifying the role of non-native species in soft-sediment community structure of San Francisco Bay, California

Day 1: Tuesday, 20 August 2013					
12:20 to 12:40	Brendan Gould	To look or not to look, is that the question? Marine biosecurity challenges in New Zealand.	**12:20 to 12:40**	Linsey E. Haram	The transformation of Southeastern salt marshes by the invasive seaweed, *Gracilaria vermiculophylla*
12:40 to 1:00	Matthew Smith	Emergency surveillance for marine pests following grounding of the container vessel, *Rena*	**12:40 to 1:00**	Sofietje E. Voerman	Biodiversity responses associated with the potential spread of a native macroalgae in Eastern Australia
1:00 to 2:00	**Lunch**		**1:00 to 2:00**		
	Session 1:	**Management of Invaders**		**Session 2:**	**Factors Affecting Invasion Success**
		Chair: Jeff Crooks			**Chair: Jeb Byers**
2:00 to 2:20	Cynthia H McKenzie	Investigating ecosystem impact and evaluating trial mitigation methods for the control of *Ciona intestinalis*, a recently detected invasive solitary tunicate in Newfoundland, Canada	**2:00 to 2:20**	Mark E. Torchin	Differential predation across two tropical oceans may reveal how biotic resistance shapes invasion patterns
2:20 to 2:40	Kate Rolheiser	Chemical treatments for controlling *Didemnum vexillum* in Pacific oyster aquaculture	**2:20 to 2:40**	Max C.N. Castorani	An invasive bivalve alters estuarine succession through habitat modification: the importance of density–impact relationships
2:40 to 3:00	Isla Fitridge	The impact and control of invasive species in Australian mussel culture	**2:40 to 3:00**	Norah Brown	The effects of ocean acidification on early succession in mesocosm-based fouling communities
3:00 to 3:20	Matthew Gubbins	*Mytilus trossulus*: Control and management of a nuisance species on Scottish shellfish farms	**3:00 to 3:20**	Brian S. Cheng	Divergent responses to multiple climate stressors in an invasive predator and native prey interaction
3:20 to 3:40	Javier Atalah	Development of augmentative biocontrol tools for managing pests on artificial and natural habitats	**3:20 to 3:40**	Kellan Korcheck	Population variation in temperature tolerance in a widely invasive bryozoan species complex (*Watersipora* spp.)
3:40 to 4:00	**Break**		**3:40 to 4:00**		
	Session 1:	**Management of Invaders**		**Session 2:**	**Factors Affecting Invasion Success**
		Chair: Jeff Crooks			**Chair: Jeb Byers**
4:00 to 4:20	April MH Blakeslee	Importation of baitworms and their live algal packing materials: Experimental treatment of algae to reduce live hitchhikers	**4:00 to 4:20**	Elisa K. Bone	How does a newly invasive ecosystem engineer affect macroinfaunal assemblages in a highly modified estuarine lagoon?

Day 1: Tuesday, 20 August 2013					
4:20 to 4:40	Lauren M. Fletcher	Scientific knowledge and the management of marine pests: lessons learned with the ascidian *Didemnum vexillum* in New Zealand	**4:20 to 4:40**	Scott Godwin	Establishment of marine alien species in a low diversity coral atoll
4:40 to 5:00	Edwin Grosholz	Resolving the conflict: eradication of invasive hybrid *Spartina* and the recovery of the California Clapper Rail	**4:40 to 5:00**	Christopher Harley	The positive effects of an intertidal ecosystem engineer are weaker in its invaded range
5:00 to 5:20	Leif-Matthias Herborg	British Columbia's *Spartina* eradication program – a long path to success?	**5:00 to 5:20**	Gil Rilov	Investigating invasive ecosystem engineers effects on species abundances, biodiversity and ecosystem functions
5:20 to 5:40	OPEN		**5:20 to 5:40**	João Canning Clode	Fouling marine invasions in offshore islands: a perspective from the Macaronesian region
6:00 to 8:00	**POSTER SESSION**		**6:00 to 8:00**	**POSTER SESSION**	

Day 2 - Wednesday, 21 August 2013

8:00 to 8:45	Registration				
8:45 to 9:00	Welcome, Introductions and Announcements				
9:00 to 9:45	**Plenary**	**JIM CARLTON**			
	Session 3:	**Invasion Vectors**		**Session 4:**	**Invasion Niche**
		Chair: Lisa Drake			**Chair: Jeff Crooks**
10:00 to 10:20	Stephan Gollasch	Comparison of ballast management options on a vessel with uptake in freshwater ballast water exchange in combination with and without a ballast water management system	**10:00 to 10:20**	Johanna Bradie	Niche determinants: searching for consistency in environmental predictors of species' distributions
10:20 to 10:40	Christine McLaughlin	Evaluating the efficacy of new U.S. ballast water regulations	**10:20 to 10:40**	Kristina Enciso	Incorporating biotic interactions into species distributions modelling
10:40 to 11:00	Kimberly Holzer	A tale of three coasts: spatial and temporal variation in ballast water management to reduce invasion risk	**10:40 to 11:00**	Paul Gribben	The value of intraspecific biogeographic comparisons in elucidating potential mechanisms underlying invasion success
11:00 to 11:20	Katharine J Carney	Coal crazy and Panamax-ready: global trade and the transport of marine organisms to Chesapeake Bay	**11:00 to 11:20**	Jennifer Loxton	Bryozoan forensics: the skeletal profile of a successful invader
11:20 to 11:40	**Break**		**11:20 to 11:40**	**Break**	
	Session 3:	**Invasion Vectors**		**Session 5:**	**Invasion Impacts**
		Chair: Lisa Drake			**Chair: Jeb Byers**
11:40 to 12:00	Chela Zabin	Managing multiple vectors in an increasingly connected world	**11:40 to 12:00**	Daniel J. Bradley	Effects of a potentially rapidly spreading native alga on large herbivores on temperate rocky reefs
12:00 to 12:20	Chad Hewitt	Facilitated dispersal: overwhelming biogeographic boundaries	**12:00 to 12:20**	Timothy M Davidson	Increased damage from a broadly introduced boring isopod at the northern edge of mangrove range
12:20 to 12:40	Kate Schimanski	The influence of vessel residency period and voyage pattern on the propagule pressure of a hull fouling species.	**12:20 to 12:40**	Jeff Wright	Mechanisms of facilitation by the habitat-forming invasive seaweed *Gracilaria vermiculophylla*

Day 2 - Wednesday, 21 August 2013

12:40 to 1:00	OPEN		**12:40 to 1:00**	OPEN	
1:00 to 2:00	**Lunch**		**1:00 to 2:00**	**Lunch**	
	Session 3:	**Invasion Vectors**		**Session 6:**	**Applying Molecular Tools**
		Chair: Graeme Inglis			**Chair: Whitman Miller**
2:00 to 2:20	Farrah Chan	Is hull fouling a potential vector for the introduction of nonindigenous species to the Canadian Arctic?	**2:00 to 2:20**	John A Darling	Biased introgression of mitochondrial genomes beyond an established range limit in a dynamic admixture zone
2:20 to 2:40	Kimberly Howland	A risk assessment model for ballast water exchange along major shipping routes in the Canadian Eastern Arctic	**2:20 to 2:40**	Cathryn Abbott	The future of molecular detection methods for invasive species: how do they work?
2:40 to 3:00	Stephan Gollasch	Risk assessment based exemptions from ballast water management - The Intra-Baltic study	**2:40 to 3:00**	Emily Angharad Brown	Early detection of aquatic invaders: Can next-generation sequencing accurately describe zooplankton communities?
3:00 to 3:20	Nathalie Simard	Discharge of ballast sediment residuals during deballasting procedures: A potential vector for the transfer of AIS?	**3:00 to 3:20**	Sharyn Goldstien	Assessing the value of population genetic data sets for the management of marine bioinvasions
3:20 to 3:40	Marie Garcia	Simulated transport conditions may select for stress-tolerant individuals in potentially invasive founder populations of *Mytilus*	**3:20 to 3:40**	Sarah Stewart-Clark	Rising water temperatures and calcareous tubeworm fouling on an oyster lease in Nova Scotia, Canada: How molecular biology can assist in developing mitigation strategies.
3:40 to 4:00	**Break**		**3:40 to 4:00**	**Break**	
	Session 3:	**Invasion Vectors**		**Session 7:**	**Fish Invasions**
		Chair: Graeme Inglis			**Chair: Chela Zabin**
4:00 to 4:20	Dianna K. Padilla	Marine invaders and bivalve aquaculture: sources, impacts and consequences	**4:00 to 4:20**	Denise Chin	Feeding ecology of the invasive lionfish (*Pterois volitans*) in Jamaica
4:20 to 4:40	Cathryn Clarke Murray	Pet or dinner? An evaluation of the live animal trade in British Columbia, Canada	**4:20 to 4:40**	Isabelle Cote	What doesn't kill you makes you scared? Effect of repeated culling on the behaviour of invasive lionfish

Day 2 - Wednesday, 21 August 2013					
4:40 to 5:00	Amy Fowler	Importation of baitworms and their live algal packing materials to the Mid-Atlantic: vector characterization	**4:40 to 5:00**	Leif-Matthias Herborg	The Burnaby snakehead – How we caught it and what we learned
5:00 to 5:20	Joshua Mackie	Assessment of antifouling paint (copper) tolerance across common fouling organisms	**5:00 to 5:20**	Adi Barash	The dusky shark in the Mediterranean: cryptic invaders from the Red Sea?
5:20 to 5:40	OPEN		**5:20 to 5:40**	OPEN	
6:00 to 8:00	**RECEPTION**		**6:00 to 8:00**	**RECEPTION**	

Day 3 - Thursday, 22 August 2013

8:00 to 8:45	Registration				
8:45 to 9:00	Welcome, Introductions and Announcements				
9:00 to 9:45	**Plenary**	**TOM THERRIAULT**			
	Session 8:	**Tunicate Invasions**		**Session 9:**	**Crab Invasions**
		Gil Rilov			**Chela Zabin**
10:00 to 10:20	Mey-Tal Gewing	Same ascidian, different substrate: early stages of establishment in natural environments of the non-indigenous ascidian *Herdmania momus*	**10:00 to 10:20**	Brett Howard	Assessing the global impact of marine invasive crabs: a meta-analysis
10:20 to 10:40	Gretchen Lambert	Evidence of ascidian community homogenization in less than 10 years	**10:20 to 10:40**	Catherine E. de Rivera	Interactive effects of temperature and predation on behavior and risk for an invasive crab
10:40 to 11:00	Ladd Johnson	"Hotspots" and "notspots": the evolution of early recruitment patterns in the invasive ascidian *Ciona intestinalis* and implications for early detection	**10:40 to 11:00**	Moana Gothland	Assessing the ecological characteristics and the demographic strategies of two alien crabs of the *Hemigrapsus* genus: experimental and in situ observations
11:00 to 11:20	Kirsty Smith	Evolution of the invasive species *Didemnum vexillum*	**11:00 to 11:20**	Carolyn Tepolt	Next-generation invasion: linking physiological and transcriptomic adaptation in the European green crab, *Carcinus maenas*
11:20 to 11:40	**Break**		**11:20 to 11:40**	**Break**	
	Session 8:	**Tunicate Invasions**		**Session 9:**	**Crab Invasions**
		Gil Rilov			**Chela Zabin**
11:40 to 12:00	Don Deibel	Post-larval recruitment in the non-indigenous ascidian *Botryllus schlosseri*: seasonal, vertical and substrate selection patterns	**11:40 to 12:00**	Clifford Garside	Spatio-temporal patterns of variation in the abundance of the European shore crab, *Carcinus maenas* in estuaries of New South Wales, Australia

Day 3 - Thursday, 22 August 2013					
12:00 to 12:20	Jocelyn C. Nelson	Climate change and species invasion: using existing temperature and salinity gradients to project future botryllid tunicate abundance in British Columbia	**12:00 to 12:20**	Kyle Matheson	Impacts of European green crab (*Carcinus maenas*) invasion on eelgrass habitat and associated fish abundance and biodiversity in Placentia Bay, Newfoundland
12:20 to 12:40	Elizabeth A. Sheets	Global population structure of the widely introduced tropical ascidian *Botrylloides nigrum*	**12:20 to 12:40**	Amanda Lynn Kelley	Thermal physiology of the invasive *Carcinus maenas*: implications for range expansion
12:40 to 1:40	**Lunch**		**12:40 to 1:40**	**Lunch**	
	Session 8:			**Session 9:**	
		Tom Therriault			**Lisa Drake**
1:40 to 2:00	Darragh Clancy	Fusion and genetic diversity of a colonial ascidian in Southeast Alaska	**1:40 to 2:00**	Sylvia Behrens Yamada	The arrival and currents status of the European green crab in the Pacific Northwest
2:00 to 2:20	Ashleigh Marie Watts	A characterisation of biofouling patterns and genetic connectivity in Pelorus Sound, New Zealand.	**2:00 to 2:20**	Elizabeth H. Wells	Flight, burial, and armor: two invasive snails exhibit different antipredator responses to the European green crab *Carcinus maenas*
2:20 to 2:40	Sarah Stewart-Clark	New suite of invasive tunicate species detection assays increases monitoring capacity on the Atlantic Coast of Canada.	**2:20 to 2:40**	L. David Smith	Induced defensive responses by snails are sensitive to variation in abundance of an invasive crab predator
2:40 to 3:00	OPEN		**2:40 to 3:00**	Brian C. Turner	Overcompensation and the European green crab
3:00 to 3:15	**CLOSING REMARKS**		**3:00 to 3:15**	**CLOSING REMARKS**	

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The future of molecular detection methods for invasive species: how do they work?

Oral presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems Session 6: Applying Molecular Tools Time: 2:20 21/08/2013

authors:

Cathryn Abbott[1], Melania E. Cristescu[2], Rob Young[3] and Sarah J. Adamowicz[3]

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[2]Department of Biology, McGill University, 1205 Docteur Penfield, Stewart Biology Building N6/1, Montreal, QC, H3A 1B1, Canada
[3]Biodiversity Institute of Ontario, University of Guelph, 50 Stone Road East, Guelph, ON, N1G 2W1, Canada

abstract:

Next generation sequencing technologies offer great promise for the early detection of invasive species. By generating comprehensive sequence data directly from complex environment samples, they can be used for the simultaneous detection of hundreds of possible invaders in the same run in a cost-effective way. However, the usefulness of this approach is a function of the availability of validated DNA barcoding datasets, such that sequences from environmental samples can be confidently 'matched-up' with a reference sequence. Setting up these initial DNA barcoding databases requires a significant initial investment of time and resources, with essential quality control requirements that must be met to avoid false-positives or false-negatives once the data are being used to aid early detection. Two large Canadian research projects currently include work towards enabling the use of DNA barcoding and next generation sequencing for early detection of aquatic invasive species. These are the Government of Canada's Genomics Research and Development Initiative project on quarantine and invasive species and the Canadian Aquatic Invasive Species Network II. In this talk I will introduce this new work, explain the methods to non-geneticists, and will briefly review the current state of the art.

Development of augmentative biocontrol tools for managing pests on artificial and natural habitats.

Oral presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems Session 1: Management of Invaders Time: 3:20 20/08/2013

authors:

Javier Atalah[1], Grant Hopkins[1] and Barrie Forrest[1]

Contact: Javier Atalah javier.atalah@cawthron.org.nz

[1]Cawthron Institute, Private Bag 2, Nelson 7010, New Zealand.

abstract:

Augmentative biocontrol, through the enhancement of native natural enemies, is a frequent practice in terrestrial and freshwater systems, however there is a lack of research investigating the feasibility of marine biocontrol. Here we present an overview of ongoing research to develop biocontrol tools for the management of marine pests, both in artificial and natural habitats of New Zealand. Initially, a theoretical framework was developed for the selection of biocontrol agents based on a range of traits that an ideal agent should satisfy before application. Seven invertebrate species were screened as potential biocontrol agents for biofouling on floating artificial structures. Predators, grazers and space pre-emptors were applied both to fouled and defouled surfaces, to evaluate response and prevention management strategies, respectively. We also present the results of a case study investigating non-target effects associated with use of the sea urchin, *Evechinus chloroticus*, as an augmentative biocontrol agent to eradicate the invasive Asian kelp *Undaria pinnatifida* in an area of high conservation value, namely Fiordland. Collectively, our research indicates that augmentative biocontrol using natural enemies could be an effective and environmentally sound method to mitigate effects of biofouling and the spread of non-indigenous species in marine habitats.

The dusky shark in the Mediterranean: cryptic invaders from the Red Sea?

Oral presentation
Symposium Theme: Evaluating the success of invaders in transitionary waters such as estuaries and waters that are changing as a result of anthropogenic activities
Session 7: Fish Invasions Time: 5:00 21/08/2013

authors:

Adi Barash[1 2], Yaron Tokochinski[3], Leon Blaustein[1] and Gil Rilov[2]

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[1]Institute of Evolution and Department of Evolutionary & Environmental Biology, University of Haifa
[2]Israel Oceanographic and Limnological Research
[3]School of Marine Sciences, Ruppin Academic Center

abstract:

Since the opening of the Suez Canal in 1869, many marine species have passed through from the Red Sea to the Mediterranean. This extensive phenomenon, known as Lessepsian migration, has so far resulted in the migration of over 400 species into the Levant Basin. Unlike other closely monitored marine megafauna such as marine mammals and sea turtles, little is known about shark populations in Israel. The dusky shark (*Carcharhinus obscurus*) is rarely found in most parts of the Mediterranean but is surprisingly common in Israel. In collaboration with Ecoocean organization, we aimed to explore the variability of dusky sharks off the Israeli coast and determine their origin by molecular techniques. Previous work on the dusky shark found the Indo-Pacific population to be genetically separated from the Atlantic one. We collected tissue samples of sharks caught by fishermen off the Israel Mediterranean coast. DNA was extracted and the mitochondrial control region (D-Loop) was sequenced. Results show that samples consisted of haplotypes from both the Atlantic and Indo-Pacific, indicating that Lessepsian migration of the dusky shark has occurred. Albeit rare, the dusky shark is indigenous in the Mediterranean, thus the usual definition of invasion does not apply. We address it as cryptic invasion, a term used for the phenomenon of individuals entering an existing population of the same species from a different biogeographic region. Identifying cryptic invasions is especially important in highly invaded regions such as the Mediterranean, where it is possible that the magnitude of invasions may substantially exceed previous estimates.

The arrival and currents status of the European green crab in the Pacific Northwest.

Oral presentation
Symposium Theme: Other Session 9: Crab Invasions Time: 1:40 22/08/2013

authors:

***Sylvia Behrens Yamada*[1]**

Contact: Sylvia Behrens Yamada yamadas@science.oregonstate.edu

[1]Zoology Department, Oregon State University and Graham E. Gillespie, Fisheries and Oceans Canada.

abstract:

European green crabs were first introduced into San Francisco Bay during the 1980's and spread northward during the 1990's via larvae carried on north-flowing ocean currents. These currents were especially strong during the unusually warm and strong El Niño event of 1997-1998, during which green crabs spread to Oregon, Washington and British Columbia. Since this initial colonizing event, green crabs in Oregon and Washington, have persisted, but only produced new cohorts after warm winters of 2003, 2005, 2006 and 2010. While green crabs are rare in Oregon and Washington, they are thriving in the inlets on the west coast of Vancouver Island. Recent range expansion into the Central Coast of British Columbia and Sooke cause concern that green crabs may soon expand their distribution to Alaska and the Salish Sea, either through larval transport in ocean currents or via movements of shellfish or culture equipment. Once a satellite population of European green crabs is established in the inland sea, the invader would spread rapidly as favorable habitats in bays and estuaries are abundant and larvae would be retained.

Importation of baitworms and their live algal packing materials: experimental treatment of algae to reduce live hitchhikers.

Oral presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems Session 1: Management of Invaders Time: 4:00 20/08/2013

authors:

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abstract:

The Maine baitworm industry has become recognized as a significant contributor to the spread of invasive species via hitchhikers associated with algal packing materials (e.g., to the US west coast, Long Island Sound, and the mid-Atlantic). The vector remains active, and until now, an investigation determining potential mechanisms to limit entrained biota had not been performed. Here, we demonstrate experimental evidence for inexpensive and easily implementable treatments to effectively dislodge and/or kill hitchhikers associated with the vector. In particular, we performed three replicated treatments on algae purchased from a Maine baitworm distributor (‘Harbor Bait’: Wiscasset), including: 1) a tap water soak (‘tap’; 0 ppt), 2) a hyper-salinity soak (‘hyper’; 60 ppt), 3) a tap water / hyper-salinity soak (‘tap-hyper’), and controls of untreated algae. Experimental algae were combined with polychaete bloodworms at the Maine distributor, where bait+algae were shipped to SERC and UC-Davis. Algae in each bait-box were systematically examined for associated organisms, which were identified (to the lowest taxonomic level) and counted under a dissecting microscope. We found a significant reduction in species richness and abundance of live organisms in all treatments compared to controls; however, our tap and tap-hyper treatments showed the greatest reductions, and our simplest treatment, tap water, was statistically as effective as the more complicated tap-hyper treatment. On the whole, our results suggest implementation of these simple, inexpensive treatments (notably tap water) could effectively and significantly reduce the number of hitchhiking species associated with packing algae, limiting the potential for further invasions nationally and globally.

How does a newly invasive ecosystem engineer affect macroinfaunal assemblages in a highly modified estuarine lagoon?

Oral presentation
Symposium Theme: Evaluating the success of invaders in transitionary waters such as estuaries and waters that are changing as a result of anthropogenic activities
Session 2: Factors Affecting Invasion Success Time: 4:00 20/08/2013

authors:

***Magdalena Georgieva*[1 2 3] *and Elisa Bone*[2 4]**

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abstract:

Changing environmental conditions in estuarine habitats may serve to facilitate the establishment of non-native species or the expansion of species into new ranges. These potential range expansions can exacerbate existing stressors in modified estuaries, and the effects on native assemblages may be most pronounced when the invader is also an ecosystem engineer. The serpulid polychaete *Ficopomatus enigmaticus* is a prominent invader across brackish estuarine regions and by forming biogenic reefs can alter sedimentary processes and water movement, with corollary effects on native assemblages. We examined the effects of translocated live and dead *F. enigmaticus* reefs on macroinfaunal assemblages within a highly modified estuarine lagoon in southern Australia. As a result of ongoing drought and water extraction, during the study period *F. enigmaticus* was showing rapid range expansion across an adjacent lake system, with further invasion into the lagoon predicted. We examined reef effects at three sites positioned along a salinity gradient from brackish to moderately hypersaline, and although we saw slight decreases in macroinfaunal abundances with reef addition treatments, these changes were not significant and were outweighed by differences across sites. Diversity and abundance both declined significantly along the salinity gradient, suggesting that the overall effect of projected increasing salinity in the region would likely outweigh any negative effects of *F. enigmaticus* reef expansion on existing macroinfaunal assemblages. Our findings highlight the importance of considering the potential for interactive effects of existing environmental stressors with those posed by newly invasive species.

Niche determinants: searching for consistency in environmental predictors of species' distributions.

Oral presentation
Symposium Theme: Defining the environmental niche space of invaders using empirical and theoretical tools themes Session 4: Invasion Niche Time: 10:00 21/08/2013

authors:

Johanna Bradie[1] and Brian Leung[1]

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abstract:

The increasing availability of species distributions and fine-scale climatic data has led to the creation of a considerable number of niche-based models (NBMs) for species' distributions. NBMs use distributional data to infer species' ecological requirements and predict their distributions. The true factors affecting species distributions are however unknown, and resultantly, NBMs are created using diverse environmental variables, many of which are not significantly predictive. As of yet, analyses to determine the environmental characteristics that predict species distributions have been done on a per species basis, and the outcome of such analyses can be dependent on model selection and model building. We conducted a meta-analysis of NBMs to determine which environmental characteristics are predictive across species. We focused our analysis on studies that used MaxEnt, because it is currently one of the most popular tools for NBMs and because it has a built-in function that analyzes the contribution of each environmental variable to model gain. We analyze how niche determinants vary between species and at different spatial resolutions. Results characterize the important determinants of species' niches in general and can be used to improve the formulation of environmental distance metrics.

Effects of a potentially rapidly spreading native alga on large herbivores on temperate rocky reefs.

Oral presentation
Symposium Theme: Other Session 5: Invasion Impacts Time: 11:40 21/08/2013

authors:

Daniel Bradley[1], William Gladstone[2], Peter Steinberg[3] and Paul Gribben[1]

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[3]School of Biological, Earth and Environmental Science, Centre for Marine Bio-Innovation, University of NewSouth Wales, Sydney, NSW, 2052, Australia

abstract:

Invasive macroalgal species on temperate rocky reefs areoften structurally different and highly chemically defended compared to native competitors.These traits of invasive macrophytes can have major impacts on native herbivore communities. Invaders from the genus *Caulerpa* such as *Caulerpa taxifolia* and *C. racemosa* are prime examples of such species. Interestingly, in South Eastern Australia a native alga, *Caulerpa filiformis*, is anecdotally becoming more abundant throughout its range and expanding its distribution. *C. filiformis* shares many of the traits exhibited by invasive species of the same genus and thus has the potential to cause impacts on subtidal herbivore communities. However, we know little about the response of native herbivore communities to the spread of this alga. Using underwater surveys we investigated the potential effects of the spread of *C. filiformis* on major large herbivores including fish and urchins. Specifically, we hypothesised that 1) fish communities would be negatively correlated with increasing *C. filiformis density* and 2) the abundance ofurchins and pit occupancy would be lower in the middle of patches than outside or on the edge. Underwater visual census surveys indicated little effect on fish communities, which varied independently of *C. filiformis* density. However, surveys indicated that the echinoid *Heliocidaris erythrogramma*, a common urchin on the rocky reefs of South Eastern Australia, had reduced abundance at patch edges compared to outside *C. filiformis* patches and was completely absent from the centre of *C. filiformis* patches. Subsequent behavioural and feeding experiments of urchins assessed the mechanisms behind these patterns.

Early detection of aquatic invaders: Can next-generation sequencing accurately describe zooplankton communities?

Oral presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems Session 6: Applying Molecular Tools Time: 2:40 21/08/2013

authors:

Emily A. Brown[1], Aibin Zhan[3], Hugh MacIsaac[2] and Melania Cristescu[1]

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abstract:

Early detection of invasive non-indigenous species has been recognised as of high priority for management plans. Methods of detection have often relied on microscopic examination of samples and traditional taxonomy. However, correct identification can be difficult for certain life stages and for cryptic species, for example. Moreover, given the sampling efforts typically used in such studies, invading species occurring at low abundances may be missed. Increasing interest has therefore arisen in using pyrosequencing to measure species diversity and to detect the presence of invasive species. Pyrosequencing of environmental samples has been demonstrated as an effective means of identifying rare species, with much higher levels of diversity revealed than previously estimated. Further research is needed in order to understand the extent to which these numbers are inflated by artefacts and errors that occur during sequencing. False negatives are also possible through, for example, primer competition or lack of universality. In order to investigate the role of these influences, we generated an artificial aquatic community with a known number of identified zooplankton species, and used a barcoding approach combined with pyrosequencing to examine whether all species included in the community could be detected. Having a known number of species in our community also provided an ideal opportunity to identity the appropriate level of intraspecific and interspecific genetic divergence for the accurate estimation of species diversity in zooplankton communities. This work will assist the analysis of datasets resulting from long-term monitoring using next-generation sequencing technologies for the early detection of invasive species.

The effects of ocean acidification on early succession in mesocosm-based fouling communities.

Oral presentation
Symposium Theme: Evaluating the success of invaders in transitionary waters such as estuaries and waters that are changing as a result of anthropogenic activities
Session 2: Factors Affecting Invasion Success Time:2:40 20/08/2013

authors:

Norah Brown[1], Christopher Harley[1] and Thomas Therriault[2]

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abstract

Increasing levels of CO2 in the atmosphere will affect ocean chemistry, causing increased acidification (i.e., lower pH). Differential responses to changes in pH, based on interspecific and ontogenetic variation in physiology, could produce changes in structure and diversity at the community level. To test the effects of ocean acidification on a mixed assemblage of native and invasive species, we conducted a study in a field-deployed flow-through mesocosm system using subtidal marine fouling communities. Initially bare recruitment plates were suspended in the mesocosms and subjected to ambient or elevated CO2 by bubbling in air or air enriched with an additional ~600 ppm of CO2 to create a 0.35 pH difference between treatments (n=12 per treatment). After ten weeks, acidification significantly altered community structure. This change was driven by changes in relative abundances of recruiting species, as total use of free space was equal between treatments. There were significantly fewer mussel recruits (*Mytilus trossulus*) in the elevated CO2 treatment than in the ambient treatment after six weeks. Recruitment of hydroids (Obelia dichotoma) was also significantly reduced after eight weeks in the elevated CO2 treatment. Conversely, the percent cover of bryozoan colonies (*Membranipora membranacea*) increased under acidic conditions over time, differences becoming apparent after six weeks. Our results indicate that the ecological impacts of M. membranacea, which is invasive elsewhere, may increase with ocean acidification. Overall, our study demonstrates that ocean acidification can act on important ecological processes like recruitment from plankton, which can result in significant shifts in community structure.

Joint-agency response to *Undaria pinnatifida* in Fiordland, New Zealand.

Oral presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems Session 1: Management of Invaders Time: 10:20 20/08/2013

authors:

Jennie Brunton[1], Kath Blakemore[2], Tim Riding[1], Richard Kinsey[3], and Derek Richards[4]

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abstract:

The Asian kelp *Undaria pinnatifida* (*Undaria*) has been introduced to numerous temperate coasts world-wide, including Europe, the Americas and Australasia. Although *Undaria* has established in many areas of New Zealand, it was absent from Fiordland until April 2010 when a mature sporophyte was found on a mooring line. The presence of *Undaria* in Fiordland is considered a threat to this globally unique marine environment. A delimiting survey conducted in July 2010 found another 360 immature sporophytes. Following consultation with stakeholders and indigenous people, a response involving the Ministry for Primary Industries, the Department of Conservation, and local government authority was initiated to eliminate *Undaria* from Fiordland. The elimination involves a three-tiered approach: (i) monthly SCUBA surveys and removal of *Undaria* sporophytes by hand; (ii) using the herbivorous sea urchin, *Evechinus chloroticus*, as a biological-control agent; and (iii) using chlorine capsules. The response has resulted in a significant reduction inthe overallnumber of *Undaria* sporophytes, with 11 or less immature sporophytes being found on each of the last 15 surveys, and no sporophytes detected on six of these surveys. Microscopic *Undaria* gametophytes can persist for ~2.5 years. As the last mature sporophyte was found in January 2012, the response now appears to be eliminating the 'seed bank'. Key factors contributing towards the success of this response include: early detection, rapid response, knowledge of *Undaria*'s life-history, co-operation by stakeholders and management agencies, and innovation. If successful, it may be the first time world-wide *Undaria* has been eliminated from natural substrate.

The ecological impacts of exotic seaweeds: variation between trophic levels and across environmental conditions.

Oral presentation
Symposium Theme: Evaluating the success of invaders in transitionary waters such as estuaries and waters that are changing as a result of anthropogenic activities
Session 2: Factors Affecting Invasion Success Time: 10:20 20/08/2013

authors:

Fabio Bulleri[1], Rebecca Mant[2], Lisandro Benedetti-Cecchi[1], Eva Chatzinikolaou[3], Tasman Crowe[4], Jonne Kotta[5], Devin Lyons[4], Gil Rilov[6] and Elena Maggi[1]

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[6]National Institute of Oceanography, Israel Oceanographic and Limnological Research, Tel-Shikmona, Haifa, 31080, Israel

abstract:

The effects of exotic seaweeds on the structure of recipient assemblages is yet to be fully elucidated. By means of meta-analyses, we assessed whether the impacts of introduced macroalgae on native species and communities vary 1) between primary producers and consumers and 2) according to local environmental conditions (estimated as Halpern's cumulative impact score). In general, seaweed effects were more negative at the same than at a higher trophic level, although their strength varied among response variables. There was little evidence for seaweed effects to depend on environmental conditions, although their impact on some of the variables tested tended to decrease when moving from pristine to degraded environments. The hypothesis of a smaller impact on native assemblages in degraded environments (generally regulated by physical conditions) than in pristine ones (generally regulated by biotic interactions) was also tested by removing the invasive seaweed, *Caulerpa racemosa*, across a human disturbance gradient. Short-term data suggest that this invader reduces spatial variability of benthic assemblages at pristine sites, while it would have negligible effects in degraded areas. Thus, competitive effects from exotic seaweeds are likely to be of greater importance than indirect effects on consumers and exotic seaweeds may represent a more serious threat to marine biodiversity when they establish in pristine areas. The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under Grant Agreement No. 266445 for the project Vectors of Change in Oceans and Seas Marine Life, Impact on Economic Sectors (VECTORS).

Biosecurity and food security: wicked problems that exacerbate each other?

Oral presentation
Symposium Theme: Other Session 1: Management of Invaders Time: 11:40 20/08/2013

authors:

Marnie Campbell[1], Chad Hewitt[2]

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abstract:

In recent years a debate has occurred in the literature (Nature and Science) that states that bioinvasion researchers as xenophobic, are over emphasising the impact that introduced species have in the environment, and concentrate on the negative aspects of invasion. We feel that the basis of this debate may stem from people's conservation philosophies and biodiversity ethics, which can be tested by juxtaposing biosecurity (management of introduced species) with food security – both of these disciplines aim to protect and help humans. As a starting point to this analysis we used a 13-question online survey to investigate how researchers, decision makers and discipline specific journal editors view biosecurity and food security and what (if any) demographics (nine demographics), philosophies (3) and ethics (3) influenced biosecurity and food security researchers, policy and decision makers. Statistical and thematic analyses were used to test these concepts with a number of correlations being explored. We targeted 40 countries and had a response rate of 54%. One of the key explorations within the survey was the knowledge of the ability of biosecurity and food security to compromise one another. Not surprisingly there was a similar consensus that both food security and biosecurity can compromise each other, with the majority (65%) of respondents feeling that both issues are equally important. Within the context of the debate that has been occurring 89% of respondents stated that they do not believe that all introduced species are bad for the environment. We present these and other findings of this study in this presentation.

Fouling marine invasions in offshore islands: a perspective from the Macaronesian region.

Oral presentation
Symposium Theme: Other
Session 2: Factors Affecting Invasion Success Time: 5:20 20/08/2013

authors:

João Canning-Clode[1 2 3], Paula Chainho[3], Paul Fofonoff[2], Linda McCann[2], James Carlton[4], Gregory Ruiz[2] and Ricardo Serrão Santos[1]

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[3]Center of Oceanography, Faculty of Sciences, University of Lisbon, Campo Grande, Lisbon, Portugal.
[4]Williams College – Mystic Seaport, Mystic, CT, USA

abstract:

While terrestrial introductions have been well documented on many island ecosystems and continue to be the focus of extensive work in invasion biology, studies on marine invasions on most of the world's islands have been poorly explored. Three island systems in the Pacific Ocean (New Zealand, Hawaiian Islands and Guam) and one in the Atlantic Ocean (Azores) are exceptions. Although the ability to compare and evaluate the extent of invasions between island and mainland systems is accompanied by a number of restraints, some studies predict that impacts of marine non-indigenous species (NIS) on biodiversity, as for terrestrial systems, will be greatest on islands. In contrast, other studies found no evidence that native marine biotas of islands are more severely affected by invasions compared to continental biotas. These contrasting hypotheses thus await more rigorous examination as more data become available. To expand our understanding of the scale and diversity of fouling marine bioinvasions on insular systems, we examine here the marine bioinvasions of Macaronesia, consisting of four archipelagos: Azores, Madeira, Canary Islands and Cape Verde. We performed the first extensive literature review of records of fouling NIS in Macaronesia and have complemented this search with data from ongoing field surveys in some of the islands. We recognize 54 NIS in the region and relate these numbers with critical variables, including latitude, ship traffic, distance to mainland ports and anthropogenic activities.

Geologic time scale events in the lifetime of invasion biologists: a look at sweepstakes dispersal through an extraordinarily rare phenomenon.

Plenary Speaker Time: 9:00 21/08/2013

authors:

James Carlton[1], John Chapman[2], Jonathan Geller[3], Jessica Miller[2], and Gregory Ruiz[4]

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[4]Portland State University, Portland OR and Smithsonian Environmental Research Center, Edgewater MD

abstract:

The disastrous *Tōhoku Earthquake and Tsunami* of March 11, 2011 set in motion an extraordinarily rare event: the launching of a vast raft field into the North Pacific Ocean from a known source at an exact time. The field consists of marine-origin debris (MOD, such as docks, buoys, floats, and vessels) and terrestrial-origin debris (TOD, such as house wood and refrigerators). A portion of this field, which became highly dispersed over 10s of millions of square kilometers, departed the Western Pacific with living Japanese marine protists, invertebrates, algae, and fish. Few data were available to accurately predict the transit duration, track, or landing point (if any) of any given rafted object (as witnessed by the fate of four dislodged large docks from the Port of Misawa), which species would survive long-distance journeys through a presumably largely oligotrophic environment, or how long such species could survive. Since June 2012 we have assessed the nature and diversity of species arriving on Japanese Tsunami Marine Debris [JTMD]. Our analyses include the guilds that are, to date, absent or rare, the genetic population structure and reproductive conditions of selected taxa, dispersal track history through shell chemical analyses, and the presence of endoparasites and endocommensals, among other studies. Finally, we compare JTMD to both the presumed nature of prehistoric rafting and to previously studied transoceanic anthropogenic dispersal vectors; propose a model of the patterns and processes of biotic acquisition, loss, and enhancement in an ocean-scale journey, and consider the invasion potential of selected species.

Coal crazy and Panamax-ready: global trade and the transport of marine organisms to Chesapeake Bay.

Oral presentation
Symposium Theme: Evaluating vectors for invaders and modes of transport
Session 3: Invasion Vectors Time: 11:00 21/08/2013

authors:

Katharine Carney[1], Kimberly Holzer[1], Katrina Lohan[1], Whitman Miller[1] and Gregory Ruiz[1]

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abstract:

Shipping is a dominant vector responsible for introducing many of the 179 established invasive aquatic species in the Chesapeake Bay. In 2012, overseas bulk cargo vessels reportedly accounted for 15% of total arrivals and 82% of total ballast water (BW) inputs. Presently bulk cargo vessels reportedly discharge 22 million m^3 of overseas BW annually, which is 1200% more than in 2005, even though total annual vessel arrivals to Chesapeake ports have only increased by 15% in the past decade. Surprisingly, there has been no observed statistical difference in the concentration of total zooplankton in ballast tanks pre- and post-management era, despite widespread use of ballast water exchange (BWE), due to high variation among ships. Furthermore, in 2012 flow through (FT) and empty refill (ER) exchange delivered statistically similar organism concentrations (FT: >4,000 individuals m-3, ER: >1,900 individuals m-3). However, global trade is driving temporal changes in input volume.The volume of BW discharged continues to rise on account of high demands for coal from international markets. Further changes are expected due to increases in vessel traffic in Chesapeake Bay Panamax-ready ports (Baltimore and Norfolk) subsequent to the expansion of the Panama Canal in 2014. This paper describes plankton assemblages collected from managed BW of bulk cargo (coal) vessels entering Baltimore and Norfolk ports in 2012–2013.Our long-term goal is to measure the response of plankton communities to shifts in vessel behavior, including ballast management (BWE and technological treatments), the growth of coal exports, and the Panama Canal expansion.

An invasive bivalve alters estuarine succession through habitat modification: the importance of density–impact relationships.

Oral presentation
Symposium Theme: Evaluating the success of invaders in transitionary waters such as estuaries and waters that are changing as a result of anthropogenic activities
Session 2: Factors Affecting Invasion Success Time: 2:20 20/08/2013

authors:

Max Castorani[1 2], Kevin Hovel[1], and Susan Williams[3]

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abstract:

Non-native bivalves are notorious estuarine invaders because of their potential for strong ecological impacts through physical engineering of benthic habitats and alteration of biogeochemical cycles. The Asian mussel *Musculista senhousia* has been introduced to several California estuaries, where it has shown the ability to cause major biogeochemical and ecological changes at high densities. However, abundances of this invader vary dramatically over space (e.g., along estuarine gradients) and time (e.g., stochastic population oscillations), making generalizations about potential impacts difficult. With this variability in mind, we investigated the effects of *M. senhousia* density on benthic succession and biogeochemistry in Mission Bay, San Diego, California, USA. In an intertidal field experiment, we manipulated the density of mussels and, after 11 weeks, sampled porewaters, sediments, mussels, benthic algae, and infauna. Increasing mussel density caused positive, nonlinear increases in fine sediment and organic matter. Higher mussel densities reduced the variability of porewater oxidation-reduction potential, ammonium concentration, and dissolved sulfide concentration, but had no effect on mean values. Increasing mussel biomass was matched by a nonlinear increase in algal biomass—primarily *Ulva* spp.—which can likely be explained by recruitment to the hard structure provided by mussel shells, mussel fertilization of algal growth, or both. Results suggest that *M. senhousia* does not have major biogeochemical and ecological impacts until a moderate density of approximately 2,000 mussels m^{-2} is reached. Our findings are particularly relevant for the management of this invader because previous studies suggest that native predators can reduce mussel populations to levels below this threshold.

Is hull fouling a potential vector for the introduction of nonindigenous species to the Canadian Arctic?

Oral presentation
Symposium Theme: Evaluating vectors for invaders and modes of transport
Session 3: Invasion Vectors Time: 2:00 21/08/2013

authors:

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abstract:

Hull fouling is a major vector of nonindigenous species (NIS) in marine ecosystems globally. Many marine species attach to ship hulls and can dislodge and/or reproduce at subsequent ports. However, there has been no scientific evaluation of current hull fouling risk in the Canadian Arctic. A combination of global warming, resource exploitation, and the resulting increase in shipping activities are expected to elevate the risk of NIS invasions in the Canadian Arctic in the near future. Therefore, assessments of the risk of NIS introduction via hull fouling to the Canadian Arctic are clearly needed. We surveyed nine military vessels immediately before, during and after Arctic transits between 2008 and 2012. Time spent in high latitude waters has been found to be negatively correlated with the extent of fouling on hulls. For each vessel, we collected hull fouling samples first in Halifax, Nova Scotia, then in Iqaluit, Nanisivik or Resolute in Nunavut, and finally again in Halifax to characterize any changes in composition and abundance of fouling organisms before and after Arctic transits. Preliminary results suggested that both species richness and abundance decreased significantly during and after Arctic transits. A total of 228 species have been identified in collected samples so far. At least two NIS were identified in pre-Arctic samples, but not in Arctic or post-Arctic ones. Our results suggest that hull fouling may be an important vector for range expansion of native temperate species, rather than introductions of new NIS.

Divergent responses to multiple climate change stressors in an invasive predator and native prey interaction.

Oral presentation
Symposium Theme: Evaluating the success of invaders in transitionary waters such as estuaries and waters that are changing as a result of anthropogenic activities
Session 2: Factors Affecting Invasion Success Time: 3:00 20/08/2013

authors:

Brian Cheng[1] and Edwin D. Grosholz[1]

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abstract:

Recently, much attention has focused on the potential for climate change and biological invasions to interact. However, climate change is often comprised of multiple environmental stressors that may interact to intensify or ameliorate the effect of invaders. We tested the potential for two climate change stressors (high water temperature and low salinity) to affect interactions between an invasive predator and native prey. In this system, invasive eastern oyster drills (*Urosalpinx cinerea*) consume the native Olympia oyster (*Ostrea lurida*). We measured lethal responses to both high temperature and low salinity as well as sub-lethal responses to warming. We also utilized two years of field data from Tomales Bay, California to assess the environmental context under which these stressors operate. Preliminary results suggest that increasing water temperatures will result in similar lethal effects on both species but sub-lethal responses will favor the oyster drill. In contrast, oysters have greater tolerance of lower salinity than oyster drills. This suggests that climate change impacts can have opposing influences on invasive and native species and will depend on the relative spatial and temporal scale over which the stressors operate.

Feeding ecology of the invasive lionfish (*Pterois volitans*) in Jamaica.

Oral presentation
Symposium Theme: Other Session 7: Fish Invasions Time: 4:00 21/08/2013

authors:

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abstract:

The invasive red lionfish (*Pterois volitans* and *Pterois miles*) has established itself in Jamaican waters since 2008 and is spreading throughout the Caribbean at an alarming rate. This invasion has been described as the fastest finfish invasion in history. Lionfish compared to other apex predators may have the capability to alter the local marine ecosystem. Though mainly piscivorous in their native (Indian and Pacific Oceans) habitat, in Jamaican waters, their diet is diverse, comprising of fish, crustaceans and molluscs. The invasion of this voracious feeder may further decrease fish stocks in Jamaica's already overfished waters. This study described the diet of lionfish the using analysis of its gut contents. Twenty teleost families were identified in the diet of these lionfish. Holocentridae >Labridae > Gobiidae were the top three ranked teleost families based on percentage occurrence. However, shrimp had the highest abundance of all prey identified. Notably, small adult and juvenile fish made up the highest percentage of the diet throughout all size classes (75-450mm TL) of lionfish examined. In addition, a single *Sepioteuthis sepioidea* (Mollusca, Cephalopoda) (67mm TL) was observed in the stomach of a lionfish (364mm TL). Overall, the diet of sampled lionfish in Jamaica (n=1489) was found mainly to consist of fish (79%), crustaceans (7 %), and partly digested unidentified proteinaceous matter (14%). Mitigation of the lionfish invasion is required for the conservation of the local marine biodiversity and the livelihood of the local fishers.

Fusion and genetic diversity of a colonial ascidian in Southeast Alaska

Oral presentation
Symposium Theme: Evaluating the success of invaders in transitionary waters such as estuaries and waters that are changing as a result of anthropogenic activities
Session 8: Tunicate Invasions Time: 1:40 22/08/2013

authors:

Darragh L. Clancy[1], Paul Norwood[2], Marnie Chapman[3] and C. Sarah Cohen[1]

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abstract:

In 2010, the colonial ascidian *Didemnum vexillum*, which has become invasive in several temperate regions around the globe, was discovered in an isolated cove near Sitka in Southeast Alaska. Alaskans have become concerned about the spread of this highly aggressive invader because of its potential effects on aquaculture and fishing industries. A recent study has suggested that invasive populations of *Didemnum vexillum* have higher rates of inter-colony fusion because of decreased genetic diversity. To learn more about the Alaskan population and whether an increased fusion rate could affect its spread, we are investigating the link between fusion behavior and genetic relatedness with field fusion assays and high-resolution microsatellite genotyping. During our fusion experiment in November 2012, three of three same-colony assay pairs fused, while three of six inter-colony pairs fused. Current genotyping from eight microsatellite loci will provide one of the first reported high-resolution population genetic studies of this species and provide information on relatedness in fusion assays. Ongoing parallel experiments that we are carrying out in California will allow us to compare fusion rates and high-resolution genetic relatedness between new and older invasive populations. In addition, we will compare the overall genetic diversity of the Alaska population to that of other populations previously reported. Genotyping a 586bp fragment of the mitochondrial gene cytochrome c oxidase subunit I (COI) has resulted in three haplotypes (haplotype diversity: 0.504 ± 0.058, $n = 48$), which suggests lower diversity than native and older California invasive populations.

Here comes the sun: imminent algal invasions at high latitudes.

Oral presentation
Symposium Theme: Evaluating the success of invaders in transitionary waters such as estuaries and waters that are changing as a result of anthropogenic activities
Session 2: Factors Affecting Invasion Success Time: 10:40 20/08/2013

authors:

Graeme Clark[1], Jonathan Stark[2], Emma Johnston[1], John Runcie[2 3], Paul Goldsworthy[2], Ben Raymond[2 4] and Martin Riddle[2]

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abstract:

Each year vast areas of coastal polar ocean are covered by a layer of sea-ice, which forms in winter and breaks-out (melts and/or is blown out to sea) during summer. Sea-ice profoundly changes the marine environment below, blocking virtually all light and turbulence to create dark, still marine habitats. Areas of shallow seabed that are covered by sea-ice for most of the year are often inhabited by dark-adapted invertebrate communities, because there is insufficient light for most algal species. However, global warming is predicted to cause early sea-ice break-out, increasing annual light availability and therefore the potential for photosynthesis. Here we examine the relationship between sea-ice duration and subtidal light availability at high latitudes, and relate this to the light requirements of Antarctic macroalgae. We show that small changes in sea-ice duration can breach critical thresholds in the viability of macroalgae. We surveyed the structure of Antarctic benthic communities along existing gradients of sea-ice duration, and found rapid transition from invertebrate- to algal-dominated communities as sea-ice duration decreased. These results suggest that shallow polar seabeds are vulnerable to abrupt tipping-point regime shifts, whereby early sea-ice loss causes algae to invade and outcompete invertebrate-dominated communities. Finally, we present a regional analysis of vulnerability to change in light, and identify geographic hotspots most likely to experience future algal invasion.

Pet or dinner? An evaluation of the live animal trade in British Columbia, Canada.

Oral presentation
Symposium Theme: Evaluating vectors for invaders and modes of transport
Session 3: Invasion Vectors Time: 4:20 21/08/2013

authors:

Cathryn Clarke Murray[1], David Scott[2], Christopher Harley[1], Jonathon Moore[2] and Leif-Matthias Herborg[3]

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abstract:

The live animal trade differs from other marine invasion pathways such as shipping in that the transportation of species occurs under conditions meant to enhance survival to the new location. In response to several incidents of local introduction events of snakehead fish (*Channa* spp.) and sea snails (*Littorina littorea* and others) we conducted a survey of the live food and aquaria trade in British Columbia, Canada. Over 40 live seafood markets and aquaria shops were visited in 2012 and revisited for Chinese New Year in 2013. At each store the live fauna available for sale was recorded and a behavioural survey administered to the proprietors. The survey asked which live species were offered for sale, the volume sold each year and how unsold products were disposed. A large number of fish and invertebrate species were recorded in both aquaria and markets, including *Littorina littorea* sea snails. Survey results suggest that the seller is not likely to be the agent of escape or release for these species and outreach efforts should be directed at the customer level. Our results demonstrate that the aquaria trade has a much higher risk than market-origin live release, as a result of both species volume and diversity and behavioural characteristics. These results have supported and focused new provincial legislation banning the import of a number of marine and freshwater species to prevent future introductions of these species and halt the invasion of the marine waters of British Columbia.

What doesn't kill you makes you scared? Effect of repeated culling on the behaviour of invasive lionfish.

Oral presentation
Symposium Theme: Other Session 7: Fish Invasions Time: 4:20 21/08/2013

authors:

Isabelle Côté[1], Emily Darling[1], Luis Malpica-Cruz[1], Nicola Smith[1] and Stephanie Green[1]

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abstract:

Being hunted can shift the behaviour of animals towards patterns and traits that make future encounters with hunters less likely. When hunting is carried out for conservation, for example to control invasive species, these behavioural changes can inadvertently impede the success of future efforts. We examined the effects of repeated culling on the behaviour of invasive predatory lionfish (*Pterois volitans*) on Bahamian coral reef patches. Manual removal by spearing is currently the only effective method of controlling lionfish populations. Lionfish on reefs under a regime of regular daytime removals were less active and hid deeper within the reef during the day than lionfish on control patches where no culling had occurred. These differences disappeared at dawn. Moreover, lionfish on culled reefs were more wary of divers and adopted a threatening alarm posture at a greater distance than lionfish on control reefs. These shifts in behaviour on reefs that were repeatedly culled should result in lionfish being less likely to be encountered and more difficult to target by spearfishers. Our results thus suggest that lionfish surviving a cull could become difficult to remove in subsequent control efforts, which has implications for the goals and design of control programs.

Biased introgression of mitochondrial genomes beyond an established range limit in a dynamic admixture zone.

Oral presentation
Symposium Theme: Other Session 6: Applying Molecular Tools Time: 2:00 21/08/2013

authors:

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abstract:

The human-assisted establishment of non-native populations, while raising substantial challenges in environmental management, also provides opportunities to explore important fundamental questions such as the factors that drive colonization success and the evolutionary dynamics of population expansion. Here, we take advantage of multiple introductions to the northwest Atlantic of evolutionarily divergent populations of the European green crab *Carcinus maenas*, a system that provides a unique opportunity to examine the genetics of a recently established admixture zone between two non-native lineages with overlapping invasion fronts. We assembled genetic datasets from nine nuclear microsatellites and a mitochondrial DNA locus (cytochrome C oxidase subunit I) for three distinct time points across a seven year period, allowing investigation of the temporal dynamics of this admixture zone. We employ both a descriptive study of the multi-locus temporal genetic datasets and simulation approaches to investigate the evolution of genetic patterns associated with this admixture zone. Our observations indicate that alleles are capable of advancing more rapidly at an invasion front when they encounter resident conspecific populations, compared to uninvaded habitat. Furthermore, this genetic stickiness of sites with resident populations is more pronounced for mitochondrial than for nuclear genomes. Our simulation studies allow us to explore this phenomenon more generally and to examine the factors driving stickiness, particularly in advective coastal systems. We discuss our results in the context of *C. maenas* reproductive biology and dispersal, and consider their implications for a general understanding of the evolutionary genetics associated with range expansions.

Induced defensive responses by snails are sensitive to variation in abundance of an invasive crab predator.

Oral presentation
Symposium Theme: Defining the environmental niche space of invaders using empirical and theoretical tools themes Session 9: Crab Invasions Time: 2:20 22/08/2013

authors:

L. David Smith[1], Sarah Tucker[1] and Olivia Cap[1]

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[1]Department of Biological Sciences, 44 College Lane, Smith College, Northampton, MA 01063-6397, U.S.A.

abstract:

Biogeographic patterns in prey defenses can result from differential developmental responses to variation in abundances of introduced predators. In the northeastern Atlantic, the snail *Littorina obtusata* develops a thicker shell in the presence of the introduced European green crab *Carcinus maenas*, which may explain positive correlations between shell thickness and green crab abundances in the Gulf of Maine. To what extent, though, do prey defenses respond to variation in predator abundance over smaller spatial scales (between and within sites)? To test the effect of crab density on shell thickness at finer spatial scales, we conducted a reciprocal transplant field experiment, manipulating snail source population and rearing location and crab density. We collected snails from two sites in Maine that differed in abundance of *C. maenas*. Snails from the site with few crabs had thinner shells than did snails at the site with many crabs. Five snails from a given site were placed, protected, inside a larger cage that held no, one, or three crabs. Half of the cages for each crab treatment were anchored at the snails' site of origin for 60 d; half were placed at the transplant site. Regardless of source population, snails reared at the high crab abundance site developed thicker shells than those reared at the low abundance site. The effect of the crab density on shell thickness was evident in snails originating from the low, but not high, crab abundance site. Our results suggest prey respond to differences in predator abundance at multiple spatial scales.

Increased damage from a broadly introduced boring isopod at the northern edge of mangrove range.

Oral presentation
Symposium Theme: Other Session 1: Management of Invaders Time: 12:00 21/08/2013

authors:

Timothy Davidson[1], Gregory Ruiz[2], and Mark Torchin[1]

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abstract:

Populations near the edge of their distributional range persist under sub-optimal conditions but may suffer disproportionately from the addition of other stressors, such as introduced species. In the Caribbean, the introduced Indo-Pacific isopod *Sphaeroma terebrans* bores into the aerial roots of red mangroves (*Rhizophora mangle*) causing damage and alterations to root morphology. We hypothesized the damage associated with isopods is greater in populations of mangroves closer to their range edge than mangroves within their central range. We compared sites in Panama (2 sites), Belize (2 sites), and Florida (3 sites) to examine the associations between latitude and isopod damage and root morphology. In each site, we measured root breakage, morphology, and isopod damage in the aerial root matrix and in individual sampled roots. In one site in Panama, we further examined the effect of isopod boring by comparing the growth of roots caged to prevent isopod boring and uncaged control roots. The mangroves in Florida sites had higher percentages of broken roots and fewer root tips per root compared to lower latitude sites and the sampled roots were more worn down, thinner, and less submerged. The percentage of burrowed roots and number of burrows per root did not vary with latitude. Our pilot experiment revealed that isopods reduced growth rates and broke the root tips they inhabited. The roots excluded from isopods grew five times longer than uncaged control roots. Thus the effects of this introduced ecosystem engineer appear to be greater near the range limit of mangroves.

Interactive effects of temperature and predation on behavior and risk for an invasive crab.

Oral presentation
Symposium Theme: Defining the environmental niche space of invaders using empirical and theoretical tools themes Session 9: Crab Invasions Time: 10:20 22/08/2013

authors:

Catherine de Rivera[1], and Gregory Ruiz[2],

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abstract:

Understanding factors that affect local to geographic distribution of organisms is central to ecology and can be used to help predict which areas will be impacted by nuisance species. Research has clearly shown that both abiotic and biotic resistance affect distribution of invading species. The interacting roles of these different types of resistance have not been as well studied, however. Here, we examine how temperature interacts with predation risk of the survival and foraging levels of European green crab, *Carcinus maenas*. We used two predators, separately, in tanks held at a constant temperature from 9-30°C: *Cancer productus*, which overlaps with *C. maenas* along estuaries in the northeast Pacific and *Callinectes sapidus*, the blue crab, which overlaps with *C. maenas* along the northwest Atlantic. We hypothesized that predation pressure would diminish and therefore foraging increase with increasing temperature if the predator is typical of cool temperate water, but predation pressure would increase, with decreased foraging, if the predator were warm-water adapted relative to its prey (at the northern part of its range) relative to the prey. We found that predation by *C. sapidus* was generally higher than that by *C. productus* and occurred from 12-30°C, while *C. productus* only preyed on *C. maenas* at 9°C. *Carcinus maenas* foraging also varied across the combinations of water temperature and predator species. Therefore, impacts of *C. meanas* are expected to vary with changing temperatures, but not linearly, and the effects of warming are expected to interact with predation differently across the coasts.

Post-larval recruitment in the non-indigenous colonial ascidian *Botryllus schlosseri* within a subarctic harbour: seasonal, vertical, and substrate selection patterns.

Oral presentation
Symposium Theme: Other Session 8: Tunicate Invasions Time: 11:40 22/08/2013

authors:

Kevin C. K. Ma[1], Don Deibel[1], J. Ben Lowen[1], and Cynthia McKenzie[2]

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abstract:

Botryllus schlosseri (Tunicata: Ascidiacea) has established extensive populations along the south coast of insular Newfoundland. This non-indigenous species is of immediate economic concern to industry, management, and policymakers in Newfoundland because ascidians are a threat to sustainable bivalve aquaculture in Atlantic Canada. A population of *B. schlosseri* within Arnold's Cove harbour, Placentia Bay, was studied to examine the recruitment phase of its life cycle. Specifically, we determined the phenology in post-larval recruitment, spatiotemporal variability in recruitment rate, larval substrate selection, and the relationship between recruitment and the prevailing abiotic factors. Sets of artificial plates were moored at 3 locations within the harbour (ca. 10 to 15 m apart) for a period of 4 weeks from March 2010 to November 2011. Plates consisted of different substrate types (aluminum, PVC, and wood; only PVC in 2011) that were randomly assigned to 3 subtidal depths at 1.0, 2.5, and 4.0 m below the surface. Annual recruitment from August to mid-October (ca. 2.5 months) was constrained by temperatures >12°C, as in its temperate range. Maximum recruitment rates were observed coincident with maximum seasonal seawater temperature in September. Recruitment rates were greater near the surface than at other depths, and on PVC than on the other substrates. The evaluation of recruitment patterns of aquatic invasive species is a vital part of a science-based management approach to develop best practices to monitor and control these species. Future control efforts should target the upper few metres of the water column in July, just before the annual onset of *B. schlosseri* recruitment.

User-friendly and evidence-based tool to predict the probability of eradication of aquatic non-indigenous species.

Oral presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems Session 1: Management of Invaders Time: 10:40 20/08/2013

authors:

David Drolet[1], Andrea Locke[2], Mark Lewis[3] and Jeff Davidson[1]

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[3]Departments of Mathematical Sciences and Biological Science, University of Alberta, 455B CAB, Edmonton, Alberta, Canada, T6G 2G1

abstract:

Managers should attempt eradication whenever the potential costs of an invasion exceed the costs of permanently removing the unwanted sprecies. However, this cost-benefit analysis is plagued by uncertainty associated with the probability of success of different management options. We present a user-friendly application developed to predict the probability of eradication based on scientific data. The software's backbone is an inferential statistical model fitted to 141 case studies. Using four incursion characteristics and three management variables, the model can independently predict the outcome of over 90% of past case studies. The user can 1) rapidly obtain a quantitative probability of success (with associated uncertainty) of a planned intervention, 2) contrast different management scenarios, and 3) prioritize information acquisition if some factors are unknown. Our framework is flexible, simple to implement, and assimilates new data as it becomes available. Similar applications could be built for any conservation/management problems. However, a big limitation is the availability of data; hopefully this work will provide an incentive for managers to quantify and publish the results of their work.

Incorporating biotic interactions into species distributions modeling: creating community assemblages using interactive community distribution modeling.

Oral presentation
Symposium Theme: Defining the environmental niche space of invaders using empirical and theoretical tools themes Session 4: Invasion Niche Time: 10:20 21/08/2013

authors:

Kristina Enciso[1] and Brian Leung[1]

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abstract:

Species distribution models (SDM) have seen widespread use to gain a better understanding of ecological processes and steer policy, especially in invasion ecology. SDMs use statistical methods to describe the relationship between environmental gradients and species distributions. Ecological niche theory states that species distributions are determined by both biotic and abiotic factors. Unfortunately, rarely do SDMs incorporate biotic interactions. Data on biotic interactions and more broadly community dynamics are quite often difficult to obtain and to quantify. Despite the increasing usage of current SDMs in ecological studies and management policies, model accuracy will likely suffer without including biotic functions. These limitations are further exacerbated with invasive species due to the lack of knowledge surrounding their distributions and interactions within the native community. We develop a novel approach interactive community distribution modelling to create community assemblages of invaded ecosystems, even when data on full communities have not been measured in the same place or time. The iCDM was tested using artificial species communities. A SDM for each species within the community was created. These SDMs were integrated in an iterative process to capture the full range of community interactions. iCDMs provide a more complete picture of ecological and environmental factors that contribute to invasive species growth and spread, increases the current body of knowledge, guide management efforts, and can pinpoint areas of future research.

The impact and control of invasive species in Australian mussel culture.

Oral presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems Session 1: Management of Invaders Time: 2:40 20/08/2013

authors:

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[1]Sustainable Aquaculture Laboratory – Temperate and Tropical (SALTT), Department of Zoology, University of Melbourne, Parkville, Victoria, 3010, Australia.

abstract:

Biofouling is one of the most significant threats to aquaculture operations worldwide through increasing production and management costs and decreasing product value. A similar suite of fouling organisms turn up in production areas around the world, having been transferred via shipping, and readily foul infrastructure such as ropes, cages, nets and bivalve shells. Port Phillip Bay (PPB), located in temperate southern Australia, has supported a thriving marine aquaculture industry for over 20 years, cultivating the blue mussel *Mytilus galloprovincialis*. However, biofouling by non-indigenous organisms is becoming a critical industry bottleneck. This research determined that fouling by three key non-indigenous species (*Ciona intestinalis*, *Styela clava* and *Ectopleura crocea*) can deter mussel recruitment, prey upon mussel larvae and impede mussel growth and condition. Several methods for control were assessed including freshwater, heated seawater and eco-friendly chemical immersions. Additionally, farm management techniques such as mussel density, rope type, rope depth and line spacing were also investigated to develop some practical strategies for mitigation. The occurrence of biofouling in marine aquaculture is a significant issue resulting in increased operational expenses and negative impacts on the species being cultured. As the marine environment changes and the industry grows, so too will the problems being faced. Clearly, fouling prevention rather than mitigation is desirable, both ecologically and economically. Whilst the aquaculture industry remains a step behind other maritime industries in control methods, it can also benefit from the broader research effort across these industries to solve this cosmopolitan, persistent and complex problem.

Scientific knowledge and the managament of marine pests: lessons learned with the ascidian *Didemnum vexillum* in New Zealand.

Oral presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems Session 1: Management of Invaders Time: 4:20 20/08/2013

authors:

Lauren Fletcher [1], Barrie Forrest [1] and James Bell [2]

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[1]Cawthron Institute, Private Bag 2, Nelson 7042, New Zealand.
[2]School of Biological Sciences, Victoria University of Wellington, PO Box 600, Wellington 6140, New Zealand.

abstract:

The colonial ascidian *Didemnum vexillum* is a recent successful invader in temperate marine communities worldwide, and is a recognised threat to commercial shellfish industries and natural environments. *Didemnum* was first recorded in the Marlborough Sounds, New Zealand's most important aquaculture region, in late 2001 and was the focus of intensive regional management for several years. An initial bay-scale eradication attempt in 2003 utilised a range of control strategies, however these were largely implemented in the absence of information on the biological processes underpinning *Didemnum*'s invasion success. Following establishment on a mussel farm in 2006, a subsequent regional surveillance and eradication programme was initiated, in conjunction with scientific research addressing knowledge gaps. Results of this research programme and the implications for management are presented, specifically assessment of *Didemnum*'s reproductive seasonality, natural dispersal potential, and negative impacts on mussel aquaculture. Our findings indicate that, contrary to assumptions based on overseas studies of *Didemnum*, and literature for related species, *Didemnum*'s biological atributes and behaviour in New Zealand make it harder to successfully manage than first envisaged. This situation highlights the limitations in inferring invasion potential of newly introduced species from other situations (e.g. other places, times, and related species). Management of marine pest species is notoriously difficult, ultimately requiring an indefinite commitment of resources to provide any lasting benefit. Even so, an understanding of a species' biological attributes with reference to local environmental conditions will greatly assist with management decisions, although difficulties remain with regards to timely availability of this information.

Importation of baitworms and their live algal packing materials to the Mid-Atlantic: vector characterization.

Oral presentation
Symposium Theme: Evaluating vectors for invaders and modes of transport
Session 3: Invasion Vectors Time: 4:40 21/08/2013

authors:

Amy E. Fowler[1], April M.H. Blakeslee[1 2], A. Whitman Miller[1], Fredrika Moser[2], João Canning-Clode[1 4] and Gregory Ruiz[1]

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[4]IMAR - DOP, University of the Azores; Center of Oceanography, University of Lisbon Campo Grande, Lisbon, Portugal

abstract:

Maine polychaetes (*Glycera dibranchiata*) are used extensively as bait in the Mid-Atlantic (New Jersey, Maryland, Delaware, Virginia, and North Carolina, USA) and abroad, and dealers ship live baitworms from Maine, USA, packed in live algae (mainly *Ascophyllum nodosum ecad scorpioides*) globally over-night. Packing algae used are associated with numerous organisms (mostly small invertebrates), which can hitchhike with bait shipments, thus providing opportunities for possible introductions. For example, three key invasions on the US West coast have been attributed to this vector – European green crab (*Carcinus maenas*), rough periwinkle snail (*Littorina saxatilis*), and the packing algae itself. Little is known regarding possible impacts of this vector in the Mid-Atlantic, nor is there any baseline information regarding diversity and abundance of organisms transported to the region. Therefore, our study assessed diversity and abundance of macro-organisms associated with baitworms/packing algae at three levels along the vector pathway: 1) Maine source habitats; 2) bait-boxes shipped from Maine distributors; and 3) bait-boxes sold in the Mid-Atlantic (in the five States listed above). Organisms were counted and identified to lowest taxonomic level seasonally from 2011-2012, and preliminary results indicate that diversity and abundance of associated biota decreases along this stepwise operation. However, there remains a large number and diversity of viable invaders arriving in recipient regions. Given the active nature of this vector, results from our study reflect the risk of introduction to other recipient regions, including global destinations like Europe, and serve as a model system for understanding live bait vectors around the world.

Simulated transport conditions may select for stress-tolerant individuals in potentially invasive founder populations of *Mytilus galloprovencialis*.

Oral presentation
Symposium Theme: Determining invaders' responses to changing waters during transport
Session 3: Invasion Vectors Time: 3:20 21/08/2013

authors:

Marie Garcia[1], Filipa Antunes[2], João Canning-Clode[3 4 5], Mark Lenz[6] and Martin Wahl[6]

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abstract:

Successful marine invasive species possibly possess a higher physiological and/or genetical potential to establish in new environments than non-successful invasive species. During transport to new habitats, invaders might pass through a selective process during which they suffer from environmental stress. Conditions during human induced transport like long-term temperature increase on ship hulls or air exposure in land over transport in fishing gear might lead to selection for more stress tolerant individuals. The native marine invertebrate *Mytilus galloprovencialis* in Portugal has already established stable invasive populations along the Pacific coast of North America. At the Marine Laboratory of Guia we exposed individuals of *Mytilus galloprovencialis* to air exposure, hyposalinity and heat temperatures, respectively, to mimic stress conditions during transport. Mussels were acclimatized in water baths to lab conditions for a one- week period. Experiments were designed in a two step procedure. During a first stress phase a subsample of 160 organisms suffered 80% mortality. Survivors recovered through an additional two week period and immediately stressed again during a second stress phase. Non pre-stressed organisms were exposed to the second stress phase as well. Mortality, byssus production and BCI for individuals of *M. galloprovencialis* were observed during the second stress phase. The present study is part of a global investigation on the stress conditions marine invaders are subjected to during transport, executed within the framework of the international training and research program GAME (Global Approach by Modular Experiments). Global results show that within pre-stressed individuals mortality is lower during the second stress compared to mortality within the non pre-stressed individuals, what fits to our hypothesis.

Spatio-temporal patterns of variation in the abundance of the European shore crab, *Carcinus maenas* in estuaries of New South Wales, Australia.

Oral presentation
Symposium Theme: Other Session 9: Crab Invasions Time: 11:40 22/08/2013

authors:

Clifford Garside[1] and Melanie Bishop[1]

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abstract:

Carcinus maenas is an omnivorous crab native to the northeast Atlantic. It is among the world's worst invasive species, establishing populations in North America, South America, Japan, South Africa and southern Australia, where it was first detected in Port Phillip Bay, Victoria over 100 years ago. Despite predictions that the environmental tolerances and opportunistic life history of *C. maenas* would enable it to rapidly spread from Port Phillip Bay to southern Queensland, its Australian distribution remains limited to the south and its abundance is low in New South Wales. One potential explanation for the disparity between the predicted and observed distributions is the coastline of southern NSW and Victoria is dominated by Intermittently Open and Closed Lakes and Lagoons (ICOLLs) which may limit crab population connectivity and have environmental conditions unsuitable for persistent populations. ICOLLs entrances alternate between being open and closed to the ocean, according to wind, wave, tidal and precipitation patterns. We tested the hypotheses that (1) permanently open lakes would contain more *C. maenas* than intermittently open lakes, and (2) among ICOLLs, those that are predominantly open would support larger populations of *C. maenas* than ones predominantly closed. Within 14 coastal lakes representing the different estuarine entrance morphologies, we performed quarterly trapping surveys over a two year period. Surveys failed to detect crabs in ICOLLs with entrances that are mostly closed to the ocean. Estuaries with permanently open entrances had fewer crabs than estuaries that periodically open and close. Differences in crab abundance among estuarine type may reflect differences in environmental conditions, connectivity to the marine environment, available habitats or predator assemblages.

Same ascidian, different substrate: Early stages of establishment in natural environments of the non-indigenous ascidian *Herdmania momus*.

Oral presentation
Symposium Theme: Other Session 8: Tunicate Invasions Time: 10:00 22/08/2013

authors:

Mey-Tal Gewing[1] and Noa Shenkar[1]

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abstract:

Among the most extensively documented phenomena of marine bioinvasion is the introduction of species from the Red Sea to the Mediterranean via the Suez Canal (known as Lessepsian migration). One such species is the solitary ascidian *Herdmania momus*. Unlike most Lessepsian ascidians, *H. momus* has been comprehensively studied and monitored during the past several years. Along the Mediterranean coast of Israel, *H. momus* distribution is associated with anthropogenic activity and it has been restricted to artificial substrates. Recently, we have been witnessing its spread to natural substrates. The solid database that exists on *H. momus* ecology and life history in both native and introduced environments, and the early detection of its expansion to natural substrate, make it an ideal candidate for studying establishment patterns of introduced ascidians. In order to asses *H. momus* current distribution periodical field surveys are conducted along the Mediterranean coasts of Israel. In addition we are expanding our data base through brochures presenting *H. momus* and marine bioinvasions circulated to recreational dive centers. Molecular tools are used to ascertain the genetic characteristics of the populations inhabiting the natural substrates, and histological sections determine their reproductive state.The full extent of *H. momus* spread in the Eastern Mediterranean and its impact on the local fauna is still unknown. Better understanding of dispersal and establishment patterns of non-indigenous ascidians in new environments may assist us in evaluating their possible impact on native communities and future dispersal to new regions, thereby providing valuable information for management and policy makers.

Establishment of marine alien species in a low diversity coral atoll.

Oral presentation
Symposium Theme: Defining the environmental niche space of invaders using empirical and theoretical tools themes Session 2: Factors Affecting Invasion Success Time: 4:20 20/08/2013

authors:

Scott Godwin[1], Holly Bolick[2] and Carey Morishige[3]

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[3]National Oceanic and Atmospheric Administration, Marine Debris Program, 1305 East West Highway, SSMC4 10th Floor, Silver Spring, MD 20910, USA.

abstract:

It has been hypothesized that biotic resistance to invasion is greater in high diversity tropical marine habitats due to stronger and more specialized interactions between species. These interactions are predicted to decrease success in the establishment of alien species. The coral reef habitats of the Hawaiian Archipelago; compared to other areas of the tropical Pacific; are characterized by lower diversity and high endemism. This lower diversity is exhibited in the paucity of native epifaunal growth on natural and man-made substrates. This creates a situation in which any predicted biotic resistance could be minimized in these epifaunal communities, especially for novel species. Preliminary species inventories for marine alien invertebrates in the Northwestern Hawaiian Islands at Midway Atoll recorded over 20 established species. The majority of these marine aliens at Midway Atoll were solitary tunicates, which are a poorly represented group in the native epifauna of Hawaii's coral reefs. These species were recorded on both natural and man-made substrates, which are closely associated at Midway Atoll. A review of the hypothesized importance of niche habitats, life history and propagule pressure in relation to the establishment of novel species in a low diversity coral atoll will be presented.

Assessing the value of population genetic datasets for the management of marine bioinvasions.

Oral presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems Session 6: Applying Molecular Tools Time: 3:00 21/08/2013

authors:

Sharyn Goldstien[1] and Graeme Inglis[2]

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abstract:

The link between genetic data and its application to the management of bioinvasions remains unclear. Rarely are we presented with an opportunity to incorporate genetic data from new incursions into invasive species data sets, yet sampling individuals as they arrive at the border is crucial to the advancement of bioinvasion knowledge and management. Here we use previously acquired genetic data to assign new incursions as they invade populations within New Zealand ports and marinas. We also investigated allelelic frequency change in these previously sampled populations over a two-year period, and assessed the effect of temporal genetic sampling on our ability to assign new incursions to their population of source. We observed spatial shifts in allele frequencies between sampling years, which were important in altering the assignment of new incursions. All of the five new incursions were assigned with highest probability to previous samples from the northern hemisphere. It is evident from this study that small samples obtained from rapid response and monitoring, in conjunction with on-going genetic sampling of important vessel nodes may assist pre-border management decisions. A proposal for the way forward may to be run a global genetic database alongside GenBank for use by managers and scientists dealing with new incursions.

Comparison of ballast management options on a vessel with uptake in freshwater - ballast water exchange in combination with and without a ballast water management system.

Oral presentation
Symposium Theme: Evaluating vectors for invaders and modes of transport
Session 3: Invasion Vectors Time: 10:00 21/08/2013

authors:

Stephan Gollasch[1], Matej David[2], Elizabeta Briski[3] and Sarah Bailey[3]

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abstract:

The International Ballast Management Convention includes provisions for two ballast water management options: ballast water exchange (BWE) and ballast water management systems (BWMS). While BWMS are expected to remove or exterminate most taxa from ballast water, BWE is particularly protective for freshwater ports by introducing a salinity barrier that reduces survival of freshwater taxa. As a result, a combination strategy using both BWE and BWMS might provide best available protection for freshwater ports. The main objective of this study is to evaluate the efficacy of the combined strategy through shipboard trials with freshwater ballast. Four treatment scenarios were selected for the test: 1) control (no treatment), this tank was filled in the freshwater Port of Hamburg; 2) BWE alone, this tank was filled in Hamburg, and exchanged in the Bay of Biscay >50 nautical miles from nearest shore in waters >200 metres depth; 3) BWMS alone; this tank was filled and treated on uptake using filtration and electrochlorination in Hamburg; and 4) BWE plus BWMS, this tank was filled and treated on uptake in Hamburg, and exchanged in the Bay of Biscay, with the incoming exchanged water again treated. All four tanks were discharged before arriving in Algeciras (Spain). Preliminary results from the first voyage indicate plankton (>50µm in minimum dimension) density decreased in all cases: BWMS alone (99.8%), BWE+BWTS (99.3%), control (90.3%) and BWE alone (89.8%). Additional work is underway to determine if taxa present after BWE are expected to have low survival if introduced to a freshwater port.

Risk assessment based exemptions from ballast water management – the Intra-Baltic study.

Oral presentation
Symposium Theme: Other Session 3: Invasion Vectors Time: 2:40 21/08/2013

authors:

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abstract:

Global requirements to prevent the transfer of harmful aquatic organisms and pathogens with ballast water were set by the International Convention for the Control and Management of Ship´s Ballast Water and Sediments (BWM Convention) . The BWM Convention includes that vessels on certain routes can be exempted from BWM requirements based on risk assessment (RA). RA needs to be conducted according to the International Maritime Organisation Guidelines for Risk Assessment under Regulation A-4 of the BWM Convention (G7 Guidelines). With the BWM Convention nearing its entry into force vessels will need to comply with requirements and the interest to conduct RA for exemptions becomes important. This paper presents a RA model for exemptions that might be granted in intra-Baltic shipping based on BWM Convention, G7 Guidelines as an elementary framework and also noting the regionally agreed Helsinki Commission RA guidance for exemptions for Baltic countries. We discuss the RA methods and elements that were selected for the application of ballast water management exemptions in intra-Baltic shipping. This is worldwide the first RA model for ballast water management exemptions under the provisions of the BWM Convention. The current lack of reliable information regarding alien and cryptogenic species, as well as human pathogens present in port areas of the ballast water donor and recipient points were found as most limiting factor to conduct RA. However, this study may be of particular interest for regional seas with similar RA relevant features, such as intensive shipping and different salinities throughout the sea.

Assessing the ecological characteristics and the demographic strategies of two alien crabs of the Hemigrapsus genus: experimental and in situ observations.

Oral presentation
Symposium Theme: Defining the environmental niche space of invaders using empirical and theoretical tools themes Session 9: Crab Invasions Time: 10:40 22/08/2013

authors:

Moâna Gothland[1], Nicolas Spilmont[1 2], Lionel Denis[1], Tarik Meziane[3], Laurent Seuront[1] and Jean-Claude Dauvin[4]

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[2]Environmental Futures Centre, Griffith University, Gold Coast QLD 4222, Australia.
[3]Biologie des organismes Marins et Ecosystèmes, Département Milieux et Peuplements Aquatiques – BOREA UMR CNRS 5178, Musée National d'Histoire Naturelles, Université Pierre et Marie Curie, F-75231 Paris, France.
[4]Université Caen Basse-Normandie, Laboratoire Morphodynamique Continentale et Côtière – M2C UMRCNRS 6143, F-14000 Caen, France.

abstract:

The presence of two Asian decapods crustaceans, *Hemigrapsus sanguineus* (Asakura & Watanabe, 2005) and *Hemigrapsus takanoi* (de Haan, 1835), along the French coast illustrates the impacts that invasive species may have on the biodiversity and the functioning of coastal and littoral ecosystems. These species, native from the northwestern Pacific, were most probably introduced to the European coast via ballast waters and/or by Asian oysters' importation. A survey of the spread of both species along the French coast of the English Channel was initiated in April 2008. In 2012, a total of 74 sites were prospected along ca. 700 km of coastline. Data were collected annually and/or monthly to assess (i) the demographic strategies of both species (average abundances, densities, breeding season and period of recruitment, sexual maturity, survival rate) and (ii) ecological characteristics of their habitat, such as sediment nature (proportions of silt, sand and coarse gravel), space use (seasonal distribution on the shore) and food preferences of these alien crabs (fatty acids and isotopic analyses (δ13C, δ15N), experimental behavioral observations). We show that *H.sanguineus* and *H. takanoi*, through their demographic behaviors correspond to populations with a 'r-like' strategy, probably in the transition from the 'expansion phase' to the 'persistence phase'. We also underline that these species have their own sedimentary ecological niche, spatial and food preferences thus allowing the description of their environment.

To look or not to look, is that the question? Marine biosecurity challenges in New Zealand: past, present and future.

Oral presentation
Symposium Theme: Other Session 1: Management of Invaders Time: 12:20 20/08/2013

authors:

Brendan Gould[1], Simon McDonald[1], Tim Riding[1], and Graeme J. Inglis[2]

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abstract:

Over a decade on and marine biosecurity management within New Zealand has developed and grown significantly. A comprehensive science based programme has evolved and has now been integrated into New Zealand's broader biosecurity system. This has bought with it significant benefits particularly around alignment and integration but also the shared learning's and application of the extensive wealth of knowledge that exists in other areas, i.e. animal and plant health biosecurity. However, it has also created a range of challenges and hurdles which have to be navigated or overcome to ensure that the progress to date is maintained and that it is able to compete with the priorities arising out of the changing economic and political environments. In this presentation I aim to provide some insights and perspectives from the New Zealand experience.

The value of intraspecific biogeographic comparisons in elucidating potential mechanisms underlying invasion success.

Oral presentation
Symposium Theme: Other Session 4: Invasion Niche Time: 10:40 21/08/2013

authors:

Paul Gribben[1], Sam I'Ons[1], Nicole Phillips[2], Shane Geange[2] and Jeffrey Wright[3].

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abstract:

Studies indicate that changes in fitness related traits may contribute to the, sometimes, 'super' abundance of species in their introduced ranges. Yet, trait and abundance studies are typically studied separately - researchers commonly employ meta-analytic techniques to multispecies data sets to establish relationships between changes of traits and abundance between invaded and native ranges. Intraspecific studies designed to test for changes in life-history traits and population parameters between introduced and native ranges provide powerful examinations of potential mechanisms underlying successful invasion, although such studies are rare. We used a biogeographic approach to directly compare patterns of life-history traits and abundance for the porcelain crab *Petrolishthes elongatus* between its native (New Zealand) and invasive (Tasmania, Australia) ranges. Specifically, we tested the hypotheses that *P. elongatus* is (i) more abundant and (ii) has a larger body size in its invasive range compared to its native range. Because porcelain crabs are sexually dimorphic we also tested the hypothesis that (iii) any changes in body size are independent of sex. Males but not females were larger in Tasmania compared to New Zealand. Abundances also differed between native and invasive regions but were dependent on tidal height, indicating a potential shift in habitat use in Tasmania. Here we provide a link between trait changes and the higher abundance of *P. elongatus* in its invaded compared to native range. The next step will be to determine understanding the mechanisms that drive trait changes.

Resolving the conflict: eradication of invasive hybrid *Spartina* and the recovery of the California Clapper Rail

Oral presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems Session 1: Management of Invaders Time: 4:40 20/08/2013

authors:

Edwin Grosholz[1], Adam Lampert[1] and Alan Hastings[1]
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abstract:

Conflicts unfortunately arise among the competing management goals in complex ecosystems. Luckily, there have been surprisingly few examples where an invasive species eradication program has run into conflict with an endangered species recovery program. We present results from long-term field data and simulation models that predicts the optimal strategy for balancing the eradication of hybrid cordgrass (*Spartina alterniflora* x *foliosa*) and the recovery of the federally endangered California clapper rail CLRA (*Rallus longirosrtis obsoletus*) in salt marshes in San Francisco Bay, CA. The *Spartina* eradication program has resulted in the broad scale elimination of invasive hybrid cordgrass, however this program was 'derailed' due to significant declines in clapper rail populations coincident with eradication. Consequently, a segment of the invaded region remains untreated to maintain CLRA populations, which now use invasive hybrid *Spartina* as nesting habitat in the absence of native *S. foliosa*. A key to CLRA recovery is manual planting of the native *Spartina* to provide new habitat quickly for breeding CLRA . Our results show that given the cost-benefit tradeoffs, extensive manual planting of native *Spartina* is not the optimal strategy depending on the speed of natural regrowth on native *Spartina*. Under most scenarios, the optimal strategy would be to invest heavily in natural recovery of native *Spartina* and to slow down eradication accordingly. Therefore, the most efficient approach to eradication would be one that is less intense, but spans a longer timeframe. This strategy sharply contrasts the optimal eradication strategy in the absence of clapper rails, which would be to eradicate all invasive *Spartina* as fast as possible. We suggest that this modeling approach would apply broadly to similar conflicts in the future, where a high priority invader provides habitat or trophic support for an endangered species resulting in conflicting management goals.
Twitter Feed: A model balancing a rare conflict between endangered species recovery eradication of invasive species eradication in San Francisco Bay, CA

Mytilus trossulus: control and management of a nuisance species on Scottish shellfish farms.

Oral presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems Session 1: Management of Invaders Time: 3:00 20/08/2013

authors:

Matthew Gubbins[1], Darryl McLennan[1], Mike Snow[2], Joanna Dias[2], Guillaume Hermann[1] and Iveta Matejusova[1]

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abstract:

The presence of thin-shelled, poor meat yield *Mytilus trossulus* was first recorded on Scottish shellfish farms in Loch Etive (a west coast sea loch) in 2005 and this species has subsequently dominated the mussel communities on aquaculture facilities the loch. Loch Etive has historically supported a large production tonnage of farmed mussels using rafts and longlines across approximately 10 farming sites. Today mussel farming is unviable in the area as a result of dominance by *Mytilus trossulus*. Diving surveys of the area have shown that *M. trossulus* (identified by species specific real-time PCR) is predominantly present on artificial structures in low salinity surface waters of the loch and that on deeper natural substrates it is either absent or a very small proportion of the mussel community. Consequently, removal of adult spawning stock from aquaculture facilities and artificial structures is likely to remove the majority of *M. trossulus* from the loch. In January 2010 growers in the area signed a management agreement to physically remove all mussels from on-growing equipment. Marine Scotland Science has monitored the removal of mussels, local water quality and the proportion of *M. trossulus* alleles in the plankton to determine the efficacy and effects of this eradication attempt. These results are presented alongside a draft Code of Practice for the shellfish industry to manage any potential for spread of *M. trossulus* from affected areas and so minimise any future impacts.

Rising water temperatures and calcareous tubeworm fouling on an oyster lease in Nova Scotia, Canada: how molecular biology can assist in developing mitigation strategies.

Oral presentation
Symposium Theme: Other Session 6: Applying Molecular Tools Time: 3:20 21/08/2013

authors:

Sarah Stewart-Clark[1] and Stephanie Hall[1]

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abstract:

Fouling organisms can cause significant challenges to shellfish aquaculture operations, and calcareous tubeworms are the latest organism to cause significant fouling in an oyster lease in Nova Scotia, Canada. In this study, molecular assays were developed to detect the presence of larval stages of the calcareous tubeworms in water samples around the oyster lease to evaluate time of year, water temperature, and placement in water column where the larvae are present in highest concentrations. This information will be used by the oyster grower to implement the appropriate management strategy to manage oyster bag flipping, oyster bag placement in the water and other mitigation strategies during the time of the year when calcareous tubeworm larval settlement is at its peak. Molecular assays can provide powerful high-throughput monitoring capabilities which provide real time information to shellfish growers so that they can make the most informed decisions regarding mitigation efforts to reduce fouling on their farms.

The transformation of Southeastern salt marshes by the invasive seaweed, *Gracilaria vermiculophylla*.

Oral presentation
Symposium Theme: Evaluating the success of invaders in transitionary waters such as estuaries and waters that are changing as a result of anthropogenic activities
Session 2: Factors Affecting Invasion Success Time: 12:20 20/08/2013

authors:

Linsey Haram[1] and James Byers[1]

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[1]Odum School of Ecology, University of Georgia, 140 E. Green St., Athens, GA 30602

abstract:

The invasion of estuaries by the red seaweed *Gracilaria vermiculophylla* continues to expand along the coasts of Europe and North America. Of particular interest is the *G. vermiculophylla* invasion in coastal communities of Georgia and South Carolina, U.S.A. Unlike other invaded regions across the globe, these states have very low diversity of native macroalgae, making *G. vermiculophylla* an entirely new life form in this region. Such an introduction may have transformative consequences for these soft-bottom ecosystems by providing a novel food source and habitat. Using a series of laboratory trials and in situ mesocosm experiments, I investigate the role that *G. vermiculophylla* plays in the Southeast, asking: How does the invasive seaweed, *Gracilaria vermiculophylla*, affect the trophic and physical structure of Southeastern estuaries? How do the seaweed's contributions change along a gradient of eutrophication? Additionally, I investigate how the *G. vermiculophylla* invasion in Georgia and South Carolina compares to that of the greater East Coast of the United States. Through a rapid assessment of populations to the north and south of Georgia and South Carolina I aim to illuminate what anthropogenic, environmental, and ecological factors control *G. vermiculophylla* abundance.

The positive effects of an intertidal ecosystem engineer are weaker in its invaded range.

Oral presentation
Symposium Theme: Other Session 2: Factors Affecting Invasion Success Time: 4:40 20/08/2013

authors:

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[2]Centro Nacional Patagónico (CENPAT-CONICET), Blvd. Brown 2915, Puerto Madryn (U9120ACD), Argentina.

abstract:

Invasive species are frequently assumed to have stronger ecological impacts in their invaded ranges, where their specific traits and ecological functions may be novel, than in their native ranges, where they have co-evolved with the rest of the community. Although much attention has been devoted to negative interactions such as competition and predation, less attention has focused on the relative strength of positive interactions between native and invaded ranges. We tested the effects of an important ecosystem engineer, the acorn barnacle *Balanus glandula*, on high intertidal communities in its native range in British Columbia, Canada, and in its invaded range in Chubut province, Argentina. Both regions support herbivorous limpets (true limpets in BC, pulmonate limpets in Argentina), ephemeral algae, and perennial algae. However, no mid- to high-intertidal barnacle existed in Chubut prior to the introduction of *B. glandula*. In both regions, *B. glandula* facilitated ephemeral algae, and limpets were able to reduce ephemeral algal cover in plots with and without barnacles. However, some of the strong positive effects of *B. glandula* in its native range, such as facilitation of herbivore abundance and perennial algal cover, were neutral in its invaded range. Although there was no identifiable negative effect of *B. glandula* on the taxa we investigated in Argentina, the overall facilitative effects of *B. glandula* were weaker in its invaded range, suggesting that the strength of facilitative relationships such as ecosystem engineering may also have some basis in coevolutionary history.

British Columbia's *Spartina* eradication program – a long path to success?

Oral presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems Session 7: Fish Invasions Time: 5:00 21/08/2013

authors:

Leif-Matthias Herborg[1], Dan Buffet[2], Becky Brown[3] and David Ralph[4]

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[3]Becky Brown, BC Ministry of Forests, Lands and Natural Resource Operations, 727 Fisgard Street, V8W 9C1,Victoria, BC, Canada.
[4]David Ralph, BC Ministry of Forests, Lands and Natural Resource Operations, 441 Columbia St,Kamloops, V2C 2T3, BC, Canada.

abstract:

Three non-native *Spartina* species have invaded BC over the last 30 years, *Spartina anglica* in the Fraser Delta, *S. densiflora* on the east coast of Vancouver Island, and *S. patens* in the Vancouver Area. Since 2004 an active eradication program in the Fraser Delta (Vancouver) has been underway with a focus on mechanical removal of the species. In 2010 BC joined a West Coast wide initiative to eradicate *Spartina* sp along the whole coastline, in a concerted effort with Washington, Oregon and California. At the same time it became clear that despite the best efforts by the *Spartina* Working Group that mechanical removal is unlikely to succeed to control and eradicate these species. So the same year steps towards a integrated pest management plan were started that include mechanical as well as chemical treatment of *Spartina*, with an initial focus on the Fraser Delta. The required federal and provincial registration process has been ongoing since July 2010 and at the time of writing it is not clear if permits will be in place for the 2013 field season. Detailed GIS based monitoring over the last few years also indicate that we are reaching a critical time window for control due to the shift from the lag to the exponential phase of the *Spartina* population in the Fraser Delta. We will be discussing this real life intertidal eradication programme, the lessons learned, major challenges to such an undertaking and the future outlook.

The Burnaby snakehead – how we caught it and what we learned.

Oral presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems Session 1: Management of Invaders Time: 4:40 20/08/2013

authors:

Leif-Matthias Herborg[1], Jonathan Moore[2], David Scott[2], Cathryn Clarke Murray[3] and Natasha Serrao[4]

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[4]Natasha R. Serrao, Fish Barcode of Life Initiative, Canadian Barcode of Life Network, Science Complex, University of Guelph, N1G 2W1, Guelph, Ontario, Canada

abstract:

A video of a snakehead in a pond in Burnaby (Vancouver) on YouTube created major public concern. The waterbody was also only one kilometer away from the Fraser River and with a small connecting stream, leading to a joint Provincial and Municipal Rapid Response. After an initial assessment it became clear that netting would be a feasible approach to removal. The likelihood of success was further increased by the ability to drain parts of the lake down to reduce depth and surface area. Intensive netting was able to remove one adult snakehead and found no other adults or juveniles. It also highlighted that this particular pond contained no native fish or amphibian species, but rather seems to have been a release spot for koi, carp, fathead minnows, bullheads, American bullfrogs and red-eared slider turtles over the years. DNA barcoding and classical taxonomic assessment identified the one adult snakehead removed as a blotched snakehead, *Channa maculate*, a tropical species. Further stable isotope analysis of that specimen, in comparison with other snakehead specimen obtained from food markets and aquarium stores determined that the fish was only a few month in the pond. This highlights the value of close collaboration of provincial and academic institution to extract the maximum amount of information from a single specimen. While dealing with media presence and public scrutiny throughout the rapid response was a challenge at times it also led to new legislation banning all snakeheads from possession, transport, trade and breeding in BC.

Facilitated dispersal: overwhelming biogeographic boundaries.

Oral presentation
Symposium Theme: Other Session 3: Invasion Vectors Time: 12:00 21/08/2013

authors:

Chad Hewitt[1] and Marnie Campbell[2]

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abstract:

As environmental stressors increasingly impact on coastal marine communities the focus of science underpinning management is increasingly concerned with determining factors influencing resilience. While many disturbance events are natural aspects of marine ecosystems, the resilience of stressed systems can become increasingly compromised, with substantial evidence from small scale studies suggesting that tipping points can be reached leading to substantial shifts from one stable state to another. The spatial scale of dispersal as a key driver of connectivity between separated habitats is critical to understand the functional resilience of ecosystems. The traditional assumption that marine systems operate in open fashion with decoupling of larval-supply from local constraints is confronted with evidence that many species have limited larval dispersal distances, effectively reducing connectivity or belying significant reliance on a suite of networked sites functioning as metapopulations and increasingly vulnerable to degradation. Empirical studies of connectivity in marine ecosystems have concentrated on larval dispersal, evaluating population genetic structure to detect connections between spatially disparate sites. These studies report the natural connectivity across spatially connected networks, but have ignored the role of anthropogenic factors that facilitate dispersal. We report a case study of the potential for anthropogenic facilitated connectivity associated with coast-wise movement of vessels in the Australian context. Evaluations of this type have previously demonstrated the probable introduction and spread of non-native species and ignored the contribution to native species transport across biogeographic barriers.

A tale of three coasts: Spatial and temporal variation in ballast water management to reduce invasion risk.

Oral presentation
Symposium Theme: Evaluating vectors for invaders and modes of transport
Session 3: Invasion Vectors Time: 10:40 21/08/2013

authors:

Kimberly Holzer[1], Katharine Carney[1], Mark Minton[1], A. Whitman Miller[1] and Gregory Ruiz[1]

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abstract:

Shipping acts as an important driver of changing species composition in seaports and coastal waters around the globe due to the massive transfer of organisms associated with ballast water and hull fouling. Although this is widely appreciated, shipping exhibits a high level of temporal and spatial variation, which has consequences for invasion dynamics that are underexplored. Here we compare commercial vessel traffic patterns and ballast water management through time for three major U.S. port systems: Chesapeake Bay (East Coast), Galveston Bay-Houston (Gulf Coast) and Prince William Sound (West Coast). In the Chesapeake Bay most ballast is discharged from overseas vessels, and the annual volume of reported overseas ballast discharge has increased 10-fold since 2005 to approximately 22 million m^3 in 2012. Although the proportion of reported annual coastwise and overseas arrivals to Gulf Coast ports remains similar, the rate of ballast discharge has tripled in the last 8 years to 34 million m^3 $year^{-1}$. In contrast, Prince William Sound continues to receive the majority of its ballast water from coastwise routes, also exhibiting a 3-fold volume increase in ballast water discharge reported from 2005–2012, reaching 12 million m^3 $year^{-1}$. This study further examines the current status and limitations of ballast water management in each region, creating strong geographic differences in vessel behavior, organism transfer and invasion potential.

Assessing the global impact of marine invasive crabs: a meta-analysis.

Oral presentation
Symposium Theme: Evaluating vectors for invaders and modes of transport
Session 9: Crab Invasions Time: 10:00 22/08/2013

authors:

Brett Howard[1] and Isabelle Côté[1]

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abstract:

Invasions by marine crabs (including the European green crab, Chinese mitten crab, and Japanese shore crabs) continue to occur worldwide, and there is growing concern that these species are capable of severely affecting native species and habitats. This has generated a large body of experimental research attempting to quantify the impact of these invaders. However, the results are often contradictory and limited in scale or scope. This variability hampers invasive species management because it is difficult to anticipate the true effect of invasive crabs. We conducted a meta-analysis of the published manipulative experiments to assess the overall effect of marine crabs (both invasive and native) on a variety of indigenous species. We found that invasive marine crabs have a greater negative effect on the survival of native prey species, particularly bivalves, than native crab species, but invasive crab species vary significantly in their predatory impact. Our results support the current perception that invasive crab species have high dietary versatility and consumption rates, which allow them to become successful and detrimental aquatic invaders.

A risk assessment model for ballast water exchange along major shipping routes in the Canadian Eastern Arctic.

Oral presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems Session 3: Invasion Vectors Time: 2:20 21/08/2013

authors:

Kimberly Howland[1], Shannon Nudds[2], Charles Hannah[2], D. Bruce Stewart[3], Jeff Higdon4, Tim Siferd[1], Robert Stewart[1], Margaret Treble[1] and Christopher Wiley[4]

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abstract:

We developed a semi-quantitative model to assess relative risks of ballast water dispersion along major vessel tracks in the Canadian Eastern Arctic with the objective of evaluating suitability of existing alternate ballast water exchange zones (ABWEZs) in this region. In this model we simulated ballast water exchange as the release of particles at various segments of a given vessel track into the surface layer of circulation models for Baffin Bay - Davis Strait - Labrador Sea and Lancaster Sound. The following metrics were individually computed and then combined to assess level of risk: 1) arrival time or the time it takes particles to reach a given zone and 2) frequency of occurrence or the percentage of total particle-days spent within a given zone. Zones within the region of interest were delineated based on a combination of depth and seasonally variable environmental characteristics expected to result in different levels of invasion risk in the event of introductions. Since the relationship between different zones and level of invasion risk has not been empirically demonstrated in this region, we used different weighting schemes to test the sensitivity of the model to these parameters. Our model was robust to different weighting schemes and consistently identified the same regions as being high risk. Results show that existing ABWEZs in the Lancaster Sound and Hudson Strait areas are at highest relative risk for introductions of invasive species and lower risk portions of major vessels tracks should be considered as alternatives. These include the Labrador Sea portion of all vessel tracks, and along the Baffin Bay – Davis Strait deep offshore vessel track at depths of greater than 1000 m.

Optimising surveillance for multiple marine pests using stochastic scenario tree models.

Oral presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems Session 1: Management of Invaders Time: 11:00 20/08/2013

authors:

Graeme Inglis[1], Don Morrisey[2], Brendan Gould[3] and Simon McDonald[3]

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abstract:

Risk-based surveillance is typically more efficient for detecting rare events, such as incursions by non-indigenous species, than conventional random or systematic sampling designs. The relative efficiency of risk-based surveillance depends on the accuracy of prior knowledge (or judgements) used to estimate the likelihood of the event occurring in different units of the survey population. In risk analysis, hierarchical probability models (Scenario Trees) are used widely to evaluate the likelihood of different outcomes in complex systems or processes. Because they are able to incorporate structured survey data with other forms of evidence, including expert judgement, and simulation modelling, they have utility for comparing different approaches to the design of complex surveillance activities. In this paper we describe the application of Stochastic Scenario Tree (SST) models to optimise the design of surveillance for early detection of marine pests. We show how SSTs can be used to incorporate estimates of relative risk associated in different strata of the surveillance system and to include uncertainty in the analysis using stochastic modelling. For surveillance programmes that are tasked with detecting multiple species, we show how the models can be used to optimise survey effort across a range of survey methods and habitats to achieve high confidence that the pests are absent (or detected if they are present).

Quantifying the role of non-native species in soft-sediment community structure of San Francisco Bay, California.

Oral presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems Session 2: Factors Affecting Invasion Success Time: 12:00 20/08/2013

authors:

Haizea Jimenez[1] and Gregory Ruiz[2]

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[1]Smithsonian Environmental Research Center, Tiburon, CA, USA,
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abstract:

While non-native species are known to be important components in many bays and estuaries, in terms of species richness and ecological impacts, there are relatively few data available that quantitatively characterize the effect of non-native species on community structure. Here, we report initial results from a survey of the soft-sediment invertebrate community in San Francisco Bay, California. We sampled benthic macrofauna in high salinity waters of this estuary in 2012, in order to formally compare native versus non-native diversity in terms of (a) species richness, (b) animal abundance, (c) eveness, and (d) functional traits. Non-native species density was greater than native species density for all phyla, accounting for 86% of all individual organisms. However, native species richness (57% of all taxa encountered) was still greater than non-native species richness for arthropods, annelids and cnidarians. Species composition was highly variable between stations for non-native species while native species composition was more homogeneous. Our data indicate that non-native species composition clearly drives overall the community composition pattern, emphasizing the importance of non-native species on community structure.

Hotspots and notspots: the evolution of early recruitment patterns in the invasive ascidian *Ciona intestinalis* and implications for early detection.

Oral presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems Session 8: Tunicate Invasions Time: 10:40 22/08/2013

authors:

Samuel Collin[1] and Ladd Johnson[1]

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abstract:

Knowledge of dispersal and establishment during the early stages of invasion is essential for allocating monitoring effort, detecting nascent populations and predicting spread. The scarcity of these data, however, provides little guidance for monitoring programs. Early recruitment patterns relative to the underlying distribution of adults were documented for a nascent population of the notorious invasive ascidian *Ciona intestinalis* in Prince Edward Island, Canada. A grid of approximately 80 stations was sampled using settling plates in four two-week periods in each of the two years (2008 and 2009) following the initial detection (2007) in Boughton River. The observation of a distinct dispersal kernel in the first sampling in 2008 became undetectable in later surveys of that year as the distribution of recruits become more homogeneous as the population expanded. Surprisingly, despite an order of magnitude increase in recruitment in the following year, the pattern of recruitment became heterogeneous again for all sampling periods in 2009. Although consistently heterogeneous, the pattern of recruitment was nevertheless spatially stable with distinct clustering of sites of high and low recruitment (hotspots and notspots). We attribute early heterogeneity to the small and restricted nature of the founding population and the latter heterogeneity and stability to a greater influence of abiotic factors on recruitment. Such information can provide valuable guidance for managers in their efforts of the early detection of aquatic invaders.

Biological invasions in changing waters: or 'stress ecology' and why everybody's doing it.

Plenary speaker Time: 9:00 20/08/2013

authors:

***Emma L. Johnston*[1]**

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abstract:

As the anthropocene marches forward, environmental conditions are being altered on local, regional and global scales. As a result, ecologists and invasion biologists are increasingly delving into 'stress ecology'. We are asking questions that might have been written in an ecotoxicology textbook. With examples from my research group, I review the basic tenets and approaches of ecotoxicology, and illustrate how they can be used in the study of bioinvasions. By combining the disciplines of invasion biology and ecotoxicology, my group have identified drivers of invasion success, indirect effects of environmental stress, plasticity of environmental niche space and substantial knowledge gaps. Intertwining the largely disparate fields of ecology and ecotoxicology enables 'stress ecology' and is an important challenge for the next decade.

Thermal physiology of the invasive *Carcinus maenas*: implications for range expansion.

Oral presentation
Symposium Theme: Defining the environmental niche space of invaders using empirical and theoretical tools themes Session 9: Crab Invasions Time: 12:20 22/08/2013

authors:

Amanda Lynn Kelley[1] and Catherine de Rivera[1]

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abstract:

Invasion physiology is an emerging field that endeavors to understand the influence of physiological traits on the establishment of non-native species in novel environments. The invasive European green crab, *Carcinus maenas*, is one of the world's most successful aquatic invaders, and is currently distributed across temperate marine ecosystems globally. The work presented here has highlighted several physiologic mechanisms that have likely facilitated establishment success. Intraspecific comparisons of crabs sampled from the northern and southern edges of their recipient range on the west coast of North America have identified both organismal and cellular physiological difference with respect to upper and lower thermal tolerances. Crabs sampled from British Columbia, Canada had significantly lower upper thermal tolerance threshold and heat shock protein synthesis-Hsp70, compared to their warm acclimated conspecifics sampled from California, USA. This species' ability to extend its current range limits was also investigated. Because range expansion has been chiefly northward, characterizing this species' response to cold stress can identify whether colder temperatures poleward may limit further range expansion. Cold tolerance capacity was determined in the laboratory, and crabs sampled from Vancouver Island, British Columbia were able to withstand the over wintering thermal regime that occurs in Sitka, Alaska, a site that is currently beyond the range limits of this species. Investigations exploring the effects of temperature on the physiology of this non-native species can provide a mechanistic understanding of the patterns and processes that accompany establishment, which can then be used to predict areas that may be susceptible to invasion.

Population variation in temperature tolerance in a widely invasive bryozoan species complex (*Watersipora* spp.).

Oral presentation
Symposium Theme: Defining the environmental niche space of invaders using empirical and theoretical tools themes Session 2: Factors Affecting Invasion Success Time: 3:20 20/08/2013

authors:

Kellan Korcheck[1], Sean Craig[1] and Joshua Mackie[2]

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[2]Department of Biological Sciences, San José State University, 1 Washington Square, San José, CA 95192, U.S.A.

abstract:

Marine habitats are under increasing threat of invasion by exotic species, the successful establishment and spread of which is poorly understood. Cryptic yet genetically distinct bryozoans in the genus *Watersipora* have invaded bays throughout California and show specific geographical patterns of invasion, with clades new sp. and A/B found more frequently in northern and southern California, respectively. This pattern suggests that successful invasions may depend on water temperature. To test whether clades within this species complex have evolved different temperature tolerances, we collected colonies of new sp. and A/B from five bays along the California coast and induced them to release larvae at the Telonicher Marine Lab. Newly settled larvae were then subjected to two environments representing the average summertime water temperatures in northern (11 ºC) and southern (18 ºC) California. After 27 weeks, colonies of clade new sp. grew significantly larger in cold water compared to colonies in the warm water treatment, while clade A/B grew significantly larger than new sp. in warm water but did not differ between treatments. In addition, mortality of clade new sp. reached 100% in warm water compared to a 40% loss of new sp. in cold water. These results suggest that differences in growth and survival of cryptic species of *Watersipora* due to water temperature regimes may help explain their pattern of invasion.

Evidence of ascidian community homogenization in less than 10 years.

Oral presentation
Symposium Theme: Other Session 8: Tunicate Invasions Time: 10:20 22/08/2013

authors:

Rosana Rocha[1], Gretchen Lambert[2], Isabela Neves[3] and James Roper[4]

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abstract:

Ascidians are often a major component of fouling communities, especially in marinas and on piers. In these habitats introduced species are common and often shared among them, which can result in an increase in similarity between sites. This homogenization is one of several negative effects that may result from bioinvasion. We used data from Rapid Assessment Surveys (RAS) performed at the same sites on two consecutive dates: 2000 and 2010 in New England (5 sites), 1997 and 2004 in San Francisco Bay (8 sites), 1994 and 2000 in southern California (12 sites). We calculated Jaccard similarity between pairs of sites within years in each of these regions to test the hypothesis that similarity (= homogenization) increases over time because of introductions. We used paired *t*-tests to compare similarity over time (the two dates). Species richness increased over time as well, and similarity increased as predicted in both San Francisco Bay (t = 2.34, p = 0,01) and southern California (t = 6.6, p <0,001), even though the time intervals between surveys were only 7 and 6 years, and 10 in New England. Both regions had the greatest proportion of introduced species in relation to total richness (89 and 83%), while New England had fewer at 73% (and lower species richness), which may explain the lack of effect there. Thus, homogenization is ocurring rapidly and since marinas and piers are the first step for natural habitat invasions, homogenization of natural habitats is likely to occur faster on the Pacific coast.

Developing a strategic plan for rapid response to aquatic invasive species in the Gulf Region of Fisheries and Oceans Canada.

Oral presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems Session 1: Management of Invaders Time: 10:00 20/08/2013

authors:

Andrea Locke[1], Anne-Margaret MacKinnon[1] and David Drolet[2]

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abstract:

The introduction of aquatic invasive species (AIS) is causing ecological and socio-economic problems throughout the world, including the southern Gulf of St. Lawrence, Canada. Invasive tunicates in Prince Edward Island are probably the best-known example of the need for AIS management in the Fisheries and Oceans Canada management unit known as Gulf region. In addition to the socio-economic and ecological reasons for management, international commitments oblige Canada to prevent introductions of invasive species or to manage them if they occur. This presentation discusses the steps toward a Strategic Plan for AIS Rapid Response, as developed by the Gulf region's multi-sector AIS Rapid Response Working Group. The Strategic Plan is a 'living document' that will reflect changes in mandate, knowledge and tools. It provides guidelines for a consistent approach to handling of future introductions in Gulf region, collates the information necessary for an efficient rapid response, and identifies areas for improvement. Operational components are included as available. Over the longer term, the toolbox of operational components provided in the Strategic Plan is expected to serve as a foundation to expedite the development of species-specific Rapid Response Plans.

Rapid Response begins with the discovery of a suspect organism. If this is confirmed to be a novel AIS or an important range expansion, the feasibility and need for containment to prevent species spread is evaluated. Containment is re-evaluated throughout the process as more information becomes available. Ecological and socio-economic risks are assessed. Then, management options are evaluated, and one is recommended for action. Management options that can be considered include eradication; controlling densities below a threshold of ecological or economic harm or to prevent spread; mitigation of the negative effects on a valued resource; ongoing monitoring without intervention; or a decision of 'no [further] response'. Collectively these comprise the goals of Rapid Response. In the event that an actioned option does not yield the desired result, adaptive management may indicate a new management approach should be attempted. Communication to appropriate agencies and stakeholders occurs at each step of the rapid response. Documentation of the process and outcomes is critical. Detailed procedures and tools for each step are outlined.

Bryozoan forensics: the skeletal profile of a successful invader.

Oral presentation
Symposium Theme: Other Session 4: Invasion Niche Time: 11:00 21/08/2013

authors:

Jennifer Loxton[1 2 3], Mary Spencer Jones[2] and Joanne Porter[1]

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abstract:

In 2011 the non-native bryozoan species, *Schizoporella japonica*, was detected in UK waters for the first time. The bryozoan has established a home in a number of marinas and harbours, particularly in Scotland, and has the potential to both displace native species and, through fouling, have a financial impact on marine industry. In this study a multi-disciplinary approach was taken to investigate the impact of seawater chemistry on the ecology, habitat preference and range of this bryozoan using data and samples collected from over 50 Scottish marinas. Techniques used for skeletal analysis were X-ray diffraction, elemental analysis, staining, ultra-SEM and energy dispersive X-ray (EDX) to investigate the spatial distribution, quantities and structures of minerals within the bryozoan skeleton. Carbonate analysis, spectrophotometry, pH, temperature and conductivity measures were used to determine seawater composition.The results of this multi-seasonal study show that, within its favoured environmental niche, *Schizoporella japonica* is able to adapt its bimineralic skeleton as a response to changes in seawater. These findings are discussed in the light of how skeleton chemistry has influenced the success of this species as an invader and whether we can use skeletally driven environmental limitations of the species to model future movements of this bryozoan in the UK and worldwide.

Assessment of antifouling paint (copper) tolerance across common fouling organisms.

Oral presentation
Symposium Theme: Defining the environmental niche space of invaders using empirical and theoretical tools themes Session 3: Invasion Vectors Time: 5:00 21/08/2013

authors:

Joshua Mackie[1], Sean Craig[2] and Kyle Martin[1]

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abstract:

Hull-fouling is of large consequence in terms of the cost of painting hulls with toxic or nontoxic antifouling surfaces, cleaning in dry docking, and the risk associated with the spread of non-indigenous species. Copper in the form of cuprous oxides is the active agent used in most antifouling paints, but questions of adaptation have been still little studied. Some widely introduced organisms could be copper tolerant, with genetic adaptations favoring spread by hull fouling. We used a settlement panel experiment in which copper-releasing paints were positioned around a non-dosed surface to compare copper tolerances of epibiotic organisms. Plates were deployed in marinas throughout California and occupancy patterns determined by analyzing photographs. Copper tolerant settlement responses were more typically seen in widely distributed non-indigenous species (including the ascidians *Botrylloides violaceus* and *Botryllus shlosseri*). The copper-sensitive organisms (species more abundant on non-dosed plates) observed, tended to be endemic species, which suggests copper use and pollution is a variable favoring community composition in favor of certain widespread organsisms. As we found responses in some populations (e.g., *Watersipora subtorquata* Bryozoa, and *Diplosoma listerianum* Ascidiacea) depended on the location sampled, intraspecific genetic variance is likely to be an important factor in determining copper tolerance.

Impacts of European green crab (*Carcinus maenas*) invasion on eelgrass habitat and associated fish abundance and biodiversity in Placentia Bay, Newfoundland.

Oral presentation
Symposium Theme: Other Session 9: Crab Invasions Time: 12:00 22/08/2013

authors:

Kyle Matheson[1], Cynthia H. McKenzie[1], Robert Gregory[1], David Robichaud[2], Ian Bradbury[1], Paul Snelgrove[3] and George Rose[4]

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abstract:

Following their initial discovery in 2007, populations of invasive European green crab (*Carcinus maenas*) have increased rapidly in Placentia Bay, Newfoundland, particularly in eelgrass meadows. Green crab can dramatically reduce eelgrass biomass through burrowing for shelter, digging for prey, and cutting basal meristems. These activities raise concern because eelgrass loss negatively influences juvenile commercial fish species (i.e. Atlantic cod, *Gadus morhua*). No previous studies have addressed green crab eelgrass relationships in Newfoundland. Before green crab was discovered in Newfoundland, Robichaud and Rose (2006) surveyed eelgrass in Placentia Bay (1997 to 1999) to measure abundance of juvenile Atlantic cod. This dataset provided a rare opportunity to compare eelgrass and associated communities before and after a green crab invasion at numerous sites with varying numbers of crab. We conducted field surveys using similar methods at the same sites to directly compare data between projects. Our results indicate that current eelgrass coverage is approximately half that observed in baseline surveys and percent change in eelgrass correlates negatively with green crab abundance. In fact, localized disappearance of eelgrass occurred at sites with highest abundances and longest established green crab populations. Fish abundance and biomass generally decreased and community assemblages changed at locations where eelgrass cover declined following green crab invasion, suggesting cascading effects following recent introductions and population explosion of green crab in Newfoundland. Such information can facilitate management decisions by identifying threshold abundances of green crab impact on these vulnerable ecosystems.

Investigating ecosystem impact and evaluating trial mitigation methods for the control of *Ciona intestinalis*, a recently detected invasive solitary tunicate in Newfoundland, Canada.

Oral presentation
Symposium Theme: Other Session 1: Management of Invaders Time: 2:00 20/08/2013

authors:

Cynthia H. McKenzie[1], Kyle Matheson[1], Don Deibel[2] and J. Ben Lowen[2]

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abstract:

The vase tunicate, *Ciona intestinalis*, has been confirmed for the first time in Newfoundland waters. The Fisheries and Oceans Aquatic Invasive Species (AIS) monitoring program in collaboration with the Department of Ocean Sciences at Memorial University of Newfoundland detected a large infestation of vase tunicate in Little Bay, Placentia Bay with the solitary tunicate on the wharf structures, eel grass and some vessels in the area. Early detection of AIS is one of the primary goals of the DFO AIS monitoring program. This early detection, with the species currently confined to a small area of Placentia Bay, provided a unique opportunity for mitigation trials to contain this species. The DFO AIS Rapid Response Framework provided the tools to the NL AIS Advisory Committee for the next steps in the regional response to this high risk invasive tunicate. Response has included communication with stakeholders, evaluation of the ecosystem impact and mitigation trials. *C. intestinalis* is a highly invasive solitary species which has created wide-spread issues with multimillion dollars impact on the mussel aquaculture industry in the Maritime Provinces. The impact on shellfish aquaculture in Newfoundland, should this species spread to any of the aquaculture sites, could be extensive and long term. The rapid response strategy recommended by the NL AIS Advisory Committee include research on the species, mitigation trials, vessel traffic analysis and a communication strategy for the public in the infested area. Scientific results from this project, particularly mitigation technologies may be applied to similar ecosystems after early detection of invasive tunicates.

Evaluating the efficacy of new U.S. ballast water regulations.

Oral presentation
Symposium Theme: Evaluating the success of invaders in transitionary waters such as estuaries and waters that are changing as a result of anthropogenic activities
Session 3: Invasion Vectors Time: 10:20 21/08/2013

authors:

Chris McLaughlin[1], John Darling[2] and Ryan Albert[1]

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abstract:

Global trade via shipping is believed to be responsible for a majority of aquatic species invasions in the U.S. To reduce the risk of invasions to aquatic ecosystems, the U.S. Environmental Protection Agency is requiring new ballast management strategies as part of the 2013 Vessel General Permit. Like previous policies, these new policies provide a unique opportunity for scientific research to plan measured, effective regulatory evaluations. Here we discuss U.S. regulatory changes and highlight potential research opportunities generated by these changes. Evaluating the efficacy of these new requirements would necessitate measuring or estimating the per-ship reductions in organisms released in ballast water discharges along with associated reductions in invasion rate. We propose a long-term surveillance program based on intensive, standardized and repeated sampling of both organisms in ballast discharge and established non-native populations in recipient systems. We provide recommendations for a cost-efficient approach that takes advantage of recent advances in detection methodologies for rare species and leverages resources through a coordinated, adaptive approach with formal project management and oversight. Assessing the effectiveness of preventative regulations must be done indirectly, as it is typically possible only to detect failures in prevention. Despite this inherent bias, a standardized monitoring effort will provide data that could help regulatory agencies determine whether to require more or less stringent ballast water discharge limits. We also address additional aims of this research program, including enhanced understanding of the risk-release relationship, which would further assist regulatory agencies in establishing environmentally protective future standards that are scientifically defensible.

Climate change and species invasion: using existing temperature and salinity gradients to project future botryllid tunicate abundance in British Columbia.

Oral presentation
Symposium Theme: Evaluating the success of invaders in transitionary waters such as estuaries and waters that are changing as a result of anthropogenic activities
Session 8: Tunicate Invasions Time: 12:00 22/08/2013

authors:

Jocelyn Nelson[1], Christopher Harley[1], Laura Tremblay Boyer[2], and Thomas Therriault[3]

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abstract:

Climate change and species invasions are two of the most serious threats to biological diversity currently faced by ecosystems. Both can induce drastic changes in marine communities and their impacts are intertwined as abiotic conditions can alter the rate and intensity of invasions. To explore the relationship between climate variability and species invasion, specifically of the botryllid tunicates *Botrylloides violaceus* and *Botryllus schlosseri*, we deployed settlement plates from eight docks in each of four regions along the west coast of North America. Study locations belonged to the same biogeographic region but spanned a range of temperatures and salinities. These natural gradients in temperature and salinity were used to predict the effects of climate change on botryllid tunicate invasions in fouling communities. Botryllid tunicates were primarily found in warmer, more saline areas, and their abundance was positively correlated with higher temperature and salinity minima. Sea surface temperature is predicted to increase in the next 50 years, with changes in salinity being region specific. Based on this, our model predicted that botryllid tunicate abundance will increase in every location in which they currently occur. This study provides an understanding of multiple stressors on a regional scale using field data, while gathering information on important invasive species that could have greater impacts given current climate predictions.

Marine invaders and bivalve aquaculture: sources, impacts and consequences.

Oral presentation
Symposium Theme: Defining the environmental niche space of invaders using empirical and theoretical tools themes Session 3: Invasion Vectors Time: 4:00 21/08/2013

authors:

Dianna K. Padilla[1], Michael J. McCann[1] and Sandra Shumway[2]

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abstract:

Aquaculture is the second leading source of introduced marine species. At present, there are at least 63 species of bivalves in aquaculture somewhere in the world, 15 (24%) of which are grown on continents outside of their native range and 33% (5 of 15) of those have been documented to have established feral populations and are having negative impacts on the systems where they have invaded. Activities associated with shellfish aquaculture have been responsible for the introduction of 48 additional noncultured species to new regions of the world. Many introduced species have impacts on bivalve aquaculture, and ironically, many of these same species were introduced via aquaculture. Introductions of nonnative bivalve species for aquaculture, even those grown in other regions of the same country or state, require special attention, and national and international efforts to develop best management practices (BMPs), standards, and certification for sustainable. Best practices to prevent accidental transfers of species, regularly included in BMP, include selecting sites for aquaculture and methods that will minimize potential fouling, cleaning or cycling of all boats, gear, and equipment that comes in contact with the water, and reporting all suspicious organisms found in an area to allow for early detection. Reducing the introduction and spread of nonnative species will benefit the aquaculture industry, managers, protect biodiversity and help conservation efforts.

Changing weather, changing climate, changing distributions: native and non-native species in New England.

Oral presentation
Symposium Theme: Other Session 2: Factors Affecting Invasion Success Time: 11:00 20/08/2013

authors:

***Judith Pederson*[1]**

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abstract:

Rapid assessment surveys of native and non-native species were conducted at 101 sites during late July/Early August 2000, 2003, 2005, 2007, 2010 from Eastport Maine to Staten Island, New York. Approximately 610 species were identified of which 34 are designated as non-native species and 37 as cryptogenic species. In addition, five new non-native species were reported in the region, but not observed during the surveys. The region includes warm cold-temperate species (southern Massachusetts to New York) and cold cold-temperate species (northern Maine). Throughout the region, three native species of the green algae (*Ulva* spp.), an anemone (*Metridium senile*) and cryptogenic hydroids (*Obelia* spp.) were present at >50% of the sites for all years. Non-native species with wide distributions and present at > 50% of the sites include two species of ascidians (*Botrylloides violaceus* and *Botryllus schlosseri*), a red alga (*Neosiphonia harveyi*), and a sponge (*Halichondria bowerbankia*). Some species are limited in distribution by temperature, several species appear to be extending their northern range as observed during the time of the study, and one alga (*Colpomenia peregrina*) has moved southward. Diversity at sites sampled for all years varied over the study period, with the greatest diversity of species in Northern Maine, which also had the fewest non-native species. The role of antecedent weather conditions in species distribution variability is discussed.

Investigating invasive ecosystem engineers effects on species abundances, biodiversity and ecosystem functions – a global analysis in marine systems.

Oral presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems Session 2: Factors Affecting Invasion Success Time: 5:00 20/08/2013

authors:

Gil Rilov[1], Tamar Guy-Haim[1], Devin Lyons[2], Jonne Kotta[3], Ana Queirós[4], Eva Chatzinikolaou[5], Christos Arvantidis[5], Henn Ojeveer[6] and Tasman Crowe[2]

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abstract:

One of the most influential forms of biological invasions is that of invasive ecosystem engineers, species that affect other biota via alterations to the abiotic environment. Such species can have wide-reaching consequences because they alter ecosystems and essentially change the rules of existence for a broad suites of resident biota. They thus affect resources or stressors that affect other organisms. As part of the VECTORS FP-7 program, we used a systematic review protocol and meta-analysis to quantify the impacts of invasive ecosystem engineers on community structure and ecosystem functioning, and to identify factors that cause their effects to vary. For that, we searched online databases to gather empirical evidence on the impacts of invasive ecosystem engineers on: (1) single species abundances and on measures of biodiversity; (2) primary and secondary productivity; and (3) biogeochemical cycling and other flows of energy and materials. Out of 2587 papers recorded in the initial search, we used 99 that had relevant and reliable data; 53% were based on experimental work, 33% were observational and 13% were both. Of the 43 species identified as invasive ecosystem engineers 57% were autogenic, 29% were allogenic and the rest were both. About 40% were macroalgae, 16% were mollusca and the rest were angiosperms, crustaceans, annelids, bryozoans, tunicates, and one fish. 38% of the studies demonstrated effects on single species abundances, 27% on local or regional diversity, 27% on ecosystem functions or services and 8% on community biomass. The meta-analysis on trends of effect sizes is still underway and will be presented in the meeting.

Chemical treatments for controlling *Didemnum vexillum* in Pacific oyster aquaculture.

Oral presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems Session 1: Management of Invaders Time: 2:20 20/08/2013

authors:

Katherine C. Rolheiser[1], Anya Dunham[2], Soleil E. Switzer[1], Christopher M. Pearce[2] and Thomas W. Therriault[2]

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abstract:

Aquatic invasive species in biofouling communities continue to cause ecological and economic impacts globally. *Didemnum vexillum*, an aggressive invasive tunicate, can have detrimental impacts on the shellfish aquaculture industry and a reliable method of control is required. In this study, cultured Pacific oysters (*Crassostrea gigas*) fouled with *D. vexillum* were treated with various concentrations of brine, freshwater, hydrated lime, and acetic acid at four exposure times (0.5, 1, 5, and 10 min). Results demonstrated that only lime and acetic acid significantly reduced total biofouling and *D. vexillum* coverage. Lime concentrations of 1 and 2% at 5 and 10 min exposures and 4% at 5 min exposure successfully removed up to 92.3% of *D. vexillum* fouling while maintaining high (≥80%) oyster survival. This led to the testing of 1, 2, 3, and 4% lime at 1 and 5 min exposures on *C. gigas* in a laboratory setting to determine potential impacts of these treatments on oyster survival, growth, and condition. The same treatments were also repeated on the mottled sea star, *Evasterias troschellii*, a major predator of Pacific oysters, to ascertain effects on sea star mortality. Combined, the results of field and laboratory experiments demonstrated that exposure to 3 and 4% hydrated lime for 5 min was effective in removing total biofouling, *D. vexillum* fouling, and predatory sea stars without causing significant adverse effects on oyster survival, growth, or condition. This study provides insights to assist the shellfish aquaculture industry with possible solutions to control invasive tunicates and other pest organisms.

The influence of vessel residency period and voyage pattern on the propagule pressure of a hull fouling species.

Oral presentation
Symposium Theme: Other Session 3: Invasion Vectors Time: 12:20 21/08/2013

authors:

Kate Schimanski[1] [2], Sharyn Goldstien[1], Grant Hopkins[2], Oliver Floerl[3] and Graeme Inglis[4]

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abstract:

Propagule pressure encompasses the number of propagules released and the frequency of release events. Previous studies have focussed on the release of propagules into the recipient environment and its influence in the successful establishment of new species. However, focussing on the end stages of translocation neglects the historical factors that may determine propagule pressure, such as the influence of life history stage during the initial stages of translocation. Using the hull fouling species *Bugula neritina* as a model organism, we examined the effect of port residency period and subsequent voyage pattern on growth and reproduction of colonies. Propagule number and individual propagule size were examined over multiple spawning events in a series of manipulative field experiments. Results suggest that long periods of stress, as may occur in long oceanic journeys, may have a greater impact on propagule pressure compared to short regional voyages independent of the age at which the propagules were placed under stress.

Marine Biosecurity Porthole: over 10 years of marine biosecurity data on the web.

Oral presentation
Symposium Theme: Other Session 1: Management of Invaders Time: 12:00 20/08/2013

authors:

Kimberley Seaward [1], Graeme Inglis [1], Simon McDonald[2] and Hernando Acosta[2]

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abstract:

Over the past decade, the New Zealand government has implemented a range of surveillance activities for marine pests, including port biological baseline surveys, targeted early detection surveys, a study of biofouling on international vessels and enhanced networks for passive surveillance. An outcome of this work has been a significant increase in understanding of the range of non-indigenous species present in New Zealand, their distributions and rates of spread. A comprehensive review of these data and other unpublished records was undertaken in 2010. Information gathered from this review were made available online in 2012 via the Marine Pest Porthole (www.marinebiosecurity.org.nz). The Porthole was developed by NIWA (National Institute of Water and Atmosphere) in partnership with MPI (Ministry of Primary Industries) to make the data publicly available to regional authorities, industry and other stakeholders. It is primarily a web-mapping application that shows the sites surveyed and the presence/absence of non-indigenous and native marine species in New Zealand waters. The data are searchable on the porthole by type of survey, location, or taxonomy and is stored and made available using open source software. It also includes a metadata catalogue of references and reports about unwanted non-indigenous species that are present in New Zealand. I will be discussing the data presented on the website, how it is displayed, future developments, and its relevance to stakeholders, managers, researchers and the general public.

Global population structure of the widely introduced tropical ascidian *Botrylloides nigrum*.

Oral presentation
Symposium Theme: Other Session 8: Tunicate Invasions Time: 12:20 22/08/2013

authors:

Elizabeth Sheets[1], C. Sarah Cohen[1], Gregory Ruiz[2] and Rosana Rocha[3]

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abstract:

Studies of marine introductions in tropical regions are extremely limited, and our current understanding of global invasion events is based mainly on information from temperate habitats. Impacts of invasions in tropical regions are becoming more apparent, highlighting a need for studies characterizing introduction processes in these communities. In this study, we are using a multi-gene approach to investigate population structure of a broadly distributed tropical ascidian, *Botrylloides nigrum*, across most of its reported global range. We are currently analyzing 277 samples from 14 locations (9 Western Atlantic, 3 Eastern Pacific, 1 Indo-Pacific, and 1 Mediterranean) at a 529-bp region of the mitochondrial cytochrome oxidase subunit I (COI) gene and a 267-bp region of the nuclear adenine nucleotide translocator (ANT) gene. At COI, we have found 12 haplotypes (4 are shared) with low nucleotide diversity. Two COI haplotypes are common and found globally, suggesting patterns of anthropogenic introduction. Populations sampled at each entrance to the Panama Canal share a single global COI haplotype, suggesting the Panama Canal may serve as an introduction corridor between the Atlantic and Pacific Oceans. Preliminary results from the ANT locus currently reveal 5 haplotypes, 4 of which are mixed throughout our sampled ocean basins. Further sequencing and statistical analysis of ANT may offer finer resolution for investigating geographic source, population connectivity among oceans, and introduction pathways.

Discharge of ballast sediment residuals during deballasting procedures: a potential vector for the transfer of AIS?

Oral presentation
Symposium Theme: Other Session 3: Invasion Vectors Time: 3:00 21/08/2013

authors:

Nathalie Simard[1], Andrea Weise[1], Chris McKindsey[1 2], André Rochon[2], Suzanne Roy[2], Elizabeta Briski[3] and Claude Rouleau[1]

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abstract:

Ship's ballast water and associated sediment residuals may be an important vector for the introduction of aquatic invasive species (AIS). Although efforts are made to minimize the uptake of sediments when loading ballast, it is not possible to prevent some entrained sediments and their associated organisms from being pumped with the water into ballast tanks. Ships cannot completely empty their ballast tanks due to structural and pumping limitations and, as a result, some ships may accumulate significant quantities of sediment after several years. Residual sediments collected from trans-oceanic and coastal ships contained adults, larvae, and resting stages of many taxa. This study addresses the existing knowledge gap concerning residual ballast sediments as a vector for the transfer of AIS. To date, propagule pressure associated with ballast water and sediments has been calculated as the product of the quantity of ballast water or sediments discharged x the density of organisms in the ballast water or sediments x the proportion of these that are viable. However, we do not know what proportion of sediments and associated organisms are released during deballasting procedures. To address this question, we sampled a commercial bulk carrier following two consecutive trans-oceanic voyages. The objectives of this study were to 1) measure at regular intervals the concentration of suspended particulate matter (SPM) in the ballast water that was being pumped out to estimate the quantity of sediments released; 2) examine in situ sediment dynamics by mapping the distribution of sediments and organisms; 3) measure the quantity of sediments remaining in the tank to estimate the proportion of sediments released; and 4) assess the depth-dependent viability of diapausing invertebrates and dinoflagellate cysts. Results show increasing SPM concentrations towards the end of deballasting procedures, some interior hull fouling organisms (anemones, hydrozoans, and bryozoans), up to 18 cm to 30 cm of sediment accumulation in some areas of the tank, abundant invertebrate eggs with concentrations varying with sediment depth and spatially, and abundant dinoflagellate cysts with viable cysts even in the deepest sediment strata (16-18 cm). Results will help to better assess propagule pressure associated with ballast sediment release and will be relevant to the management of residual sediments and AIS.

Evolution of the invasive species *Didemnum vexillum*.

Oral presentation
Symposium Theme: Other Session 8: Tunicate Invasions Time: 11:00 22/08/2013

authors:

Kirsty Smith[1 2], Yasunori Saito[2], Cathryn Abbott[3] and Andrew Fidler[1]

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abstract:

Bioinvasions provide an excellent opportunity to gain insights into evolutionary processes over short timescales and are increasingly used to investigate ecological and evolutionary processes. Phylogenetic analyses of the globally invasive marine tunicate *Didemnum vexillum*, using the mitochondrial COI gene, revealed two distinct clades. One clade (denoted 'B') is still restricted to *D. vexillum*'s native region (north-west Pacific Ocean, including Japan), while the other (clade A) has, in the past few decades, expanded into temperate coastal areas around the world. Persistence of clade B's restricted distribution may reflect it being inherently less invasive than clade A. An ability to tolerate a wide range of ambient temperatures has long been proposed as a critical trait for enhancing a species' ability to establish in new environments. Full mitochondrial genomic sequences from *D. vexillum* clades A and B have been obtained and they predict significant sequence differences in enzymes involved in oxidative phosphorylation. Current experiments focus on examining the functional properties of the corresponding enzymes, in particular contrasting the thermal optima of A and B clade enzymes. In addition, whole organism / colony experiments are examining the thermal stress tolerance of *D. vexillum* colonies from clades A and B. More generally, such comparative studies of invasive and non-invasive sibling clades / species are a promising avenue for investigating the genotypic and phenotypic variation involved micro-evolutionary adaptation.

Emergency surveillance for marine pests following grounding of the container vessel, Rena.

Oral presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems Session 1: Management of Invaders Time: 12:40 20/08/2013

authors:

Matthew Smith[1], Graeme Inglis[2], Serena Wilkens[3], Dane Buckthought[1] and Don Morrisey[4]

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abstract:

The grounding of the container vessel Rena on Otaiti (Astrolabe) Reef near Tauranga (northeast New Zealand) in October 2011 necessitated entry into New Zealand under emergency measures of vessels to assist in the salvage operations. One of these, a support barge, had sat idle in Port Curtis, Gladstone, Australia for up to two years before mobilisation. In-water inspection of the barge and its support tug on arrival at Tauranga found well-developed biofouling assemblages, with several non-indigenous species (NIS) that had not previously been recorded from New Zealand, including the tropical crabs, *Metapograpsus* spp. and the alga, *Grateloupia* sp. filicina-type, a notifiable and unwanted organism under the Biosecurity Act 1993. A monitoring programme for NIS was established as part of the Rena Long Term Recovery Programme. The programme involved a mix of training and active dive searches, shore searches and crab trapping within Tauranga Harbour where the salvage vessels had been berthed. Outreach materials and training workshops were also delivered to other providers and community groups involved in monitoring the impact of the grounding. In a second phase of the programme, high-risk locations and habitats offshore, on Otaiti Reef and nearby Mōtītī Island, where the barge and support vessels had been operating during the salvage process were surveyed. These locations are of particular significance to indigenous Māori communities. Their involvement in implementing the surveys ensured compliance with Māori protocols (kawa) and customs (tikanga). This talk will describe the implementation process, including engagement with local Māori, and give an overview of the programme's outcomes.

New suite of invasive tunicate species detection assays increases monitoring capacity on the Atlantic Coast of Canada.

Oral presentation
Symposium Theme: Other Session 8: Tunicate Invasions Time: 2:20 22/08/2013

authors:

Sarah Stewart-Clark[1], Spencer Greenwood[2] and Jeff Davidson[3].

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abstract:

Invasive tunicates are causing significant challenges to the shellfish aquaculture industry on the Atlantic Coast of Canada. Since 2009, DNA-based species specific molecular assays for *Ciona intestinalis*, *Styela clava*, *Botrylloides violaceus*, *B. schlosseri* and *Diplosoma listerianum* have been implemented in the monitoring and management plans for these tunicate species within the aquaculture industry in PEI, NS, NB and Quebec. Recognizing that this region is at risk for future invasions of invasive tunicates, a list of target high risk species was developed. To better prepare this region for future invasions of invasive tunicates to the Atlantic Coast, 15 additional assays were created to facilitate highthroughput species specific and highly sensitive monitoring for target high risk invaders to Atlantic Canada. This new suite of assays are now available for monitoring of water samples in Canadian aquaculture regions to better protect the industry with early detection methods. Having validated, specific and highly sensitive monitoring techniques will enhance industry protection by providing early detection methods that can detect invasions as early in the invasion process as possible. This study also further highlights the suitability of 18S rDNA and COI genes as suitable species specific markers for invasive tunicate species.

Next-generation invasion: linking physiological and transcriptomic adaptation in the European green crab, *Carcinus maenas*.

Oral presentation
Symposium Theme: Other Session 9: Crab Invasions Time: 11:00 22/08/2013

authors:

Carolyn Tepolt[1], George N. Somero[1] and Stephen R. Palumbi[1]

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abstract:

The European green crab (*Carcinus maenas*) has been highly successful across a wide gradient of thermal environments in its native and invasive ranges. Thus, the species may provide a template for the mechanisms underpinning success in a rapidly changing climate. We combined physiology and next-generation sequencing to examine thermal tolerance, gene expression, and gene sequence across seven locations in the species' native European and invasive North American ranges. Even after common-temperature acclimation, crabs differed in their thermal tolerance between sites, suggesting local adaptation in the native range. This adaptation may have facilitated invasion across a wide thermal gradient on the East Coast of North America. Using mRNA-sequencing, we uncovered a suite of genes with expression changes that are associated with acclimation to hot and cold temperatures. In animals acclimated to a common temperature, we explored adaptive gene expression differences between populations. These same mRNA-seq data were used to generate a panel of thousands of variable SNPs that detected subtle structure between sites (for example, between the East and West Coasts of North America). Using F_{ST} outlier analyses, we found several candidate genes likely under selection in their local environments. Despite high gene flow, green crabs do appear to be locally adapted to their environments at the levels of physiology, gene expression, and gene sequence.

Characterizing and predicting Aquatic Invasive Species distributions: reconciling large-scale model predictions with small-scale observations and the potential role of multiple stressors.

Plenary speaker Time: 9:00 22/08/2013

authors:

***Thomas W. Therriault*[1]**

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abstract:

Early detection of new invaders is essential for management interventions as successful eradication or control is higher when populations are small and localized. Thus, monitoring programs need to target locations where both the probability of introduction and the suitability of environmental conditions are both high. Further, it is recognized that invasions, like other stressors in marine environments, seldom are uniform and that some locations will have conditions amenable to supporting large populations of invaders while others will not. Since impacts often are closely related to population sizes for many invasive species, it is important to identify the amount of habitat capable of supporting populations at an "invasive" level and these habitats should form core monitoring sites. As part of the Second Canadian Aquatic Invasive Species Network (CAISN II) we have been characterizing the relative density of European green crab (*Carcinus maenas*) populations in both Barkley and Quatsino Sounds, along the west coast of Vancouver Island, British Columbia along with environmental measures potentially influencing the distribution of this species. In addition, we have been examining how climate variability and ocean acidification may interact with invasive tunicates (mostly *Botrylloides violaceus* and *Botryllus schlosseri*) to negatively impact native biodiversity. Combined, these refinements to predictive models should allow managers to better target limited resources for early detection of new invaders in the most susceptible environments.

Differential predation across two tropical oceans may reveal how biotic resistance shapes invasion patterns.

Oral presentation
Symposium Theme: Evaluating the success of invaders in transitionary waters such as estuaries and waters that are changing as a result of anthropogenic activities
Session 2: Factors Affecting Invasion Success Time: 2:00 20/08/2013

authors:

Mark Torchin[1], Gregory M. Ruiz[2] and Amy Freestone[3]

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abstract:

In temperate marine systems invasions are occurring at a rapid pace, but less is known about patterns and processes of tropical marine invasions. This disparity may be the result of limited studies of invasions in the tropics relative to temperate regions. Alternatively, the tropics may be less susceptible to invasion for reasons of environmental unsuitability and biotic interactions. Panama provides an especially important model system for testing predictions about marine invasions in the tropics and affords the ability to experimentally examine processes facilitating invasions in two oceans separated by less than 80 km. Latitudinal patterns of introduced species richness suggest fewer successful invasions in the tropics, relative to temperate regions. Further, biotic resistance to invasion, particularly through predation, may be stronger in the tropics than at higher latitudes and could shape invasion patterns. At the entrances to the Panama Canal, a greater proportion of introduced marine sessile invertebrates occur in the Pacific compared to the Atlantic. To begin to examine factors that drive differences in patterns of invasions across oceans and to specifically test for differences in biotic resistance from predators, we asked whether introduced tunicates that are established in both regions were more effectively excluded from experimental habitats by predation. Using a predator exclusion experiment, conducted on both sides of the Isthmus of Panama, we show that predation on sessile invertebrates is stronger in the Pacific compared to the Atlantic and differentially alters community composition. In some cases predators completely excluded the presence of introduced tunicates in the experiment.

Overcompensation and the European green crab.

Oral presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems Session 9: Crab Invasions Time: 2:40 22/08/2013

authors:

Brian Turner[1], Catherine de Rivera[1], Edwin Grosholz[2] and Gregory Ruiz[3]

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abstract:

Population size can decline or, via overcompensation, increase, as mortality increases from harvest efforts targeting adults. Overcompensation increases in likelihood with high fecundity, and short juvenile stages, likely attributes of successfully invasive species. Overcompensation was documented as the result of removal efforts targeting the invasive small mouth bass, but has rarely been investigated for marine invaders. With increasing efforts of managing destructive non-indigenous marine species, such as the European green crab, *Carcinus maenas*, it is important to determine the likelihood of overcompensation to inform whether removal efforts must be intense (to outweigh the overcompensation effect) or are not even worthwhile. We examined the overcompensation potential of *C. maenas*, with experiments and surveys performed in Bodega Harbor, CA. Species that exhibit strong negative interactions between adults and juveniles are more likely to overcompensate. Therefore, these experiments examined cannibalism rates by *C. maenas* with and without alternative prey, survivorship of juvenile *C. maenas* at varying adult densities, impacts of the presence of adults on the foraging rates of juveniles, impacts of the presence of adults on juvenile growth. Adult presence does not appear to significantly affect juvenile growth or survivorship: we detected minimal cannibalism and only short-term reductions in foraging rates. Therefore it is unlikely that *C. maenas* will overcompensate in response to removal, and this conclusion is consistent with survey data on demographics in Bodega Harbor, throughout a removal effort.

Biodiversity responses associated with the potential spread of a native macroalgae in Eastern Australia.

Oral presentation
Symposium Theme: Evaluating the success of invaders in transitionary waters such as estuaries and waters that are changing as a result of anthropogenic activities
Session 2: Factors Affecting Invasion Success Time: 12:40 20/08/2013

authors:

Sofietje Voerman[1], Dilys Zhang[1], Hannah B. Lloyd[1], Tim M. Glasby[2] and Paul E. Gribben[1].

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abstract:

In marine ecosystems, invasive macrophytes have a broad range of negative impact effects. In particular, several species of the genus *Caulerpa* are notorious invaders. Like many invasive species, some native species are spreading rapidly and/or having ecological and economic impacts. Such native species have been termed 'native invaders'. In temperate southeastern Australia, the native green macroalgae *Caulerpa filiformis* is undergoing a potential range expansion and may be replacing species of brown algae as kelp. *C. filiformis* forms dense mats in the lower intertidal and shallow subtidal zone, occupying 100s m^2 at some sites. The spread of *C. filiformis* is of concern for biodiversity because it is structurally different from species it competes with and it is chemically defended. However, little is known about *C. filiformis*' potential impacts on native biodiversity. We investigated whether colonisation of the New South Wales coastlines by *C. filiformis* would affect intertidal assemblages, as a change in associated fauna community composition and a decrease in diversity was expected. We compared assemblages in *Caulerpa* and two widespread and abundant co-occurring macrophytes in intertidal habitats at multiple sites throughout *C. filiformis*' range. Against our expectations, Shannon-Wiener indices showed similar or higher diversity in *Caulerpa* compared to the other macrophytes. However, multivariate analyses indicated that assemblages in *C. filiformis* were different from the other macrophytes at all sites. Communities in *Caulerpa* were dominated by worms whereas others by gastropods. This may be driven by increased sediment entrapment, possibly changing the function of coastal habitats where *C. filiformis* is abundant.

Defining environmental cues of the red alga *Prionitis* that induce larval settlement of the invasive bryozoan *Watersipora* spp.

Oral presentation
Symposium Theme: Defining the environmental niche space of invaders using empirical and theoretical tools themes
Session 2: Factors Affecting Invasion Success Time: 11:40 20/08/2013

authors:

Pamela Ward[1], Sean Craig[2] and Joshua Mackie[3]

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abstract:

For sessile marine animals, larval settlement involves crucial choices that determine future survival, reproduction, and invasion success. Marine bryozoans in the genus *Watersipora* have invaded bays and harbors all around the world due, in part, to larval niche traits which enable them to land on ship hulls, ride to a new port, and then disperse larvae which succeed. Our larval settlement studies demonstrated that the invasive bryozoan *Watersipora* spp. preferentially settle on the red alga *Prionits* spp. when given a choice between four different algal species commonly found in Humboldt Bay, California. We conducted experiments to identify settlement cues used by these larvae, introducing them to algae in one of three treatments: (1) live (untreated), (2) ethanol-killed and (3) plastic algal mimics. Results showed live algae most strongly induced larval settlement. Chemical cues were then tested by introducing larvae to a crude extract of *Prionitis* and to seawater in which *Prionitis* had been immersed: neither induced larval settlement. To test for biological cues, we treated *Prionitis* with an anti-bacterial cocktail that significantly reduced surface bacteria, which resulted in significantly fewer settled larvae. A comparative study of the native *Celleporella hyalina* showed less discrimination among algal choices, possibly due to their smaller size (and shorter time period for settlement). Our results indicate biological cues are important, even for invasive species, and that the size/time period available for settlement in lecithotrophic larvae may be an important factor in the evolution of larval settlement specificity.

Evaluating the success of invaders in transitionary waters such as estuaries and waters that are changing as a result of anthropogenic activities: A characterisation of biofouling patterns and genetic connectivity in Pelorus Sound, New Zealand.

Oral presentation
Symposium Theme: Evaluating the success of invaders in transitionary waters such as estuaries and waters that are changing as a result of anthropogenic activities
Session 8: Tunicate Invasions Time: 2:00 22/08/2013

authors:

Ashleigh Watts[1 2], Grant Hopkins[2] and Sharyn Goldstien[3]

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abstract:

Biotic invasions are an important component of anthropogenic activities. This is particularly true for commercial marine activities such as aquaculture, where invasive species can become dominant components of biofouling communities. However, these biofouling communities are often transitory in nature with high species turnover in variable environmental conditions. Aquaculture farmers are all too aware of the changing nature of the biofouling community, as they struggle to keep up with the next invader ready to make its mark as a dominant species. Estuaries, in which much of the aquaculture is located, are by nature very complex bodies of water with variable conditions at both spatial and temporal scales. Therefore, it is essential that we understand the processes facilitating regional spread of invasive species through these estuarine environments. In this presentation we describe a study that characterises the composition and distribution of problematic biofouling species in Pelorus Sound, New Zealand. In January 2013, a total of 83 mussel farms (*Perna canaliculus*) were sampled (photoquadrats and video footage) along the length of the Sound. In addition, genetic samples from populations of *Didemnum vexillum* were collected throughout the region in the summers of 2008 and 2013. Using these data, the study aims to determine the role of connectivity (genetic analyses), environmental gradients (CTD casts), and aquaculture infrastructure (GIS mapping) in the regional distribution and spread of these species.

Flight, burial, and armor: two invasive snails exhibit different antipredator responses to the European green crab *Carcinus maenas*.

Oral presentation
Symposium Theme: Defining the environmental niche space of invaders using empirical and theoretical tools themes Session 9: Crab Invasions Time: 2:00 22/08/2013

authors:

Elizabeth Wells[1] and Ted Grosholz[1]

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abstract:

Predator-prey interactions in an invaded community, particularly those with invasions from multiple locations, may include novel interactions among species with no shared evolutionary history. We studied anti-predator responses of two introduced gastropods, the Western Atlantic mud snail *Ilyanassa obsoleta* and the Asian horn snail *Batillaria attramentaria*, to predation by the introduced European green crab *Carcinus maenas*. We used a series of behavioral experiments to compare the flight, burrowing, and shell-thickening responses of the two snails in response to olfactory cues of crushed snails and live crabs. We found that the two snails responded differently to the same predation cues. While *Batillaria* responded to crushed conspecifics with increased burrowing, *Ilyanassa* showed no flight or burrowing response to any crab or prey cues. Both snails increased their shell mass more in response to crushed *Batillaria*, and less in response to crab presence. The results of these experiments, along with earlier predation-preference research, indicates that *Carcinus maenas* has the potential for larger consumptive and nonconsumptive effects on *Batillaria* than on *Ilyanassa*. Therefore, our results suggest that the effect of non-consumptive effects may increase rather than mitigate the strength of consumptive effects for some prey species faced with unfamiliar predators. These results emphasize that interactions between evolutionarily novel species can be difficult to predict, but are important in understanding the total impact of an invasive species and future community structure.

Mechanisms of facilitation by the habitat-forming invasive seaweed *Gracilaria vermiculophylla*.

Oral presentation
Symposium Theme: Other Session 5: Invasion Impacts Time: 12:20 21/08/2013

authors:

Jeff Wright [1], Jeb Byers[2], Jayna DeVore[2] and Erik Sotka[3]

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abstract:

Invasive ecosystem engineers can have far-reaching effects on invaded ecosystems especially where they add novel physical structure to the new environment. In several marine ecosystems, invasion of habitat-forming ecosystem engineers increases faunal diversity and abundance but the mechanisms determining the facilitation remain largely unknown. The invasive Japanese seaweed *Gracilaria vermiculophylla* is abundant on mudflats on the Atlantic coast of southern USA where high densities of small invertebrates use it as a host. Previously, these mudflats were devoid of macrophytes. Here we identify the mechanisms behind the facilitation of a dominant grazing amphipod on *Gracilaria*, *Gammarus mucronatus*, by determining both their trophic (feeding) and non-trophic (protective) responses to *Gracilaria*. A combination of stable isotope analysis and feeding experiments showed that despite its abundance, amphipods rarely use invasive *Gracilaria* as food. The benefit *Gracilaria* provides to amphipods is to protect them from predators at high tide and abiotic stress at low tide: in the presence of *Gracilaria*, predation on amphipods by shrimps and crabs was ~ 3 times lower while non-predation mortality at low tide was ~ 10 times lower. These results highlight the strong engineering effects of *Gracilaria* and how the addition of a novel habitat-forming invasive species has the potential to strongly influence food webs.

Invasion of phytoplankton species in Pearl River estuarine and coastal waters, China.

Oral presentation
Symposium Theme: Evaluating the success of invaders in transitionary waters such as estuaries and waters that are changing as a result of anthropogenic activities
Session 2: Factors Affecting Invasion Success Time: 10:00 20/08/2013

authors:

Kedong Yin [1 2], Jianzhang He[1] and Paul J. Harrison[3]

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abstract:

The Pearl River is the second largest river in China. We used 14 years (1991-2004) data sets on salinity, nutrients, and phytoplankton species abundance and composition in Hong Kong waters. Hong Kong is one of the largest ports in the world and therefore, subjects to the invasion of foreign species, particularly phytoplankton. Ballast waters in Hong Kong was reported to contain many red tides species. During the 14 years, total phytoplankton species richness appeared to increase, indicating an increase in invasive species. Diatoms are dominant group of phytoplankton. However, dinoflagellate species richness and abundance increased, too. This coincided with the increased frequency of harmful algal blooms of dinoflagellates, particularly during spring. It was believed that transport of seed populations of HABs and the introduction of non-native species are responsible for the widespread occurrences of HABs. Temperature is usually about 15°C in Hong Kong waters in winter and about 20°C in April, which is near an optimum range for many temperate species of phytoplankton in summer. The highest frequency of HABs is during spring. The summer temperature >25°C is too high for most temperate species. Therefore, when these temperate strains are in Hong Kong waters, they can do better than native strains during winter and spring. In other words, the spring in Hong Kong is almost like the summer for temperate species, which find ecological niches in Hong Kong waters.

Managing multiple vectors in an increasingly connected world.

Oral presentation
Symposium Theme: Evaluating vectors for invaders and modes of transport
Session 3: Invasion Vectors Time: 11:40 21/08/2013

authors:

Chela Zabin[1 2], Susan Williams[3 4], Gail Ashton[1], James Carlton[5], R. Eliot Crafton[6], Ian Davidson[7 8], Rachel Fontana[3 6], Edwin Grosholz[2], Jae Pasari[3], A. Whitman Miller[8] and Gregory Ruiz[8]

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abstract:

The continual arrival and successful establishment of marine invasive species remains a major environmental problem. Managing the vectors of introduction is the most effective means to mitigate this problem, yet many vectors are in operation, and it is unclear how they compare in importance and management tractability. We analyzed the historical and potential contemporary contributions of eight maritime vectors to the establishment and impacts of non-indigenous species (NIS) in California. Of the at least 235 NIS established in the state, 90 were likely introduced by a single vector. The remaining 145 species were associated with two to six vectors. While ballast water has been important historically, vessel biofouling looms large both as a major vector and a management opportunity. There were too few studies of the impacts of NIS to quantify the risk posed by the different vectors. Lack of standardized data on species abundances currently arriving in each vector prevents a robust contemporary cross-vector comparison. We recommend a vector blitz in which the number of species and individuals arriving to the state via these vectors would be quantified over a standardized time period, as a first step in estimating species flux. As a stopgap measure, expert opinion could be used to assign relative risk of the collective impacts of species delivered by each vector. Despite data gaps, management opportunities exist for reducing invasion rates from multiple vectors. We suggest that the focus must shift away from one or two target vectors to coordination across multiple vectors.

Poster Presentations

DNA barcoding of Canadian native aquatic species to enable molecular identification of invaders.

Poster presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems

authors:

Magalie Castelin[1], Niels Van Steenkiste[1], Geoff Lowe[1], Marina Wright[1], Tom Therriault[1] and Cathryn Abbott[1]

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abstract:

Canada has the longest coastline in the world and the potential risks posed by aquatic invasive species (AIS) to the Canadian economy and ecosystems are immense. Prevention and early detection of new invasions are critical. DNA barcoding has the potential to be used for rapid, cost-effective, and accurate identification of AIS from complex environmental samples (e.g. ballast water) without reliance on morphological information. However, a prerequisite is a reliable and well-populated public database containing DNA sequence 'barcodes' that are traceable back to curated voucher specimens. These voucher specimens will have been accurately taxonomically identified and have associated relevant data (e.g. geography, morphology or ecology). Towards this goal, we are working on establishing an inventory of shallow-water marine invertebrate groups in Canada that contain high risk invasive species. In the first year of this study we have collected over 1500 specimens from the intertidal sea shore to 20 m depth on the Canadian west coast, and have integrated them into a DNA barcoding workflow that includes conscientious vouchering of material for DNA and morphological taxonomy. A complete database of this information will eventually be made public. We are testing multi-gene DNA barcoding methods (using the standard DNA CO1 barcoding marker and the nuclear 28S-rDNA marker) in attempts to develop standardized molecular species identification methods that are robust enough for eventual use for regulatory testing. Finally, diagnostic molecular characters will be developed to reliably distinguish introduced from native species.

Experimental evaluation of the effects of predation and competition on the invasion success of rocky intertidal barnacle *Balanus glandula* in Northern Japan.

Poster presentation
Symposium Theme: Evaluating the success of invaders in transitionary waters such as estuaries and waters that are changing as a result of anthropogenic activities

authors:

A.K.M. Rashidul Alam[1] and Takashi Noda[1]

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abstract:

The barnacle, *Balanus glandula* has recently invaded the Pacific coast of eastern Hokkaido. To understand the effects of competition and predation on the invasion success of *B. glandula* at the rocky intertidal coast of eastern Hokkaido, a field experiment, in which the abundances of the whelk, endemic barnacles and seaweeds were manipulated, was conducted from June 2011 to October 2012. The results showed that the endemic barnacle, *Chthamalus dalli* and whelk, *Nucella lima* negatively affected the invasion of *B. glandula*. However, their simultaneous effect was compensative rather than additive presumably due to keystone predation. In conclusion, endemic barnacle and whelk may have played important roles in decreasing invasion success of *B. glandula*. This may be a reason for which *B. glandula* is still rare on natural habitat along the coast of Northern Japan.

Assessing the risk of transporting non-native species to Scotland via biofouling on vessels.

Poster presentation
Symposium Theme: Evaluating vectors for invaders and modes of transport

authors:

Lyndsay Brown[1] and Tracy McCollin[1]

Contact: Lyndsay Brown

[1]Marine Scotland Science, Marine Laboratory, PO Box 101, 375 Victoria Road, Aberdeen AB11 9DB UK

abstract:

Very little information exists on the risks that biofouling on the hulls of commercial vessels pose in transporting non-native species into Scottish waters. In 2009 Marine Scotland Science initiated a project to investigate the risks posed by national and international vessels sailing into Scottish waters by assessing the species assemblages present on their hulls. Vessels were examined as they came in for repair and maintenance in three dry docks in Scotland. All vessels sampled had been operating in the North Sea with the majority servicing the oil and gas industry. Inter-island ferries were also sampled. Visual inspections were carried out and niche fouling areas identified. Samples representative of the fouling communities present were collected, preserved and identified. Species observed were typical of North Sea communities. No non-native species new to the UK were found although previously reported non-native genera including *Elminius modestus*, *Caprella mutica*, *Balanus amphitrite* and *Jassa marmorata* were present. Other native organisms present included mussels, barnacles, amphipods, polychaetes and isopods. Common vessel fouling areas were the propellers, bow thrusters, sea chests, anodes and hull undersides. This study has demonstrated that vessels operating within the North Sea have reasonably low levels of fouling. Further investigation is required of larger international vessels not restricted to North Sea ports.

Distribution trends of non-indigenous species in Portuguese estuaries, coastal areas and islands.

Poster presentation
Symposium Theme: Evaluating vectors for invaders and modes of transport

authors:

Paula Chainho[1], João Canning-Clode[1 2 3], Ana Amorim[1 4], Sérgio Ávila[5], João Castro[6], Ana Costa[5], José Costa[1,7], Teresa Cruz[6], António Fernandes[1], Clarissa Grazziotin-Soares[1], Ricardo Melo[1 4], Joana Micael[5], Manuela Parente[5], Jorge Semedo[9],Teresa Silva[6], Dinah Sobral[8], Mónica Sousa[8], Paulo Torres[5], Vera Veloso[1] and Maria Costa[1 7]

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[6]Center of Oceanography, University of Évora
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[8]Institute for Nature Conservation and Forests.9Portuguese Port and Maritime Transport Institute.

abstract:

The number of non-indigenous species (NIS) registered in estuaries and coastal areas around the world has increased significantly along the last decades with globalization of international trade, but also because of an increase on the number of studies focused on this subject. The major objective of this study was to provide an updated list of NIS registered in Portuguese coastal and estuarine waters and to identify what factors determine different introduction patterns in estuaries, coastal areas and islands. A comprehensive literature review was carried out for NIS registers, including mainland Portugal and the Azores and Madeira islands and sampling surveys on phytoplankton, zooplankton, macroalgae, benthic and nectobentic invertebrates were conducted on soft and hard substrates nationwide. A list of 109 NIS was registered for the Portuguese estuarine and coastal aquatic systems, most of which were in mainland Portugal. The number of NIS registered in mainland areas was correlated to the locations of important harbors and recreational marinas, confirming that shipping is the most important vector of introduction in these ecosystems. Nevertheless, that relationship was not found in the island ecosystems, with a considerable number of NIS was registered in spite of a much lower shipping volume.

Striking range of genetic variability in introduced species of copepods in the San Francisco Estuary.

Poster presentation
Symposium Theme: Evaluating vectors for invaders and modes of transport

authors:

Erica Perry[1], Carrie Craig[1], Vanessa Miller-Sims[1], Catherine Alves[12], Wim Kimmerer[1], and C. Sarah Cohen[1]

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abstract:

The San Francisco Estuary has a high concentration of introduced species, including copepods that now serve as the main food source for native fishes. Introduced species may show reduced genetic diversity although higher genetic diversity is thought to result in greater invasion success. We examined the genetic diversity of seven introduced copepod species (n=18-33) with the barcoding gene cytochrome c oxidase I (COI). Previous work found unusually high haplotype diversity (0.997) in the introduced copepod, *Tortanus dextrilobatus*. Present results also show extremely high haplotype diversity (1.000, n=15), in a native congener of *T. dextrilobatus*, *T. discaudatus*, suggesting that high COI diversity may be characteristic of this genus. Haplotype diversity of the remaining species was widely distributed, ranging from 0.177 to 0.856. Variation in COI diversity may reflect diversity of source populations, life history traits, post-arrival demographic variation, selective effects, or idiosyncrasies in COI evolution. The range of variation among these estuarine invaders in a common habitat offers the opportunity for comparative tests of hypotheses on the origin and maintenance of diversity focused on species with extremely high (~109) population abundance.

Life at the limits: life-history adaptations in a non-indigenous colonial tunicate (*Botryllus schlosseri*) to phenological time constraints imposed by a sub-arctic environment.

Poster presentation
Symposium Theme: Defining the environmental niche space of invaders using empirical and theoretical tools themes

authors:

J. Ben Lowen[1], Don Deibel[1], Kevin C. K. Ma[1], Cynthia McKenzie[2], and Ray Thompson[1]

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abstract:

Botryllus schlosseri is a ubiquitous marine fouling organism that may disrupt benthic coastal communities and bivalve aquaculture ventures. Aided by maritime trade, it has spread rapidly from the Mediterranean Sea to the world's temperate oceans and is now found in the sub-arctic waters of Newfoundland in the Northwest Atlantic. We determined how *B. schlosseri* could achieve reproductive success in the sub-arctic waters of Arnolds Cove, Newfoundland, one of the coldest environments it has yet colonized. In this context, *B. schlosseri* represents a useful model organism for testing predictions as to how invasive ascidians might adapt to colder sub-arctic waters outside of their temperate range. Our results help to explain why *B. schlosseri* currently persists at 23 harbours in Newfoundland, several of which were recently predicted to be too cold for this species. Its phenology of growth and reproduction in sub-arctic waters was more severely time constrained by temperature than in temperate waters. Consequently, *B. schlosseri* has not adapted to grow or reproduce below the temperature limits (or at a faster rate for a given temperature) of its temperate range. Its persistence could instead be explained by: i) The unexpectedly high overwintering survival (~90%) of dormant colonies recruiting in the fall, many of which reproduced the following growing season. ii) Earlier maturation than in temperate waters. When reproduction is increasingly time constrained, in this case by temperature, the production of as many generations as possible through early maturation may result in a self-sustaining population.

Detection and management of invasives: citizen education for citizen science.

Poster presentation
Symposium Theme: Other

authors:

E. Garcia-Vazquez[1], E. Dopico[2], M. Kim[3] and F. Juanes[4]

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abstract:

Citizen-science programs are being successfully applied in conservation and management of marine ecosystems. They integrate education and monitoring networks for increasing public awareness and engagement in different subjects, for example the surveillance of fragile coral reefs (e.g. CoralWatch, launched in 2002). Citizen participation is crucial for detection and management of invaders. The arrival of foreign species as a consequence of climate change has been detected thanks to historical observations made by scientists and amateurs alike. There is a need to involve citizens in ecosystem monitoring and management for purposes of controlling and mitigating marine invasions. Education has an essential role in this process. Citizen science should move into middle- and high-school classrooms to achieve marine conservation goals, with collaboration among scientists, teachers and students. We introduce here Atlantic salmon as a case study. Citizen opinion about the introduction of potentially invasive farmed salmon into wild ecosystems has been tackled in Europe and North America, yielding contrasting views about its risks and consequences. Educational approaches at different levels are explored and proposed for a citizen science program based on this controversial subject.

Sorting through the errors and artefacts of pyrosequencing data: can next-generation sequencing accurately estimate species richness?

Poster presentation
Symposium Theme: Other

authors:

Jullien Flynn[1], Emily Brown[1], Aibin Zhan[2 3], Hugh MacIsaac[3] and Melania Cristescu[1 3]

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abstract:

Next-generation sequencing, combined with a barcoding approach, may become a valuable method for both the estimation of species richness in environmental samples and the early detection of invasive species. However, it has been argued that this method can lead to an inaccurate estimation of species diversity. There are several reasons for this including errors and artefacts generated during the PCR and sequencing steps as well as inappropriate data analysis. The filtering and clustering procedures used when analysing pyrosequencing data are essential to the correct interpretation of the data. Sequences are clustered into groups called operational taxonomic units (OTUs) based on similarity, which are then used to identify the species present. Before clustering reads, low quality sequences containing errors should be removed. Chimeras, which are artefactual sequences commonly generated during PCR, can also inflate OTU estimates considerably and thus must be detected and removed. Singletons are sequences that only appear once within the data and thus are often thought to be or erroneous or chimeric. These sequences are commonly discarded as a result, but it is possible that some may represent a species present in low abundance in the sample. We investigated the filtering and clustering schematics available in order to identify the most effective approaches to trim and filter the pyrosequencing reads, cluster them into OTUs and assign species to the OTUs. Optimizing this process will assist in the careful use of next-generation sequencing to identify species in a sample, which will be applicable to biodiversity assays or detecting invasive species.

Range expansion of the rhizocephalan *Loxothylacus panopaei* (Gissler, 1884) in the northwest Atlantic.

Poster presentation
Symposium Theme: Other

authors:

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abstract:

This report describes the first documented occurrence of the rhizocephalan *Loxothylacus panopaei* (Gissler 1884) north of the Chesapeake Bay in North America, where it has recently been observed in Long Island Sound. We present field survey data of the parasite's prevalence and size distribution of infected host crabs; in addition, we include genetic data indicating the parasite's possible source region. We discuss potential source vectors for this *L. panopaei* range expansion and the parasite's likelihood in affecting other native crabs.

Molecular investigation of the invasive sponge *Hymeniacidon sinapium* in Elkhorn Slough, California.

Poster presentation
Symposium Theme: Evaluating vectors for invaders and modes of transport

authors:

Timothy Fuller[1] and Jeffery Hughey[2]

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abstract:

Elkhorn Slough (ES) is an estuary in central California, USA, which hosts many exotic species. Of the more conspicuous invaders is an orange sponge tentatively considered to be the Halichondrid *Hymeniacidon sinapium* (de Laubenfels, 1930); however, this identification requires genetic confirmation due to this sponge's variable morphology. A genetic examination also could address the *H. sinapium* theorized vector and source populations. This *Hymeniacidon* species is thought to be introduced from oyster culturing industries in ES and other U.S. Pacific wetlands. Though this sponge is endemic to Japan and Korea, a potential synonym on the Atlantic coast, *H. heliophila* (Parker, 1910), might be the source population due to Atlantic oyster importations. Twenty-three tissues sampled from across ES were analyzed using the nuclear rDNA internal transcribed spacers (ITS1 + ITS2) and the 5.8S exon. ES sequences were compared to other *H. sinapium* populations in Tomales Bay and San Diego, California, as well as Japan and South Korea. All ES sponges were very different from *H. heliophila*, but matched *H. sinapium* with only 3 positions of difference (155, 181, and 195) in the ITS1. These intragenomic polymorphisms in *H. sinapium* composed 5 persistent genotypes in the slough. One of the genotypes was identical to a population in San Diego while three other sequences were heterogenetic for characters from San Diego and the Asian populations. Also, ES hosted imported Japanese oyster spat from 1929 to 1960. These results confirm *H. sinapium* in ES, support its suspected vector, and confirm its origins from Japan.

Aquaculture as a gate for invasions: hybrid zones of invasive NIS and native *Mytilus* mussels are linked to farm density on Vancouver Island.

Poster presentation
Symposium Theme: Other

authors:

V. Crego-Prieto[1], F. Juanes[2], A. Roca[1]., F.J. Taylor[2] and E. Garcia-Vazquez[1]

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abstract:

Aquaculture promotes the introduction of non-indigenous species (NIS) into wild marine environments, especially when containment is not secured and larvae and/or adults escape from farms. NIS escapees may hybridize with natives and cause profound changes at the genotypic level. Here we analyze mussels sampled from fourteen coastal locations with different farm densities on Vancouver Island (British Columbia, Canada). Two NIS, *Mytilus edulis* and the invasive *M. galloprovincialis*, are cultivated in those farms. Mussels were genotyped for two species-specific loci (Glu-5' and Me 15/16). The mitochondrial cytochrome c oxydase subunit 1 (COI) gene was employed to characterize the maternal species in hybrids. The proportion of NIS and hybrids of *M. galloprovincialis* and the native *M. trossulus* was positively correlated with farm density. In addition, hybrids between the two native *M. trossulus* and *M. californianus* were also identified. Marine currents and different habitat preferences of NIS provide additional explanations of the present distribution of alien and native species along Vancouver Island coasts. As a whole, our results emphasize the role of aquaculture as a vector for the introduction of invasive species and a promoter of hybrid zones.

Are there non-indigenous species in high risk Canadian Arctic ports?

Poster presentation
Symposium Theme: Examining management, rapid response, the eradication of invaders and efforts to restore ecosystems

authors:

Kimberly Howland[1], Jesica Goldsmit[2] and Philippe Archambault[2]

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abstract:

Increased shipping activity in the Canadian Arctic combined with global warming and resource exploitation are expected to increase risk of aquatic invasive species (AIS) introductions in the near future. The Canadian Arctic coastline is one of the longest in the world, however, the distribution of the native taxa and the extent of AIS incursions are unknown. The objective of this work is to develop an inventory of existing benthic biota in areas of the Canadian Arctic with high risk for introduction of AIS and compare with historical biodiversity distribution information to test for temporal changes. Focal high risk ports were selected based on a recent risk assessment of current shipping activity along with information on probability of future increases in shipping activity. Baseline surveys of benthic macro-invertebrates from different depths (subtidal and intertidal) and habitat types (brackish and marine) were conducted using a combination of SCUBA diving and intertidal standard methods. All specimens were identified to the lowest taxonomic level possible. Current species lists for each port were compared with historical and recent distribution lists from databases and several biodiversity information systems on the web to a) identify any new species records for the port/local region, and b) determine probable source of new species. Preliminary results from three of these ports: Churchill MB (2007, 2011), Tuktoyaktuk, NT (2008) and Iqaluit, NU (2011) show that approximately 30% of the identified species represent new records in a given port region. Over half of the new records (17%) were species that had been previously found in other regions of the Canadian Arctic, while the remaining new records were species with previous closest records in temperate Canada (10%) and Arctic Europe (3%). New taxa were predominantly in the Polychaete group, followed by Arthropods and Molluscs.

Galapagos marine invasive species.

Poster presentation
Symposium Theme: Other

authors:

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abstract:

Invasive species are the number one threat to Galapagos ecosystems and although a lot of preventive and corrective measures have been applied to terrestrial problems, the marine environment has received relatively little attention to date. The marine ecosystems of Galapagos harbour distinctive biological communities given a unique confluence of currents connecting distinct regimes in the Eastern Tropical Pacific. They also sustain a high incidence of endemic species, which are nonetheless regularly subjected to extreme climate variability through El Niño–Southern Oscillation events. The potential invasion of non-native marine species into the Galapagos Marine Reserve (GMR) given such climate shifts, the effects of trade globalization, increased marine traffic and connectivity (through ship based nature tourism and routine cargo shipping from mainland Ecuador) today presents an unqualified risk for local biodiversity, the future of local livelihoods, and a management challenge for the Ecuadorian authorities. We describe an ongoing baseline study of existing marine introduced species in the GMR and their status along with risk assessments based on monitoring of the main ports and anchorages. Species such as *Caulerpa racemosa* and *Aspargopsis taxiformis* that have the potential to become invasive have been identified through these surveys. Geospatial treatments of local-global marine invasive species distributions and GMR sensitive areas are to be combined with marine traffic routes to help identify hotspots for transmission and propagation and high risk areas of particular concern within the GMR and the wider Eastern Pacific. Given the backdrop of shifting climate in the region, a comprehensive long-term monitoring program, early warning system and mitigation measures (designed and implemented in collaboration with local authorities and locals) would minimize the negative impacts of invasive species on marine biodiversity, help retain ecosystem functions and services and increase resilience of the Galapagos Marine Reserve.

2002 vs. 2012: A re-assessment of the marine bioinvasions in the Southwestern Atlantic (SWA, 34º- 55ºS) coast.

Poster presentation
Symposium Theme: Other

authors:

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abstract:

We conducted a re-assessment of the marine bioinvasions of Argentina and Uruguay combining (1) updated taxonomic and systematic works with (2) an exhaustive review of the historical literature and museum records, with the goal of performing a detailed spatio-temporal analysis. The number of exotic species recorded in 2012 was three times higher (n=97) than previously (2002) known (n=31); 43% of the new records are from the literature and 15% are new arrivals during the last ten years. Crustaceans comprised 24.4% of the exotics species followed by macroalgae with 17.5%. Among the exotics, 75% of the species originated from the northern hemisphere, with only 6% originating from the southern hemisphere. The rate of discovery increased over time but the steepest rate was between 1960 and 1970. Ship fouling was the most likely vector (38%) followed by ship fouling and ballast water combined (i.e. multiple vectors, 27.8%). Cryptogenic species followed a similar trend as exotics: 43 (2002) to 65 (2012) species, with nearly half found in the literature. Crustaceans were also the dominant taxa (21.5%); hydroids, polychaetes and macroalgae followed in importance (15% of the records each). The rate of discovery showed similar patterns of exotics species as well as the likely vector, with 46% for multiple vectors and 41% for ship fouling alone. Our results bring new light to the understanding of marine bioinvasions at a regional scale pointing out the relevance of taxonomic work, and also contribute to improve the effectiveness of regulations and management strategies across regions.

Marine fouling communities in an increasingly active international harbor: temporal patterns of native and exotic species.

Poster presentation
Symposium Theme: Other

authors:

Evangelina Schwindt[1], Marcos Tatián[2], Verónica Savoya[1], Graciela Casas[1], Cristian Lagger[2] and Alejandro Bortolus[1]

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abstract:

We report the first results of a study on the patterns and processes characterizing the fouling native community invaded by non native ascidians in a cold temperate harbor of Patagonia, Argentina. Fouling plates were deployed with four treatments (with and without exotics, macro-predators exclusion and control cages, n = 7 replicates each) in the increasingly active international harbor of Puerto Madryn city (42 SL) since September 2011. The experiment was seasonally replicated and temperature, salinity and chlorophyll values were monthly obtained together with the cover and density of the organisms settled. Interactions were variable among seasons. Ascidians were absent in winter in all treatments. Native species (mobile and sessile, invertebrates and macroalgae) showed always higher density and cover values than invasive ascidians in all treatments and seasons. The exception was observed in exclusion cages in summer when high ascidian recruitment occurred. Results suggest that a combination of environmental factors (in winter) and macro-predators prevent the invasive ascidians from dominating the native fouling community, which would indirectly have a positive effect on native species.

Evaluating detection limits of next-gen sequencing for the surveillance and monitoring of international marine pests.

Poster presentation
Symposium Theme: Other

authors:

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abstract:

Most surveillance programmes for marine invasive species (MIS) require considerable taxonomic expertise, are laborious, and unable to identify species at larval or juvenille stages. Therefore, marine pests may go undetected at the initial stages of incursions when population densities are low. In this study, we evaluated the ability of the benchtop GS JuniorTM 454 pyrosequencing system to detect the presence of MIS in complex sample matrices. An initial in-silico evaluation of the mitochondrial cytochrome c oxidase subunit I (COI) and the nuclear small subunit ribosomal DNA (SSU) genes, found that multiple primer sets (targeting a c. 400 base pair region) would be required to obtain species level identification within the CO1 gene. In contrast a single universal primer set was designed to target the V1-V3 region of SSU, allowing simultaneous PCR amplification of a wide taxonomic range of MIS. Artificial contrived communities (10 species from 5 taxonomic groups) were created using varying concentrations of known DNA samples, PCR products, and environmental samples (water and sediment) spiked with one or five 160 hr old *Asterias amurensis* larvae. Pyrosequencing results showed that both the DNA/PCR artificial communities of MIS present at greater than 0.64% abundance were detected. Additionally, single *A. amurensis* larvae were detected from both water and sediment samples despite the co-occurrence of a large array of environmental eukaryotes, indicating an equivalent sensitivity to quantitative PCR. NGS technology has tremendous potential for the early detection and management of invasive species worldwide.

A biogeographic comparison of cuticle thickness, claw resistance to breakage, and genetic variation in the invasive European green crab *Carcinus maenas*.

Poster presentation
Symposium Theme: Defining the environmental niche space of invaders using empirical and theoretical tools themes

authors:

Sarah Tucker[1] and David Smith[1]

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abstract:

The success of the European green crab *Carcinus maenas* as an invasive predator is due, in part, to the ability of its dimorphic claws to crush and manipulate hard-shelled prey. While claw size and crushing ability have been examined extensively, little is known about factors affecting cuticle strength and resistance to breakage. If closing forces exceed cuticle strength, claw damage will result and foraging effectiveness will be reduced. In this study, we tested for: (1) morphological (claw size and cuticle thickness) variation and functional differences in claw resistance to breakage and (2) genetic variation among populations of *C. maenas* over a latitudinal temperature gradient in the eastern North Atlantic. Our study revealed within- individual (crusher vs. cutter claws), between-individual, and regional differences in claw size, cuticle thickness and claw resistance to breakage in *C. maenas* populations in the Gulf of Maine. Crusher claws of crabs from the northern Gulf of Maine possessed relatively smaller claws, thinner cuticles and were more easily broken than their southern counterparts. No regional differences were observed for cutter claws. Although dispersal of mitochondrial haplotypes from a recent secondary invasion in the Canadian Maritimes has increased genetic variation in the northern Gulf of Maine, *C. maenas* populations in the Gulf of Maine remain relatively homogeneous. Both the regional differences in claw morphology and performance and genetic similarity among sampled populations suggest that observed biogeographic patterns are the result of ecophenotypic responses to diet and temperature rather than to genetic differentiation

Inducible defenses in introduced versus native populations of the purple varnish clam, *Nuttallia obscurata*.

Poster presentation
Symposium Theme: Other

authors:

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abstract:

Invasive species that can identify and respond to novel, native predators in a manner that reduces predation risk, such as the expression of inducible defenses, will be more likely to establish and spread. Few studies have examined if native predators trigger inducible defenses in invasive species, and those that have used species that have coexisted for decades rather than prey naïve to predator cues. Naïve specimens, particularly from their native range, would best represent how a species responded to predator presence and activity during the earliest stages of the invasion process. The purple varnish clam, *Nuttallia obscurata*, was introduced to British Columbia from its native range in Asia and has expanded its range southward to Oregon. Crab predators native to the Pacific Northwest (PNW) are known to consume *N. obscurata*, so it is probable that at least the oldest established populations have come to recognize native predator cues. Specimens of *N. obscurata* will be collected from their native range and from introduced populations into PNW. We plan to expose specimens from these different populations to cues from damaged conspecifics, Dungeness crabs (*Metacarcinus magsiter*), and the two combined. We hypothesize that only *N. obscurata* from PNW will respond to native predator cues by increasing burrowing depth. This study will provide insight into species interactions that occured at the earliest stages of *N. obscurata*'s introduction and the role that geographic origin plays in relation to the vulnerability of invasive species to predation.

Early detection of marine invasive species in Changjiang Estuary.

Poster presentation
Symposium Theme: Evaluating the success of invaders in transitionary waters such as estuaries and waters that are changing as a result of anthropogenic activities

authors:

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abstract:

Ecosystem of Changjiang estuary experience continuous change due to fast urbanization and project along Changjiang drainage area under the background of global change. Lying midway on China's coastline, the port of Shanghai is the largest port in China and also biggest in the world. Shanghai has more than 30 regular shipping lines for foreign trade and has trade ties with more than 200 countries and regions in the world. More than 20,000 coasters and river steamers and 2,000 ocean-going freighters call at this port every year, thus enhancing China's suffering from alien invasive species by ballast water. According to investigation about 82.4% ship don't discharge ballast water and 17.8% discharge, plankton sample and environmental parameters in ballast water and Shanghai port were analyzed by quantity, and also . The appearance of some Harmful species has become questionable whether they belong to exotic or indigenous species in the Changjiang Esturay. Some sensitive assay methods were developed for rapid detection of harmful alien species.