The American Lobster in a Changing Ecosystem

A US-Canada Science Symposium

Charlottetown November 3-6 2015

www.peifa.org/lobster_symposium
About the Symposium

The American lobster fishery is a major economic driver of coastal communities in Atlantic Canada and the Northeast United States. Changes in the seasonality and volume of lobsters landed have led to uncertainty in the marketplace and to vulnerability of the associated fishery and those communities dependent on this resource. Climate change remains a prime suspect.

Opportunities for the scientific community studying the American lobster to interact are limited. The inaugural symposium held in Portland, ME, in 2012 saw participants representing academia, government, resource managers, and industry identify research priorities common to both Canada and the US and forge new cross-border collaborations. **The American Lobster in a Changing Ecosystem – II: A US-Canada Science Symposium** will continue to build on these accomplishments.

The four themes of the 2015 symposium, hosted by the Prince Edward Island Fishermen’s Association, progress through increasing levels of organisation and complexity beginning with the Individual Lobster, moving to the dynamics of Lobster Populations and then on to Lobster Ecosystems and Food Webs. The symposium includes presentations on the American lobster, *Homarus americanus*, and the closely related European lobster, *Homarus gammarus*. New to the 2015 symposium is a special theme focusing on “The Business of Lobstering” where presentations will examine how the lobster industry is adjusting to varied aspects of its own changing economic, social, and cultural environments.

“The PEI Fishermen’s Association is pleased to convene the 2015 US-Canada Lobster Science Symposium; bringing together researchers, governments and industry participants for meaningful discussions on all aspects of lobster.”

*Craig Avery, President, PEIFA*

Cover photo credit:

Prince Edward Island Department of Economic Development and Tourism / Barrett & MacKay
**Organising Committee**

Andrea Battison (co-chair), CrustiPath, Prince Edward Island  
Ian MacPherson (co-chair), Prince Edward Island Fishermen’s Association  
Carl Wilson (co-chair), Maine Department of Marine Resources  
Ann-Lisbeth Agnalt, Institute of Marine Research, Norway  
Cathy Billings, Lobster Institute, University of Maine  
Kathy Castro, University of Rhode Island  
John Garland, Clearwater Seafoods, Nova Scotia  
Melanie Giffin, Prince Edward Island Fishermen’s Association  
Marc Lanteigne, Fisheries and Oceans Canada, Gulf Region  
Jean Lavallée, Aquatic Science & Health Services, Prince Edward Island  
Robert MacMillan, Department of Agriculture and Fisheries, Province of Prince Edward Island  
Patrice McCarron, Maine Lobstermen’s Association  
Richard Wahle, University of Maine

**Sponsors**

Air Canada  
Clearwater Seafoods  
CrustiPath  
Homarus Inc.  
Lobster Institute  
Maine Department of Marine Resources  
Maine Sea Grant  
Margaret Chase Policy Center, University of Maine  
MRSB Consulting Services  
Prince Edward Island Department of Agriculture and Fisheries  
Prince Edward Island Department of Economic Development and Tourism  
Prince Edward Island Atlantic Shrimp Corporation  
Prince Edward Island Fishermen’s Association  
Prince Edward Island Seafood Processors Association  
New Brunswick Department of Agriculture, Aquaculture and Fisheries  
Newfoundland and Labrador Department of Fisheries and Aquaculture  
Nova Scotia Fisheries and Agriculture  
University of New Brunswick  
University of Prince Edward Island

**Exhibitors**

Ketchum Manufacturing Inc.  
King Fish  
Vemco
# AGENDA AT A GLANCE

## Tuesday November 3rd

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>4:00 p.m. – 8:00 p.m.</td>
<td>Registration Open</td>
<td>Lobby</td>
</tr>
<tr>
<td>6:00 p.m. – 8:00 p.m.</td>
<td>Welcome Reception</td>
<td>Georgian Ballroom</td>
</tr>
</tbody>
</table>

## Wednesday November 4th

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:30 a.m. – 5:00 p.m.</td>
<td>Registration Open</td>
<td>Lobby</td>
</tr>
<tr>
<td>7:30 a.m. – 8:30 a.m.</td>
<td>Breakfast</td>
<td>Provinces Room &amp; Terrace</td>
</tr>
<tr>
<td>8:30 a.m. – 9:00 a.m.</td>
<td>Opening &amp; Welcome Remarks</td>
<td>Georgian Ballroom</td>
</tr>
<tr>
<td>9:00 a.m. – 9:45 a.m.</td>
<td>Plenary Presentation I: Ecosystems &amp; Food Webs</td>
<td>Georgian Ballroom</td>
</tr>
<tr>
<td>9:45 a.m. – 10:30 a.m.</td>
<td>Plenary Presentation II: Population Dynamics</td>
<td>Georgian Ballroom</td>
</tr>
<tr>
<td>10:30 a.m. – 11:00 a.m.</td>
<td>Health Break</td>
<td>Victorian Room</td>
</tr>
<tr>
<td>11:00 a.m. – noon</td>
<td>Ecosystems &amp; Food Webs Presentations</td>
<td>Georgian Ballroom</td>
</tr>
<tr>
<td>Noon – 1:30 p.m.</td>
<td>Lunch</td>
<td>Provinces Room &amp; Terrace</td>
</tr>
<tr>
<td>1:30 p.m. – 2:45 p.m.</td>
<td>Population Dynamics Presentations</td>
<td>Georgian Ballroom</td>
</tr>
<tr>
<td>2:45 p.m. – 3:15 p.m.</td>
<td>Health Break</td>
<td>Victorian Room</td>
</tr>
<tr>
<td>3:15 p.m. – 4:45 p.m.</td>
<td>Population Dynamics Presentations</td>
<td>Georgian Ballroom</td>
</tr>
<tr>
<td>6:00 p.m. – 8:00 p.m.</td>
<td>Brewery Tour and Tasting Opportunity</td>
<td>PEI Brewing Co.</td>
</tr>
</tbody>
</table>

## Thursday November 5th

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
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</tr>
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<tbody>
<tr>
<td>7:30 a.m. – 8:00 p.m.</td>
<td>Registration Open</td>
<td>Lobby</td>
</tr>
<tr>
<td>7:30 a.m. – 8:30 a.m.</td>
<td>Breakfast</td>
<td>Provinces Room &amp; Terrace</td>
</tr>
<tr>
<td>8:30 a.m. – 8:45 a.m.</td>
<td>Announcements</td>
<td>Georgian Ballroom</td>
</tr>
<tr>
<td>8:45 a.m. – 9:30 a.m.</td>
<td>Plenary Session III: The Individual Lobster</td>
<td>Georgian Ballroom</td>
</tr>
<tr>
<td>9:30 a.m. – 10:00 a.m.</td>
<td>The Individual Lobster - Presentations</td>
<td>Georgian Ballroom</td>
</tr>
<tr>
<td>10:00 a.m. – 10:30 a.m.</td>
<td>Health Break</td>
<td>Victoria Room</td>
</tr>
<tr>
<td>10:30 a.m. – noon</td>
<td>The Individual Lobster - oral presentations</td>
<td>Georgian Ballroom</td>
</tr>
<tr>
<td>Noon – 1:30 p.m.</td>
<td>Lunch</td>
<td>Provinces Room &amp; Terrace</td>
</tr>
<tr>
<td>1:30 p.m. – 2:00 p.m.</td>
<td>The Individual Lobster- presentations</td>
<td>Georgian Ballroom</td>
</tr>
<tr>
<td>2:00 p.m. – 3:00 p.m.</td>
<td>Ecosystems and Food Webs &amp; Population Dynamics: Moderated Discussion</td>
<td>Georgian Ballroom</td>
</tr>
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<td>3:00 p.m. – 3:30 p.m.</td>
<td>Health Break</td>
<td>Victoria Room</td>
</tr>
<tr>
<td>3:30 p.m. – 4:30 p.m.</td>
<td>The Individual Lobster: Moderated Discussion</td>
<td>Georgian Ballroom</td>
</tr>
<tr>
<td>6:00pm – 8:00 p.m.</td>
<td>Poster Session Reception &amp; Awards</td>
<td>Victoria Room</td>
</tr>
</tbody>
</table>

## Friday November 6th

<table>
<thead>
<tr>
<th>Time</th>
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<tbody>
<tr>
<td>7:30 a.m. – 2:00 p.m.</td>
<td>Registration Open</td>
<td>Lobby</td>
</tr>
<tr>
<td>7:30 a.m. – 8:30 a.m.</td>
<td>Breakfast</td>
<td>Provinces Room &amp; Terrace</td>
</tr>
<tr>
<td>8:30 a.m. – 8:45 a.m.</td>
<td>Announcements</td>
<td>Georgian Ballroom</td>
</tr>
<tr>
<td>8:45 a.m. – 10:30 a.m.</td>
<td>Plenary Presentations IV: The Business of Lobstering</td>
<td>Georgian Ballroom</td>
</tr>
<tr>
<td>10:30 a.m. – 11:00 a.m.</td>
<td>Health Break</td>
<td>Victorian Room</td>
</tr>
<tr>
<td>11:00 a.m. – noon</td>
<td>The Business of Lobstering – oral presentations</td>
<td>Georgian Ballroom</td>
</tr>
<tr>
<td>Noon – 1:30 p.m.</td>
<td>Lunch</td>
<td>Provinces Room &amp; Terrace</td>
</tr>
<tr>
<td>1:30 p.m. – 2:30 p.m.</td>
<td>The Business of Lobstering – oral presentations</td>
<td>Georgian Ballroom</td>
</tr>
<tr>
<td>2:30 p.m. – 3:00 p.m.</td>
<td>Health Break</td>
<td>Victorian Room</td>
</tr>
<tr>
<td>3:00 p.m. – 4:00 p.m.</td>
<td>Panel Discussion: ‘The Business of Lobstering’</td>
<td>Georgian Ballroom</td>
</tr>
<tr>
<td>4:00 p.m. – 4:15 p.m.</td>
<td>Closing remarks</td>
<td>Georgian Ballroom</td>
</tr>
</tbody>
</table>
FLOOR PLAN - RODD CHARLOTTETOWN HOTEL
## PROGRAM

### Tuesday November 3\textsuperscript{rd}

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### Wednesday November 4\textsuperscript{th}

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<tr>
<td>7:30 a.m. – 8:30 a.m.</td>
<td>Breakfast</td>
<td>Provinces Room &amp; Terrace</td>
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</table>

**Georgian Ballroom**

**Session Chair: Ian MacPherson**

8:30 a.m.  **Opening & Welcome Remarks**
Craig Avery, President, Prince Edward Island Fishermen’s Association
Hon. J. Alan McIsaac, Minister of Agriculture and Fisheries, Province of Prince Edward Island
Dr. Wendy Watson-Wright, Regional Director General, Gulf Region, Fisheries and Oceans Canada

9:00 a.m.  **Plenary Presentation I: Ecosystems & Food Webs**
Lobster in a changing ocean: Nasty neighbours, bad food, and lousy accommodations
Dr. Paul Snelgrove, Memorial University of Newfoundland

9:45 a.m.  **Plenary Presentation II: Population Dynamics**
Predicting effects of climate change on the demography of the American lobster *Homarus americanus*
Dr. Rémy Rochette, University of New Brunswick

10:30 a.m.  **Health Break**

11:00 a.m.  **Using integrated modeling to predict the effects of climate change and variability on the American lobster fishery**
Ecosystems & Food Webs
Le Bris, Arnauld; Pershing, Andrew J.; Dayton, Alexa M.; Holland, Daniel S.; Mills, Katherine E.; Sun, Jenny

11:15 a.m.  **Expansion of lobster nursery habitat in eastern Maine**
Annis, Eric R.; Wilson, Carl J.; Reardon, Kathleen M.; Robert D. Russell

11:30 a.m.  **Interactions between European green crabs and American lobsters in Great Bay Estuary, New Hampshire, USA**
Morrissey, Elizabeth M.; Goldstein, Jason S.; Moretti, Erika D.; Watson, Winsor H.

11:45 a.m.  **Quantifying fecundity of American lobsters along a spatial gradient surrounding the Eastport Marine Protected Areas (MPAs)**
Howse, Victoria J.; Rowe, Sherrylynn; Schneider, David C.

Noon  **Lunch**
Provinces Room & Terrace
<table>
<thead>
<tr>
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<th>Presenters</th>
</tr>
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<tbody>
<tr>
<td>1:30 p.m.</td>
<td>The influence of vertical movement on dispersal of American lobster (Homarus americanus) larvae</td>
<td>Georgian Ballroom</td>
<td>Marc Lanteigne</td>
<td>Stanley, R.R.E.; Daigle, R.M.; Snelgrove, P.V.R.; deYoung, B.; Pedersen, E.J</td>
</tr>
<tr>
<td>1:45 p.m.</td>
<td>Validation of settlement predictions from an improved bio-physical larval drift model for American lobster across the species’ range</td>
<td>Georgian Ballroom</td>
<td>Marc Lanteigne</td>
<td>Quinn, Brady K.; Chassé, Joël; Haarr, Marthe L.; Rochette, Rémy</td>
</tr>
<tr>
<td>2:00 p.m.</td>
<td>Tracking American lobster cohorts over their first year after settlement suggest consistent regional differences in survival</td>
<td>Georgian Ballroom</td>
<td>Marc Lanteigne</td>
<td>Wahl, Richard; Allen, Steven</td>
</tr>
<tr>
<td>2:15 p.m.</td>
<td>Forecasting the American lobster fishery in the Gulf of Maine and southern New England: Trouble on the horizon?</td>
<td>Victorian Room</td>
<td>Ann-Lisbeth Agnalt</td>
<td>Oppenheim, Noah G.; Wahl, Richard A.; Brady, Damian C.; Lawton, Peter</td>
</tr>
<tr>
<td>2:30 p.m.</td>
<td>Migration patterns, inferred from fishery independent surveys, as a basis for stock definition in the US New England fishery</td>
<td>Victorian Room</td>
<td>Ann-Lisbeth Agnalt</td>
<td>Shank, Burton</td>
</tr>
<tr>
<td>2:45 p.m.</td>
<td><strong>Health Break</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>3:15 p.m.</td>
<td>Spatial patterns of female American lobster mating activity in the inshore waters of southern Massachusetts</td>
<td>Georgian Ballroom</td>
<td>Ann-Lisbeth Agnalt</td>
<td>Pugh, Tracy L.; Glenn, Robert P.; Watson III, Winsor H.</td>
</tr>
<tr>
<td>3:30 p.m.</td>
<td>Size-at-maturity of female lobsters, Homarus americanus, has declined in Atlantic Canada since the mid-twentieth century</td>
<td>Georgian Ballroom</td>
<td>Ann-Lisbeth Agnalt</td>
<td>Haarr, Marthe Larsen; Tremblay, John; Comeau, Michel; Sainte-Marie, Bernard; Rochette, Rémy</td>
</tr>
<tr>
<td>3:45 p.m.</td>
<td>A size-dependent relationship in mating may limit egg production for female American lobsters</td>
<td>Georgian Ballroom</td>
<td>Ann-Lisbeth Agnalt</td>
<td>Gaudette, Julien; Tremblay, John</td>
</tr>
<tr>
<td>4:00 p.m.</td>
<td>Using temperature-dependent embryonic growth models to predict time of hatch of American lobster, Homarus americanus, in nature</td>
<td>Georgian Ballroom</td>
<td>Ann-Lisbeth Agnalt</td>
<td>Miller, Erin H.; Haarr, Marthe L., Rochette, Rémy</td>
</tr>
<tr>
<td>4:15 p.m.</td>
<td>Potential impacts on conservation discards in a growing lobster population in the Gulf of Maine</td>
<td>Georgian Ballroom</td>
<td>Ann-Lisbeth Agnalt</td>
<td>Reardon, Kathleen; Wilson, Carl; Shank, Burton</td>
</tr>
<tr>
<td><strong>----TBD------</strong></td>
<td>Brewery Tour and Tasting Opportunity*</td>
<td>PEI Brewing Co.</td>
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</table>

*sign up at registration desk
## Thursday November 5th

<table>
<thead>
<tr>
<th>Time</th>
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<th>Speakers/Details</th>
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<td>Breakfast</td>
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<tr>
<td>8:30 a.m.</td>
<td>Announcements</td>
<td>Georgian Ballroom</td>
<td></td>
</tr>
<tr>
<td>8:45 a.m.</td>
<td>Plenary Session III: The Individual Lobster</td>
<td>Georgian Ballroom</td>
<td>Session Chair: Melanie Giffin; Dr. Susan Waddy, Fisheries and Oceans Canada</td>
</tr>
<tr>
<td>9:00 a.m.</td>
<td>Plenary Session III: The Individual Lobber</td>
<td>Georgian Ballroom</td>
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</tr>
<tr>
<td>9:30 a.m.</td>
<td>Linking ocean acidification and warming to the larval development of the American lobster (<em>Homarus americanus</em>)</td>
<td>Georgian Ballroom</td>
<td>Waller, Jesica D.; Wahle, Richard; Fields, David; Greenwood, Spencer</td>
</tr>
<tr>
<td>9:45 a.m.</td>
<td>3D-microXray tomography reveals additional features of American lobster shell structure</td>
<td>Georgian Ballroom</td>
<td>Kunkel, Joseph G.; Rosa, Melissa; Bahadur, Ali</td>
</tr>
<tr>
<td>10:00 a.m.</td>
<td>Health Break</td>
<td>Victoria Room</td>
<td></td>
</tr>
<tr>
<td>10:30 a.m.</td>
<td>Impact of sublethal concentrations of agricultural and aquacultural pesticides on larval American lobster</td>
<td>Georgian Ballroom</td>
<td>Clark, K. Fraser; Daoud, Dounia; Greenwood, Spencer J.</td>
</tr>
<tr>
<td>10:45 a.m.</td>
<td>The American lobster (<em>Homarus americanus</em>) lacks susceptibility to White Spot Syndrome Virus (WSSV) infection following <em>per os</em> experimental challenge</td>
<td>Georgian Ballroom</td>
<td>Byrne, Philip J.; Clark, K. Fraser; Greenwood, Spencer J.; Roux, Louise-Marie D.</td>
</tr>
<tr>
<td>11:00 a.m.</td>
<td>Effect of temperature on the pathogenicity and immune response of American Lobster experimentally infected with White Spot Syndrome Virus</td>
<td>Georgian Ballroom</td>
<td>Roux, Louise-Marie D.; Byrne, Philip J.; Clark, K. Fraser; Wright, Glenda M.; Wadowska, Dorota W; Greenwood, Spencer J.</td>
</tr>
<tr>
<td>11:15 a.m.</td>
<td>Implications of export of live American lobster (<em>Homarus americanus</em>) to Norway; crossbreeding and ecological implications</td>
<td>Georgian Ballroom</td>
<td>Agnalt, Ann-Lisbeth; Grefsrud, Ellen S.; Farestveit, Eva; Jørstad, Knut E.</td>
</tr>
<tr>
<td>11:30 a.m.</td>
<td>Experiences with American lobster (<em>Homarus americanus</em>) and shell disease from Norway</td>
<td>Georgian Ballroom</td>
<td>Sandlund, Nina; Agnalt, Ann-Lisbeth; Einen, Ann Cathrine B.; Fiksdal, Ingrid U.; Karlsbakk, Egil</td>
</tr>
<tr>
<td>11:45 a.m.</td>
<td>Are green crabs (<em>Carcinus maenas</em>) a vector for American lobster (<em>Homarus americanus</em>) pathogens?</td>
<td>Georgian Ballroom</td>
<td>Clark, K. Fraser; Elliott, Brad; Tobin-Huxley, Gillian; Rao, Zhixu; Stewart-Clark, Sarah E.</td>
</tr>
<tr>
<td>Noon</td>
<td>Lunch</td>
<td>Provinces Room &amp; Terrace</td>
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## Thursday November 5\(^{th}\) (continued)

<table>
<thead>
<tr>
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<th>Session</th>
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<th>Presenters</th>
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<tbody>
<tr>
<td>1:30 p.m.</td>
<td>Optimising flow for oxygen consumption and feed availability in a controlled sea based environment</td>
<td>Georgian Ballroom</td>
<td>Andrea Battison</td>
<td>Daniels, Carly; Boothroyd, Dominic; Johanning, Lars; Halswell, Peter</td>
</tr>
<tr>
<td>1:45 p.m.</td>
<td>The influence of off-shore aquaculture on American lobster (\textit{Homarus americanus}) movement</td>
<td>Georgian Ballroom</td>
<td></td>
<td>McKindsey, Christopher; Archambault, Philippe; Comeau, Luc</td>
</tr>
<tr>
<td>2:00 p.m.</td>
<td>Ecosystems and Food Webs &amp; Population Dynamics: Moderated Discussion</td>
<td>Georgian Ballroom</td>
<td>Julien Gaudette &amp; Rick Wahle</td>
<td></td>
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<td>3:00 p.m.</td>
<td>Health Break</td>
<td>Victoria Room</td>
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<td>3:30 p.m. – 4:30 p.m.</td>
<td>The Individual Lobster: Moderated Discussion</td>
<td>Georgian Ballroom</td>
<td>Amélie Rondeau &amp; Carl Wilson</td>
<td></td>
</tr>
<tr>
<td>6:00 p.m. – 8:00 p.m.</td>
<td>Poster Session Reception &amp; Student Presentation Awards</td>
<td>Victoria Room</td>
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<td>8:45 a.m.</td>
<td>Plenary Presentations IV: The Business of Lobstering</td>
<td>Session Chair: Jean Lavallée</td>
</tr>
<tr>
<td>8:45 a.m.</td>
<td>Economics of the lobster industry</td>
<td>Robert Fraser, Gardner-Pinfold Consulting</td>
</tr>
<tr>
<td>9:00 a.m.</td>
<td>Maine’s lobster industry from trap to shore</td>
<td>Patrice McCarron, Maine Lobstermen’s Association</td>
</tr>
<tr>
<td>9:45 a.m.</td>
<td>PEI Lobster Harvesters: MASTERS of their own brand</td>
<td>Craig Avery, PEI Fishermen’s Association</td>
</tr>
<tr>
<td>10:00 a.m.</td>
<td>Lobster is a Shell Game …</td>
<td>Stewart Lamont, Tangier Lobster Company Limited</td>
</tr>
<tr>
<td>10:45 a.m.</td>
<td>Health Break</td>
<td>Victorian Room</td>
</tr>
<tr>
<td>11:00 a.m.</td>
<td>Changes to the US Marine Mammal Protection Act and impact on lobster trade between US and Canada</td>
<td>Georgian Ballroom, Session Chair: Carl Wilson, Tselikis, Annie</td>
</tr>
<tr>
<td>11:30 a.m.</td>
<td>How the characterization of lobster fishing practices allowed for targeted regulations aimed at reducing whale entanglements</td>
<td>Summers, Erin; Cotnoir, Sarah; Wilson, Carl</td>
</tr>
<tr>
<td>11:45 a.m.</td>
<td>Ghost trap retrieval in the Bay of Fundy</td>
<td>Recchia, Maria; Brown, Reid; Hunter, Roger</td>
</tr>
<tr>
<td>Noon</td>
<td>Lunch</td>
<td>Provinces Room &amp; Terrace</td>
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<tr>
<td>1:30 p.m.</td>
<td>Spatio-temporal trends in Magdalen Island’s lobster fishery: implications for management</td>
<td>Georgian Ballroom, Session Chair: Robert MacMillan, Labbé-Giguère, Stéphanie; Brêthes, Jean-Claude</td>
</tr>
<tr>
<td>1:45 p.m.</td>
<td>Potential use of mussel farms as multitrophic on-growth sites for American lobster, <em>Homarus americanus</em>.</td>
<td>Wang, Guoqiang; McGaw, Iain J.</td>
</tr>
<tr>
<td>2:00 p.m.</td>
<td>Live holding water quality</td>
<td>Nickerson, Philip</td>
</tr>
<tr>
<td>2:15 p.m.</td>
<td>Changing climate, changing economics: Global market Integration of US-Canada American lobster in the emerging Chinese market</td>
<td>Sun, Jenny; Chiang, Frank; Le Bris, Arnault</td>
</tr>
<tr>
<td>2:30 p.m.</td>
<td>Health Break</td>
<td>Victorian Room</td>
</tr>
<tr>
<td>3:00 p.m.</td>
<td>Panel Discussion: ‘The Business of Lobstering’</td>
<td>Georgian Ballroom</td>
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<tr>
<td>4:00 p.m.</td>
<td>Closing remarks</td>
<td>Georgian Ballroom</td>
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ABSTRACTS

PLENARY PRESENTATION I: ECOSYSTEMS & FOOD WEBS

Lobster in a changing ocean: Nasty neighbours, bad food, and lousy accommodations
Snelgrove, Paul
Ocean Sciences Centre, Memorial University of Newfoundland, St. John’s NL A1C 5S7
psnelgrove@mun.ca

The oceans of Atlantic Canada are among the most dynamic and productive in the world, providing jobs, food, and economic opportunity. But multiple pressures, ranging from invasive species to global climate change challenge ocean sustainability, including American lobster, the single most valuable commercial fishery on the east coast. Although people recognize that all species, including humans and lobsters, are part of complex food webs that respond to both natural and human induced change, our limited understanding of those changes creates challenge and opportunity. This presentation begins with the assumption that we cannot manage natural ecosystems but we can manage how we interact with them to enhance sustainability. It will then consider how different life history stages interact with different ecosystem components, from the ocean surface to the muddy seafloor, and the implications of those interactions in changing oceans and how we use them.

PLENARY PRESENTATION II: POPULATION DYNAMICS

Predicting effects of climate change on the demography of the American lobster Homarus americanus
Rochette, Rémy¹; Quinn, Brady²; Chassé, Joël²
¹University of New Brunswick (Saint John), Saint John, NB, E2L 4L5; Maurice Lamontagne Institute, Department of Fisheries and Oceans, Sainte-Flavie, QC, GOJ 2LO
rochette@unb.ca

Climate change is expected to affect the demography of many coastal marine organisms over the coming decades, including some species that are of considerable socio-economic importance. However, the nature and extent of these impacts have only recently started being the object of scientific investigation. Here we first review the literature on lobsters and other decapods to identify demographic parameters of the American lobster Homarus americanus that may be affected by climate change. Second, we use a coupled global climate change model and greenhouse gas emission scenario to forecast (2011-2015 versus 2061-2065) changes in American lobster habitat range based on changes in bottom temperature. We also integrate sea-surface-temperature and circulation projections of this model into a bio-physical model of larval dispersal to predict changes in larval dispersal over this same time period. We then utilize results of the later simulations to explore the effects of climate-driven changes to larval dispersal on lobster connectivity and stock structure. We conclude with a general discussion of potential effects of climate change on the demography of American lobster, including genetic structure and local adaptation, and of the need for future research and monitoring to be designed to quantify and (where possible) allow adaption to these changes.
PLenary Presentation III: The Individual Lobster

Influence of temperature on lobster reproductive cycles
Waddy, Susan
Scientist Emeritus, Fisheries & Oceans Canada, Biological Station, Saint Andrews, NB  E5B 1R7
susan.waddy@dfo-mpo.gc.ca

The reproductive response of lobsters to climate change is expected to be complex, because molting and reproduction are timed using both temperature and daylength cues. An underlying circannual rhythm determines how lobsters “interpret” the temperature and daylength cues that determine if the response to temperature is “go” or “no go”. In both sexes, molt and reproductive cycles occur sequentially, and if the two conflict, molting always wins. If female lobsters are exposed to an increase in winter temperature, the alternating relationship between molt and reproduction can be disrupted, resulting in erratic molt cycles and reduced spawning rates. In contrast, when winter temperatures are low, lobsters have predictable and synchronized cycles. In studies on over 3000 females held for several years under natural daylength and local seawater temperature, spawning began each year on 27-28 June and > 95% spawned over the next 4 weeks. Over 98% of the females molted and mated the following year, after their eggs hatched. Males also have well-defined reproductive cycles, with those in the reproductive phase of their cycle inseminating as many as 52 females in one season. The probability that a male would transfer a spermatophore to a newly-molted female was 0.25 if he had already inseminated another female that day, 0.78 after 24 hr, and 0.98 if the opportunity to mate occurred 3 or more days after the previous insemination.

Plenary Presentations IV: The Business of Lobstering

Economics of the lobster industry
Fraser, Robert
Gardner Pinfold Consulting, Halifax, Nova Scotia
rfraser@gardnerpinfold.ca

The lobster industry employs over 50,000 people on boats and in processing facilities in Eastern Canada and the US Northeast. With landed value exceeding $1.0 billion, the industry supports hundreds of coastal communities throughout these regions. Catches have risen by about 80% since 2007. Prices went through an extended cycle of decline after 2002, creating economic hardship throughout the industry. The industry turned an economic corner in 2015, as prices and incomes began to recover. This presentation traces the economic history of the industry over the past 15 years, examining its structure and competitive conditions, and how these factors, as well as global markets, have contributed to the shifts in prices and revenues. The presentation concludes with a look ahead at demand conditions in light of free trade agreements and economic performance in key export markets.
Maine’s lobster industry from trap to shore  
McCarron, Patrice F.  
Maine Lobstermen’s Association, Kennebunk, ME 04043  
patrice@mainelobstermen.org

In 2014, Maine’s lobster industry was comprised of 4,900 owner operated harvesting businesses. Over the past 10 years, Maine’s lobster landings have increased by 73% and the value increased by 58%. During this same time period, the average boat price decreased by 9%. Maine lobstermen have explored a variety of strategies to adapt and maximize profitability in the face of rapid increases in landings of Maine lobster, corresponding market growth and impact on value of the product. Strategies include improvements in lobster handling techniques, maximizing the efficiency of vessel operations, investing in dockside infrastructure and handling, and investment in marketing and brand development.

PEI Lobster Harvesters: MASTERS of their own brand  
Avery, Craig  
Prince Edward Island Fishermen’s Association, Charlottetown, Prince Edward Island  
hcraigavery@gmail.com

Over the last decade marketing North Atlantic Lobster has been at the forefront of the industry’s objectives. The development of the Maine Lobster Marketing Collaborative and the formation of the Lobster Council of Canada in addition to regional efforts, have been geared towards finding the best way to market North East Atlantic Lobster.

The Prince Edward Island Fishermen’s Association looked at an opportunity to market our own fresh, wild caught lobster through the creation of the Lobster Fishers of Prince Edward Island Marketing Board. Our fishery is certified sustainable by the Marine Stewardship Council and is sold as a fair trade product. Master Lobster is one of the first seafood products to ensure a premium is paid back to the harvesters and their organization.

The Master Brand story includes where the product came from, how it is harvested and how we are keeping the resource sustainable. MASTER LOBSTER has just launched in a major North American retail chain. It is also being sold in China, France and other parts of central Europe. Much of the marketing involves fishers travelling to these countries to meet directly with their customers and potential buyers. This has contributed greatly to the PEI Lobster harvesters slogan “MASTERS of their own brand.”

“Lobster is a Shell Game… (...But could you really call it a Business...)? “  
Lamont, Stewart  
Tangier Lobster Company Limited, Tangier, Nova Scotia  
stewart@tangierlobster.com

An effort is made, in a bit of a playful manner admittedly, to make the assertion that lobster is a lot of things, but it is surely not a business. We don’t adopt business like procedures and measurements in so many cases, and therefore it is at the very least misleading to think of our enterprise in this way. The bottom line? Lobster economics is a kind of a pretend world on the best of days …..

The presentation tries to give the audience real food for thought as to tangible ways we fall short of the mark, and why this shortchanges the lobster sector in its entirety. Fortunately, in the foreseeable future we could see the error of our business ways and do things dramatically differently for the benefit of all stakeholders …
**ECOSYSTEMS & FOOD WEBS**

**Using integrated modeling to predict the effects of climate change and variability on the American lobster fishery**

Arnault, Le Bris\(^1\)\(^2\); Pershing, Andrew J.\(^1\); Dayton, Alexa M.\(^1\); Holland, Daniel S.\(^2\); Mills, Katherine E.\(^1\); Sun, Jenny\(^1\)\(^3\)

\(^1\)Gulf of Maine Research Institute, Portland, ME 04101, \(^2\)Northwest Fisheries Science Center, Seattle WA 98112

alebris@gmri.org

The lucrative American lobster fishery occurs over a steep temperature gradient, providing a unique case study to evaluate the consequences of climate change and variability on socio-ecological systems. In this study, we report on the development of a size-structure life-history model to simulate lobster population dynamics. First, we demonstrate that the effects of increasing temperature on lobster population dynamics can be predicted using general life-history and metabolic theories. Using data extracted from the literature and from sea-sampling datasets, our results show that as temperature increases, early growth rate increases and size at maturity and maximal size decrease. Second, a size-spectrum approach is used to quantify predation pressure on lobster. Data from bottom-trawl surveys are used to compute the size-spectrum of the community of lobster predators. In warmer conditions, the slope of the lobster predator community becomes more negative, leading to increased predation on small lobster size-classes and decreasing predation on larger lobster size-classes. The model is able to explain the change in lobster productivity across the steep temperature gradient and links the recent increase in lobster biomass in the northern Gulf of Maine to long-term warming. The generality and flexibility of the approach developed in this study will allow for more detailed projections of climate impacts on the American lobster population and the future productivity of the fishery and its economic performance.

**Expansion of lobster nursery habitat in eastern Maine**

Annis, Eric R\(^1\); Wilson, Carl J.\(^2\); Reardon, Kathleen M.\(^2\); Russell, Robert D\(^2\)

\(^1\)Hood College, 401 Rosemont Ave, Frederick, MD 21710, USA; \(^2\)Maine Dept. Of Marine Resources, 195 McKown Pt. Rd., West Boothbay Harbor, ME 04575, USA.

annis@hood.edu

Lobster settlement and subsequent development in Eastern Maine is strongly influenced by the Eastern Maine Coastal Current (EMCC). The cold well mixed water of the EMCC has been shown to restrict the settlement of lobster larvae to embayments where water temperatures are near or above 12 degrees Celsius during the late summer months (July-September). The Maine Dept. Of Marine Resources has seen, through its sampling programs, a significant increase in the numbers of juvenile lobsters in eastern Maine out to depths of 100 m and a concurrent increase in commercial landings in Lobster Management Zones A, B and C. In recent years the average monthly temperatures of the EMCC have increased to a point where, during the late summer months, more area in eastern Maine is above the threshold for successful settlement and development. We will examine the impact and evidence of warming waters on early benthic phase lobsters and how to adapt current sampling programs.
**ECOSYSTEMS & FOOD WEBS**

**Interactions between European green crabs and American lobsters in Great Bay Estuary, New Hampshire, USA**
Morrissey, Elizabeth M.; Goldstein, Jason S.; Moretti, Erika D.; Watson, Winsor H.
1 University of New Hampshire, Department of Biological Sciences, Durham, NH 03824; 2 Eastern Connecticut State University, Department of Biology, Willimantic, CT 06226.
jsgoldstein2@gmail.com

The Great Bay Estuary (GBE) in New Hampshire supports a robust commercial and recreational American lobster (*Homarus americanus*) fishery. In recent years Great Bay, like many other New England estuaries, has seen a precipitous increase in European green crabs (*Carcinus maenas*) that have been implicated in a variety of ecological changes. The goal of this project was to document the distribution and abundance of green crabs in the GBE and investigate possible impacts they might have on resident lobster populations. Sea sampling surveys were conducted from 2013-2014 using modified lobster traps. We found that green crabs were more abundant in the upper reaches of the estuary further from the coast, with a mean catch-per-unit-effort (CPUE) of 24.85 crabs/trap, and least abundant at sites closest to the coast (CPUE_{avg} = 0.02 crabs/trap). In contrast, lobsters were most abundant closest to the coast (CPUE_{avg} = 3.54 lobsters/trap) and least abundant in the upper reaches of the GBE (CPUE_{avg} = 0.08). The cause of the difference in distribution patterns is being examined. This differential could be due to dissimilar temperature preference, tolerance to low salinities, or interspecific competition. Studies are currently underway to try and discriminate between these possible explanations and gain further insight into the impact of green crabs on the lobster fishery in the GBE.

**Quantifying fecundity of American lobsters along a spatial gradient surrounding the Eastport Marine Protected Areas (MPAs)**
Howse, Victoria J.; Rowe Sherrylynn; Schneider David C.
1 Centre for Fisheries Ecosystems Research, Fisheries and Marine Institute, Memorial University, St. John’s, Newfoundland, A1C 5R3, Canada; 2 Department of Ocean Sciences, Memorial University of Newfoundland, St. John’s, Newfoundland, A1C 5S7, Canada
victoria.howse@mun.ca

MPAs are frequently established to allow protected portions of populations to develop, so that larger individuals and offspring may ultimately enhance surrounding fishing areas through dispersal. To examine whether MPAs achieve these goals, BACI design studies are typically implemented. Our study investigated spillover of larger more fecund American lobster from the Eastport MPAs, which were established in Bonavista Bay, NL in 1997. Since neither data prior to establishment nor clear controls were available, this study alternatively employed a gradient design. Gradients were examined 2, 6, and 12 km from the MPA boundaries. However, no evidence of spillover for fecundity or carapace length at any distance from MPA was found. The study demonstrated a small change in size-specific fecundity with distance, when measured 2km from MPA boundaries. These results may not have been anticipated given the small size of the MPAs (2.1 km^2) and short time since establishment.
**POPULATION DYNAMICS**

**The influence of vertical movement on dispersal of American lobster (*Homarus americanus*) larvae**  
Stanley, R.R.E.; Daigle, R.M.; Snelgrove, P.V.R.; deYoung, B.; Pedersen, E.J.  
Memorial University of Newfoundland, Department of Oceans Sciences and Biology Department, St. John’s, NL A1C 5C1; University of Toronto, Department of Biology; McGill University, Department of Biology; Memorial University of Newfoundland, Department of Physical and Physical Oceanography  
rstanley@mun.ca

We applied a bio-physical semi-Lagrangian model to predict the drift of larval American lobster from hatch to post-larval settlement. Packets of simulated larvae were released from St. George’s Bay, in the Gulf of St. Lawrence, and were allowed to drift within the model domain of coastal Atlantic Canada at 2 km resolution. We set pelagic residency according to temperature-dependant stage durations. Laboratory experiments helped evaluate swimming capability and relative vertical position of four pelagic larval stages under various lighting conditions. We observed variable vertical distribution for first stages, subsurface distributions for intermediate stages, and surface distributions for final stage larvae. We formulated behavioural rules of simulated larvae for each developmental stage from laboratory observations. Vertical movement in the water column, time of release, and release location all significantly influenced simulated dispersal trajectories and distance. In particular, increased vertical movement significantly extended dispersal compared to the static surface distributions often utilized in larval dispersal models. Our results highlight the implications of behaviour on dispersal and connectivity of larval American lobster and demonstrate how incorporation of realistic behavioural inputs into bio-physical models offers a powerful tool to advance understanding of larval transport and recruitment.

**Validation of settlement predictions from an improved bio-physical larval drift model for American lobster across the species’ range**  
Quinn, Brady K.; Chassé, Joël; Haarr, Marthe L.; Rochette, Rémy  
University of New Brunswick, Saint John, NB E2L 4L5; Department of Fisheries and Oceans Canada, Maurice Lamontagne Institute, Mont-Joli, QC G0J 2L0  
bk.quinn@unb.ca

Drift of lobster larvae is an important component of the dynamics and structure of lobster stocks, or populations. Recent work with a bio-physical model of larval dispersal across eastern North America demonstrated potential drift of larvae among management zones, including those separated by considerable (≤ 700 km) distances, indicating the possibility for different management zones to be components of the same biological units. However, this model must be validated through comparisons of its predictions against real-world data, and may require inclusion of additional biological information to more accurately predict dispersal. In this study, a preliminary version of this model, which simulated drift based mainly on physical forces, was used to predict larval settlement in different locations across the lobster’s range. Predicted settlement will be compared to available empirical datasets of lobster benthic recruitment, including the American Lobster Settlement Index, across eastern North America; a good match between predicted and observed benthic recruitment would validate the model and indicate that it predicts natural patterns well, whereas a poor match would suggest changes are needed to improve the model. If changes are needed, a new version of the model with updated biological inputs, including realistic variability in larval productivity and hatch time across the species’ range, will be used, and its predictions tested against observed benthic recruitment. After this has been achieved, model predictions can be used to identify lobster stocks and their dynamics to inform fisheries management.
POPULATION DYNAMICS

Tracking American lobster cohorts over their first year after settlement suggest consistent regional differences in survival
Wahle, Richard; Allen, Steven
University of Maine, School of Marine Sciences, Darling Marine Center, Walpole, ME 04573
richard.wahle@maine.edu

Forecasting recruitment of the American lobster to the commercial fishery has been a long-standing goal. As part of a concerted US-Canadian effort to evaluate the predictive power of the American Lobster Settlement Index (ALSI) for trends in lobster fishery recruitment we assessed how well the abundance of newly settled young-of-year (YoY) lobsters predicts the abundance of 1-year-olds the following year. For most regions from southern New England to Atlantic Canada we found a consistent, nearly linear, relationship of between 45 to 85% survival over a range of settlement density in cobble nursery habitat up to about 4 YoY m⁻². However, a few locations that tend to receive especially high densities of settlers > 4 YoY m⁻², show evidence of density-dependent losses at when cohort densities are high. Our survivorship estimates assume we have assigned correct ages to lobsters in our samples, and that emigration and immigration is trivial during the first year, sources of uncertainty that warrant further investigation. Toward that end, we describe an approach to accurately define YoY and 1-year-old size ranges throughout the ALSI monitoring domain. ALSI’s quarter-century time series is the only fishery independent data set that will permit such an analysis for the American lobster. It will aid our understanding of natural mortality rates and density-dependent processes operating in the first years after larval settlement well before lobsters recruit to the fishery, thereby informing the development of predictive models of fishery recruitment.

Forecasting the American lobster fishery in the Gulf of Maine and Southern New England: Trouble on the horizon?
Oppenheim, Noah G.; Wahle, Richard A.; Brady Damian C.; Lawton, Peter
University of Maine, Department of Fisheries & Oceans Canada
oppenheim.noah@gmail.com

Accurate predictions of fishery recruitment represent the holy grail of fisheries science and management. As is true for many lobster fisheries, spawner-recruit relationships for the American lobster (Homarus americanus) in the northwest Atlantic have been particularly elusive to science. However, settler-recruit relationships, which track cohorts after larvae have settled to the sea bed, are proving more useful in several species. Here we describe a set of recruitment forecasting models for the American lobster fishery, covering management areas from Southern New England to Atlantic Canada. The models use the American Lobster Settlement Index (ALSI), an annual survey of juvenile year-class strength, and environmental and ecological indicators used to directly parameterize life history processes to predict temporal trends in lobster recruitment at the management unit scale. Validation against landings indicates that the forecasts are accurate in the majority of cases. Of particular note, the forecasts suggest a significant downturn in fishery recruitment in the eastern Gulf of Maine in the coming years after a sustained record-breaking surge over the past decade, as well as continuing declines in southern New England’s fishery. We anticipate that these models will allow industry members, scientists, and managers to enhance decision making related to the regulation and prosecution of this important fishery.
POPULATION DYNAMICS

Migration patterns, inferred from fishery independent surveys, as a basis for stock definition in the US New England fishery
Shank, Burton
NOAA / NMFS Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA USA 02543
burton.shank@noaa.gov

The US New England lobster fishery is assessed as three stocks: the Gulf of Maine (GOM), Georges Bank (GBK), and Southern New England (SNE). The federal offshore survey for all stocks exhibits a seasonal cycle with higher abundances in the fall than spring which has been interpreted as changes in the availability of lobsters to the gear. However, the magnitude of the seasonal cycle on GBK has increased markedly over recent years and the fall “population” now consists primarily of large (>100mm CL), female lobsters that are not previously observed as smaller individuals. The seasonal appearance and subsequent disappearance of these large individuals vastly complicates the GBK assessment. Closer examination of subsets of the trawl survey data revealed that the seasonal cycle for large female lobsters in the GOM is the reverse of what is observed for males and smaller females in the GOM with higher abundances in the spring than the fall. Swept-area estimates indicate that the total number of large females “disappearing” from the GOM in the fall is very similar across the time series to the number of large females “appearing” on GBK in the fall, suggesting a mass-balance for the combined stocks. This is further supported by tag-recapture studies that have found a sex-specific ontogenetic shift in movement patterns where individuals observed to move long distances were predominantly large females. Based on these findings, the GOM and GBK were assessed both as independent stocks and as a combined stock in the most recent assessment. New areas of research from this are determining any linkages between these migrating individuals and inshore stocks and if this increased migration is simply due to recent increases in the GOM stock or changes in behavior due to climate.

Spatial patterns of female American lobster mating activity in the inshore waters of southern Massachusetts
Pugh, Tracy L.1; Glenn, Robert P.2; Watson III, Winsor H.3
1Massachusetts Division of Marine Fisheries. 30 Emerson Ave. Gloucester, MA 01930; 2Massachusetts Division of Marine Fisheries. 1213 Purchase St. New Bedford, MA 02740; 3Dept. of Biology, University of New Hampshire. Durham, NH. 03824
tracy.pugh@state.ma.us

A field study in southern Massachusetts examined 3,851 female lobsters (46 – 103 mm CL) for mating activity, and results showed some large, presumably mature females (≥ 86 mm) had not mated. Larger females that had not mated occurred primarily in warmer waters inside Buzzards Bay, while mating activity in both large and small size classes was higher in cooler waters just outside the Bay. Mating activity was positively correlated with female-skewed sex ratios, contrary to initial expectations. Two alternative hypotheses were explored to explain the spatial difference in mating activity. First, female mating activity in the inner regions may be lower because they were disproportionately immature compared to outer region females. Mature females may be more sensitive to thermal extremes, making them more likely to avoid the extremely warm waters inside Buzzards Bay, leaving behind only immature females. While morphometric data indicated potential differences in maturity status between inner and outer region females (primiparous vs multiparous, respectively), this would not explain the lack of mating in some large inner region females. Second, differences in lobster abundance between the inner and outer regions (as documented by ventless trap surveys) may affect localized mating opportunities. Low abundance in the inner regions may reduce encounter rates between receptive females and available males, resulting in a mate-finding Allee effect. Depleted stock conditions in Southern New England may produce local pockets of lobsters that are unable to mate successfully. More work is required to understand how abundance affects reproductive potential in American lobster stocks.
**Population Dynamics**

Size-at-maturity of female lobsters, *Homarus americanus*, has declined in Atlantic Canada since the mid-twentieth century

Haarr, Marthe Larsen¹; Tremblay, John²; Comeau, Michel³; Sainte-Marie, Bernard⁴; Rochette, Rémy ¹

¹University of New Brunswick Saint John, Saint John, NB, Canada; ²Bedford Institute of Oceanography, Fisheries and Oceans Canada, Dartmouth, NS, Canada; ³Gulf Fisheries Centre, Fisheries and Oceans Canada, Moncton, NB, Canada; ⁴Maurice Lamontagne Institute, Fisheries and Oceans Canada, Mont-Joli, QC, Canada

marthe.haarr@unb.ca

Size-at-maturity (SM) is an important parameter in fisheries management, especially in fisheries that utilise minimum legal size (MLS) regulations with the objective of allowing individuals to reproduce at least once prior to recruiting to the fishery. SM is not necessarily a constant parameter, however, as maturation schedules can be plastic in response to changes in for example population density, food availability and temperature. Harvesting of immature individuals can also result in evolutionary change towards smaller-maturing individuals over time. The American lobster, *Homarus americanus*, is Canada’s most valuable fishery and exploitation rates are substantial, yet no concerted effort has been made to date to determine whether SM has changed during the history of the fishery. In this study we assess available historic and recent data on SM of female American lobsters for evidence of changes over the past century, and results do suggest female SM has been declining, in some areas by as much as 30%, since the 1930s. We attempt to elucidate the mechanism behind these declines by comparing the magnitudes and rates of decline spatially across different Lobster Fishing Areas (LFAs) to (1) the magnitude of fishery-induced size-based selection, measured as the discrepancies between MLS and SM, (2) the magnitude of changes in abundance, measured as landings trends, and (3) the magnitude of temperature change, measured as trends in mean summer SST.

A size-dependent relationship in mating may limit egg production for female American lobsters

Gaudette, Julien ¹; Tremblay, John ²

¹St Andrews Biological Station, Fisheries and Oceans Canada, St Andrews, NB, Canada; ²Bedford Institute of Oceanography, Fisheries and Oceans Canada, Dartmouth, NS, Canada

Julien.Gaudette@dfo-mpo.gc.ca

Maintaining the reproductive capacity of any commercial stock is a vital management objective to ensure sustainability. To better understand the dynamics of egg production in the American lobster, we assessed the role of mating success and compared size-class contributions to reproduction between their potential and realized production from the at-sea sampling database. In 1978-79 and 2011, mating success in the Bay of Fundy was monitored during size-at-maturity studies and mating ogives were generated. We found that mating opportunities dropped in 2011 and that mating failure might affect egg production over a wide range of sizes. More importantly, we observed an unexpected size-dependent relationship for mating success of both mature and immature females in 2011. These relationships suggest that males have a limited capacity to discriminate female maturity status, and may prefer mating with larger females. In addition, we observed in both time periods that contribution to realized egg production by small female size-classes was generally trivial in comparison to their reproductive potential, while the larger size-classes contributed the most to egg production despite lower potential. We believe this discrepancy was caused by the common occurrence of mating failure among small mature females. This study raises new questions on the potential role male mate selection may play in egg production and highlights the possibility that broodstock biomass measure may overestimate the reproductive capacity of lobster stocks by overlooking at mating success.
**POPULATION DYNAMICS**

**Using temperature-dependent embryonic growth models to predict time of hatch of American lobster, Homarus americanus, in nature**

Miller, Erin H.; Haarr, Marthe L.; Rochette, Rémy
University of New Brunswick, Saint John, NB E2L 4L5
Kathleen.Reardon@maine.gov

Hatch time affects the temperature experienced by developing American lobster (Homarus americanus) larvae, and hence the time and distance they will drift before settling. In principle hatch time can be estimated by working with fishermen and inspecting the brood of gravid females caught in their traps. However, this requires frequent sampling, given the hatch period is protracted, and (more importantly) would often require dedicated and expensive sampling as hatch occurs “outside” of the fishing season over much of the species’ range. To address these limitations, we tested the accuracy with which hatch time in nature can be predicted by (1) taking egg samples in Cheticamp, NS, during the fishing season, (2) estimating embryo development using embryonic eye size and lab-derived temperature-dependent development functions, and (3) comparing predicted hatch dates to the period of hatch observed by sampling out-of-season alongside fishermen. Utilizing samples obtained up to 18 days prior to the beginning of hatch we were able to predict with surprising accuracy the period over which hatch occurred, including hatches up to ≈ 9 weeks in the future. We successfully predicted 100% of the observed 50-day hatch period, and 98% of predicted hatch dates fell within this observed hatch period. Our results suggest that, over much of the American lobster’s range, samples can be obtained in collaboration with fishermen to predict hatch time with sufficient accuracy to enhance our ability to predict spatial connectivity via dispersal of larvae.

**Potential impacts on conservation discards in a growing lobster population in the Gulf of Maine**

Reardon, Kathleen1; Wilson, Carl1; Shank, Burton2
1 Maine Department of Marine Resources, West Boothbay Harbor, ME 04575
2 NMFS Northeast Fisheries Science Center, 166 Water St, Woods Hole, MA 02543
Kathleen.Reardon@maine.gov

The practice of v-notching to protect reproductive female lobsters has been a cornerstone of lobster conservation in Maine since the 1920’s. The Atlantic States Marine Fisheries Commission Lobster Stock Assessment model has incorporated v-notch rates to produce conservation discard estimates for all managed areas for the past two assessments. Since 1985, the Maine Department of Marine Resources has monitored the characteristics of the discards of the lobster fishery through an at-sea sampling program. Over the past 30 years, the lobster landings in Maine have skyrocketed from 20 million pounds in the 1980’s to 125 million pounds in 2014 and the vnotching rates appeared to be stable, but, in the past decade, the catch rates of v-notched females have increased, especially in eastern Maine. Considering a different metric, since a peak in 2008, the rate of ovigerous females already bearing a notch has exhibited a downward trend. Is this a change in fishery behavior or a population shift of proportions? Using the estimates from the ASMFC Lobster Stock Assessment model (2015) of the legal population and conservation discards, we explore trends over time to assess the growing population changes and possible impacts to the conservation discards.
**POPULATION DYNAMICS**

**Decline of American lobster abundance in Buzzards Bay, Massachusetts between 2005-2006 and 2013-2014**

Cassidy, K. S.; Stokesbury, K. D. E.

Department of Fisheries Oceanography, University of Massachusetts, School for Marine Sciences and Technology, 200 Mill Road, Suite 325, Fairhaven, MA 02719

kcassidy@umassd.edu

While American lobster (*Homarus americanus*) landings in the Gulf of Maine have increased, the landings in Southern New England have declined over the past decade. In 2005-2006, 13 sites were examined in Buzzards Bay, and the number of lobster per m$^2$ was estimated using a ventless trap survey and tagging experiment. Here we repeat those estimates using similar techniques. We examined the lobster density at the same locations using the same ventless trap and tagging design during the same months of 2013-2014. The abundance at each site was statistically compared between the two time periods. We saw a large decline in the majority of sites surveyed. Decreasing lobster catch per unit effort was correlated with increasing water temperature. Lobsters in Southern New England are near the threshold of their optimal temperature limit and as sea temperature increases we expect their distribution to shift towards deeper cooler water, which was supported by several recaptured lobsters outside of the Buzzards Bay area.
THE INDIVIDUAL LOBSTER

Linking ocean acidification and warming to the larval development of the American lobster (*Homarus americanus*)

Waller, Jessica D.\(^1\); Wahle, Richard\(^2\); Fields, David\(^2\); Greenwood, Spencer\(^3\)

\(^1\) University of Maine, School of Marine Sciences, Darling Marine Center, Walpole, ME, USA 04573
\(^2\) Bigelow Laboratory for Ocean Sciences, East Boothbay, ME, USA 04544
\(^3\) University of Prince Edward Island, Charlottetown, Prince Edward Island, Canada C1A 4P3

jesica.waller@maine.edu

The input of anthropogenic carbon in the atmosphere is an emerging threat to marine calcifying organisms. While global warming has received significant attention over the past decade, few studies have examined how ocean acidification (OA) may impact marine organisms. It is especially important to understand these effects for commercially important species such as the American lobster (*Homarus americanus*). Lobster larval stages are likely to be the most vulnerable to acidification, but only one study has examined OA effects on larvae. In a full factorial experiment this US-Canadian collaboration was able to quantify the interactive effects of warming and acidification on five aspects of larval performance: 1) survival, 2) development, 3) respiration, 4) gene expression, and 5) prey consumption. Understanding how the most vulnerable life stages of the lobster life cycle will respond to changing conditions is essential in connecting the geographic shifts projected by habitat quality models, and the underlying physiological and genetic mechanisms that drive their ecology. In particular, the effect of changing temperature and OA on the regulation of well described genes in lobster has never been examined. Preliminary experiments suggest that larvae lower respiration rates under elevated CO\(_2\) levels, but maintained body mass and length similar to control larvae. Larvae raised in the high temperature treatments experienced significantly higher mortality and development rates. These results suggest that projected end-century temperature changes may be more influential than anticipated acidification levels in determining the fate of lobster larval development.

3D-microXray tomography reveals additional features of American lobster shell structure

Kunkel, Joseph G.\(^1\); Rosa, Melissa \(^1\); Bahadur, Ali \(^2\)

\(^1\) UNE Biddeford ME and \(^2\) Bruker Research Lab, Bilerica MA

jkunkel1@une.edu

The structural heterogeneity of *Homarus americana* exo- and endocuticle is greater than previously suggested when viewed using 3-D microXray tomography on small medallion samples extracted from a lobsters exoskeleton. Sequential medallion samples from individual lobsters allow a temporal series of shell development to be established. The minimal injury to the lobster can be validated by further study of the medallion extraction site. The rapidity of sample preparation and analysis will allow study of the spatial and developmental aspects of shell architecture that correspond to well established features of claw, carapace and pleopod molting stages. Preliminary analysis of 3.5 um and 0.5 um resolution data from a Bruker Skyscan 1272 micro CT suggest that the previously described evenly spaced organule cell clusters contribute to foci for calcite structures extending into the inner exocuticle and endocuticle. The ease of sample preparation and analysis will allow population and seasonal variation in lobster shells to be established. Supported by RI Sea Grant New England Lobster Research Initiative.
The Individual Lobster

Impact of sublethal concentrations of agricultural and aquacultural pesticides on larval American lobster

Clark, K. Fraser,1,2; Daoud, Dounia; Greenwood, Spencer J.1,2
1Department of Biomedical Sciences, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown PE, Canada; 2AVC Lobster Science Centre, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown PE, Canada; 3Homarus Inc., Shédiac, New Brunswick, Canada.

fclark@upei.ca

The Canadian lobster fishery is a significant economic driver of hundreds of rural Atlantic Canadian communities. Many of these coastal communities are in close proximity to either industrial agriculture operations, or small to medium scale aquaculture operations. The routine use of pesticides is critical for maintaining economically sustainable harvests for both the agriculture and aquaculture sector. Periodic release of these pesticides into the marine environment following aquacultural bath treatment or heavy rainfall events, has the potential to affect non-target marine crustaceans such as the American lobster (Homarus americanus). This study was designed to determine the effects that sublethal concentrations of the agricultural pesticide permethrin, and the anti-sea lice treatment deltamethrin (AlphaMax®), have on larval lobsters. RNA-Seq was used to investigate the differences in global gene expression that occurs in larval lobsters following exposure to several concentrations of these pesticides. Almost 450 genes were differentially expressed following permethrin exposure while almost 3200 genes were differentially expressed following deltamethrin exposure. Genes from a variety of functional classes were differentially expressed including those involved in: detoxification, immunity, stress, moulting and cuticle proteins. This study highlights the potential impact that agricultural and aquacultural pesticides could have on larval lobster.

The American lobster (Homarus americanus) lacks susceptibility to White Spot Syndrome Virus (WSSV) infection following per os experimental challenge

Byrne, Philip J.1,4; Clark, K. Fraser; Greenwood, Spencer J.2,3; Roux, Louise-Marie D.1,2,3
1Gulf Biocontainment Unit, Fisheries and Oceans Canada, Charlottetown, PE, Canada; 2Department of Biomedical Sciences, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown PE, Canada; 3AVC Lobster Science Centre, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown PE, Canada; 4Department of Pathology and Microbiology, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown PE, Canada (adjunct faculty)

philip.byrne@dfo-mpo.gc.ca

The American lobster is found on the east coast of North America (Newfoundland and Labrador to the North Carolina). The American and Canadian lobster industry is valued in the hundreds of millions of dollars. Mitigating the threat posed by regulated diseases is one way the Canadian National Aquatic Animal Health Program (NAAHP) works to protect the aquatic animal resources of Canada. Shrimp viral pathogens, known mostly from culture facilities in warmer climates (south-east Asia, India, central and south America), are considered a potential threat to more temperate climate European and North American lobster industries. Experimental work at the Gulf Biocontainment Unit (GBU) provides evidence that the American lobster is not susceptible to White Spot Syndrome Virus infection (or disease) when exposed to the virus under realistic conditions. Market sized lobster were fed WSSV-infected shrimp pieces and held for 84 days at 10°C (3 groups of 10 lobsters), 20°C (1 group of 10) and uninfected controls at 10°C (1 group of 10). Non-lethal haemolymph samples taken at 3, 6 and 9 weeks post-exposure and lethally obtained haemolymph and tissues collected at 12 weeks post-exposure were negative for WSSV using RT-qPCR. Details of WSSV challenge work at GBU and the use of disease susceptibility criteria will be discussed.
THE INDIVIDUAL LOBSTER

Effect of temperature on the pathogenicity and immune response of American lobster experimentally infected with White Spot Syndrome Virus

Roux, Louise-Marie D. 1,2,3; Byrne, Philip J. 2,4; Clark, K. Fraser 1,3; Wright, Glenda M. 1; Wadowska, Dorota W. 5; Greenwood, Spencer J. 1

1 Department of Biomedical Sciences, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown PE, Canada; 2 Gulf Biocontainment Unit, Department of Fisheries and Oceans Canada, Charlottetown, PE, Canada; 3 AVC Lobster Science Centre, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown PE, Canada; 4 Department of Pathology and Microbiology, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown PE, Canada; 5 Electron Microscopy, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown PE, Canada

Lroux@upei.ca

Water temperature influences basic life history traits of the American lobster (Homarus americanus) such as growth, reproduction and migration. Yet, relatively little is known about the effects of water temperature on the immune response of Homarus americanus. This study involved controlled white spot syndrome virus (WSSV) infections in lobster using intramuscular inoculations and a range of temperatures (10, 15, 17.5 & 20°C) over a 2-week period. Results are presented on the immune and tissue response of American lobster. Changes in haemocyte concentration (as an indicator of health) and WSSV-qPCR testing of haemolymph indicate that disease profiles vary depending on the host’s ambient water temperature.

Results from gene expression analysis, using a lobster specific microarray, highlight 205 significantly differentially expressed genes among the temperature groups. In WSSV infected lobster hypertrophied nuclei with nuclear inclusions were seen in various tissues using light microscopy; electron microscopy revealed the presence of viral particles in these same areas. Results suggest that differences in temperature are associated with differences in gene response, viral load and tissue changes. The use of multiple testing approaches allows us to better understand overall temperature effects in this economically important shellfish species.

Implications of export of live American lobster (Homarus americanus) to Norway; crossbreeding and ecological implications

Agnalt, Ann-Lisbeth 1; Grefsrud, Ellen S. 1; Farestveit, Eva 1; Jørstad, Knut E. 2

1 Institute of Marine Research, P.O. Box 1870 Nordnes, 5817 Bergen, Norway; 2 Jørstad Marine AS, Landåsvingen 25, 5840 Bergen, Norway

Ann-Lisbeth.Agnalt@imr.no

The USA and Canada export live American lobster (Homarus americanus) to several continents, including the European market. As American lobster do not naturally occur in Europe, introductions of live specimens impose a high risk of interactions with the native European lobster (H. gammarus). In 2000, the first American lobsters collected from Norwegian waters were identified using DNA testing. Since then, 145 specimens captured in the wild have been DNA-tested, of which 58 proved to be American: Norway n = 28; Sweden n = 24; Denmark n = 1; and, Ireland n = 3. Six of the females captured in Norway were ovigerous. If the eggs hatched in the wild, this could lead to competition with the European lobster. Although the chances for crossbreeding are considered small, analysis of eggs has routinely been carried out. In 2009, the first evidence of a successful cross-mating was found in Norway and is the first documented case of hybridization between the two species under natural conditions. The hybrids were successfully hatched in 2010 at Institute of Marine Research. Larvae and juvenile development was monitored and characterized. Hybrid juveniles showed a high degree of asymmetry e.g., the abdomen twisted to one side was a common finding. Hybrids also showed a high variation in growth. Records in 2014 showed that females ranged from 31 to 59 mm CL, and males from 35 to 73 mm CL. The largest hybrid males are now sexually mature and fertility tests will be conducted on the males.
**THE INDIVIDUAL LOBSTER**

**Experiences with American lobster (Homarus americanus) and shell disease from Norway**

Sandlund, Nina; Agnalt, Ann-Lisbeth; Einen, Ann Cathrine B.; Fiksdal, Ingrid U.; Karlsbakk, Egil
Institute of Marine Research, P.O. Box 1870 Nordnes, 5817 Bergen, Norway
ninasa@imr.no

Through DNA analysis, 28 lobsters captured in Norwegian waters 2000-2015 have been verified as American lobster (Homarus americanus). Being a valued seafood, and importation of live American lobster to Europe has increased the last decades. The release or escape of live American lobster in European waters may introduce exotic parasites and other disease agents, and hence represent a threat to European lobster populations as well as to other decapods. Six of the American lobsters captured in Norway between 2009-2012 had symptoms of being infected with shell disease, similar to Epizootic Shell-Disease (ESD). ESD is of great concern in American lobster stocks, particularly in USA. Analysis of histological samples suggests the lesions are due to bacteria degrading the exoskeletal matrix. This is supported by the identification of bacterial isolates form the exoskeleton lesions. Follow-up studies of European lobsters (Homarus gammarus) in an area where several diseased American lobsters were caught have not revealed similar lesions in those. The presence of live American lobster in Norwegian waters has raised concerns about disease transfer, ecological interactions and hybridisation with the European lobster.

**Are green crabs (Carcinus maenas) a vector for American lobster (Homarus americanus) pathogens?**

Clark, K. Fraser; Elliott, Brad; Tobin-Huxley, Gillian; Rao, Zhixu; Stewart-Clark, Sarah E.
1Department of Biomedical Sciences, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown PE, Canada; 2AVC Lobster Science Centre, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown PE, Canada; 3Department of Plant and Animal Sciences, Faculty of Agriculture, Dalhousie University, Truro, Nova Scotia, Canada.
fclark@upei.ca

European green crabs (Carcinus maenas) are an invasive crustacean that has spread throughout the Northeastern United States and is spreading throughout Atlantic Canada and Newfoundland. Pathogen surveys of green crabs around the United Kingdom have found at least 13 pathogens within green crabs; at least three of which are known to also infect American lobster. As green crab populations increase along the Eastern seaboard of North American they are causing significant ecological and commercial devastation to the coastal areas they inhabit. Recently proposed mitigation measures including the establishment of green crab fisheries have been suggested in several Canadian and American jurisdictions; where the harvest would be sold as low-cost lobster bait. To date, no research has been published on pathogens that are infecting North American green crab populations. We have undertaken a survey of green crab populations around Nova Scotia for parasitic, bacterial and viral pathogens known to infect American lobster. In addition, lobsters from Nova Scotia have been surveyed to determine the prevalence of the green crab acanthocephalan parasite Profilicollis botulus in lobster populations. Our early results indicate P. botulus prevalences of over 30% in several green crab populations, and over 50% in several lobster populations. Our results will be presented in the context of whether or not green crabs could act as a vector of American lobster pathogens.
THE INDIVIDUAL LOBSTER

Optimising flow for oxygen consumption and feed availability in a controlled sea based environment

Daniels, Dr. Carly; Boothroyd, Dominic; Johanning, Prof. Lars; Halswell, Dr. Peter
1National Lobster Hatchery, Cornwall, UK; 2University of Exeter, Cornwall, UK.
carly.daniels@nationallobsterhatchery.co.uk

Lobster Grower is a multi-organisation, interdisciplinary research project, funded by Innovate UK/BBSRC, which aims to develop a sea based aquaculture system for rearing European lobster (*Homarus gammarus*). The key to successfully developing Sea Based Container Culture (SBCC) systems is optimising environmental conditions to maximise growth. High flow velocities have been shown to reduce feeding and cause physical damage to the lobsters. Low flow rates reduce the oxygen availability and thus reduce growth rates. Flow rates will also affect planktonic feed availability and settlement of potential feed species. This research therefore focuses on determining flow rates in various designs of SBCC systems: Oyster, SBCC1, SBCC2 and SBCC3. Internal flow measurement were assessed against lobster specific performance indicators (mainly oxygen consumption and feeding rates); internal flow was too low in Oyster and too high in SBCC3. External flow visualisation using dye-tracing also uncovered varying flow patterns. Yaw rotation motion showed variation in stability between designs of different shape with Oyster and SBCC2 providing stable yaw rotation motion. As predicted biofouling showed to reduce flow and results highlight how the performance of the SBCC system will deteriorate during its life time at sea. All data showed variation between the four designs with SBCC1 and SBCC2 providing the most appropriate environmental conditions for *H. gammarus*. Results allowed a fair comparison between the prototype SBCC systems and have helped confirm the novel SBCC designs to be taken forward for full-scale sea trials. Results of the current work are highly applicable for American lobster *Homarus americanus* aquaculture.

The influence of off-shore aquaculture on American lobster (*Homarus americanus*) movement

Simard, Emilie; Drouin, Annick; McKindsey, Christopher; Archambault, Philippe; Luc, Comeau
1 Institut des sciences de la mer, Rimouski, Qc G5L 3A1; 2Institut Maurice-Lamontagne (DFO), Mont-Jolie, Qc G5H 3Z4; 3 Gulf Fisheries Centre (DFO), Moncton, NB E1C 9B6
emilie.simard2@videotron.ca

Mussel aquaculture tends to aggregate lobsters due to the provision of physical structures (anchor blocks) and food resources (mussel fall-off and aggregation of benthic species). In this study, acoustic methods were used to determine the affinity of lobsters to an off-shore mussel culture site in Îles-de-la-Madeleine, Canada. The tested hypothesis is that lobsters spend more time and their home ranges are smaller in an area under a mussel farm relative to areas without mussel culture because of the proximity and abundance of shelter and food resources. Lobster movements were followed within 3 arrays of 1.8 km², where each contains 10 fixed receivers (VR2W). One of them was under the mussel farm and the other two experimental areas were adjacent to the farm site. Acoustic transmitters (V9) were attached to 15 lobsters found within the culture site and 15 lobsters found in each of two other areas outside the culture site and placed back to where they were captured. A further 15 lobsters were caught outside of the mussel farm, and placed within the farm site. Spatial analysis was used to compare the time that lobsters spent within different areas, and also the distance and the speed of movement of lobsters in each area. Contrary to expected results, some results show that 85% of lobsters leave the mussel farm in less than a week. However, it is noteworthy that the lobsters showed rectilinear movement across the different areas, which corresponds to a nomadic lifestyle, rather than to a sedentary one.
**The Business of Lobstering**

**Changes to the US Marine Mammal Protection Act and impact on lobster trade between US and Canada**  
Tselikis, Annie  
Maine Lobster Dealers’ Association, Scarborough, Maine 04107  
annie@mainelobsterdealers.org

The US National Oceanic and Atmospheric Administration (NOAA) is working on implementation of a rule within the MMPA that would ban US imports of fish and fish products from harvest nations that do not have equal marine mammal protection standards. The draft rule states that there will be a 5-year period for other nations to come into compliance with the law. The impact to US and Canadian lobster dealers and processors could be significant. This is an informational session covering the background and timeline. Learn about ways for industry to comment on the policy development and stay informed.

**How the characterization of lobster fishing practices allowed for targeted regulations aimed at reducing whale entanglements**  
Summers, Erin; Cotronio, Sarah; Wilson, Carl  
Maine Department of Marine Resources, West Boothbay Harbor, ME 04575  
erin.l.summers@maine.gov

The National Oceanic and Atmospheric Administration’s Fishery Service has been regulating the lobster, and other fixed gear fisheries, in the United States since 1997 through the Atlantic Large Whale Take Reduction Plan to reduce the risk of entanglement to endangered large whales. Following the blanket measure for the use of sinking groundline between traps in 2008, an initiative began to provide more detailed information on fishing practices to regulators in an effort to target measures to areas that have the most potential to reduce risk. Voluntary paper survey methods were employed to document fishing practices by month, Lobster Management Zone, and distance from shore. The results of these surveys were paired with the Department of Marine Resources Dealer Reporting data to quantify the seasonal scale of the fishery and determine where adjustments could be made to fishing practices that would reduce vertical lines, and therefore risk, in areas of high overlap with endangered whale distributions. The resulting proposal, made by the State of Maine and approved by the Atlantic Large Whale Take Reduction Team, was adopted into federal regulation and marked one of the first regulatory measures that are tailored to fit existing regional fishing practices. The Final Rule, which was published in 2014 and is being implemented in 2015, is providing a conservation benefit to endangered species in the form of a more than 37% reduction in the co-occurrence of gear and whales in strategic habitats.

**Ghost trap retrieval in the Bay of Fundy**  
Recchia, Maria; Brown, Reid; Hunter, Roger  
Fundy North Fishermen’s Association, St. Andrews, NB E5B 3W9.  
mariarecchia@nb.aibn.com

Ghost fishing gear is a problem in many jurisdictions including in the Bay of Fundy. It is a problem for fishermen and a problem for wildlife, especially whales. For the last 7 years, members of the Fundy North Fishermen’s Association have participated in a ghost trap retrieval project. Fishermen designed grapnels to suit different conditions and have retrieved over 1000 derelict lobster traps in addition to other lost fishing gear and marine debris. We will discuss the causes of gear loss off SW New Brunswick, how to retrieve it, and how to prevent it.
THE BUSINESS OF LOBSTERING

Spatio-temporal trends in Magdalen Island's lobster fishery: Implications for management
Labbé-Giguère, Stéphanie; Brêthes, Jean-Claude
Chaîne UNESCO en analyse intégrée des systèmes marins, UQAR-ISMER, 310, Allée des Ursulines, Rimouski (QC), G5L 3A1
Stephanie.Labbe-Giguere@uqar.ca

In the context of ecosystem-based fishery management, identification of spatial and temporal processes becomes paramount. Hence, Magdalen Islands' lobster (Homarus americanus) fishery is economically important and the possible establishment of a marine protected area in this region requires investigating possible interactions between conservation and exploitation. Facing the lack of information on fishing effort distribution and lobster abundance, it was decided to combine two types of knowledge. First, the traditional ecological knowledge comes from local lobster harvesters and the second from official landings data recorded for each port. This complementary approach lead to a global understanding in terms of production areas and areas favorable for conservation. The observed spatio-temporal trends have shown a reduction of the production area as well as a reduction of the time devoted to each at-sea activity of the lobster fleet since 1980. The catch (kg) per unit of effort (trap haul) (CPUE) increased between 1985 and 2012. During the same period, a faster reduction of the CPUE within the season has been observed. Modifications of fishery strategies and the movement of harvesters from one wharf to another over the years seem to have influenced the CPUE pattern. These observations allow identifying the coastal zone as a proper area for resource conservation. Hence, this approach allowed to link annual and seasonal CPUE variations with changes in the abundance of the resources, social-economic perspectives and fishery strategies. Understanding fishery dynamic and its controlling factors should allow resource manager to make sound decisions within the social-economic constraints of the fisheries.

Potential use of mussel farms as multitrophic on-growth sites for American lobster, Homarus americanus
Wang, Guoqiang; McGaw, Iain J.
Department of Oceans Sciences, Memorial University, St John's, NL Canada, A1C 5S7
jimcgaw@mun.

Moultmg, growth rates and blood protein concentrations of cage-held adult lobsters were monitored at in the field (under mussel culture lines) and the lab during a 6 month period. Although survival rates were high under mussel lines (> 95%), the moulting rate was low (13%) and analysis of blood protein concentration showed that lobsters maintained in the field were in a poorer condition than fed lobsters in lab experiments. In the laboratory diet type, temperature, feeding frequency and compartment size were manipulated to determine possible factors influencing survival and growth of the lobsters in the field. In the lab, moulting was highest at 15°C and survival lowest at 5°C, and lobsters fed a mixed versus a mussel only diet were healthier. Lobsters that were fed twice weekly grew larger than those fed once per month. However, feeding frequency did not affect survival or the number of animals that moulted. The lab experiments suggested that the combination of low temperature and infrequent food input was the likely cause of the low moulting rate and overall quality of the lobsters in the field. This project showed although lobsters can be stored in benthic cages in the field for up to 6 months, relying on mussel drop-off alone is limited, and lobsters may need supplemental feeding in order to produce a larger, higher quality product for market. Initial results also suggest the promise of incorporating lobsters into a multitrophic aquaculture system as a means to remove moribund mussels underneath culture lines.
THE BUSINESS OF LOBSTERING

Live holding water quality
Nickerson, Philip
Aqua Production Systems, 111 Elshirl Rd, New Glasgow, NS, B2H 5C5
philipnickerson@gmail.com

If a lobster is strong enough to hunt for, detect, locate, and eat the food in a fisherman’s trap, why would he die in a live holding tank? Assuming proper handling, the only answer is poor water quality. Water quality in a live holding tank directly affects shrinkage, shipping success, and even mortality. In aquaculture, tanks are designed to maintain good water quality such that the animals are robust and want to feed at peak rates 365 days per year.

A live holding tank is a simple aquaculture engineering problem as the animals are not typically fed. Three distinct lessons for live lobster holding from aquaculture engineering are presented with practical examples from industry. Temperature, oxygen, and solids control are the keys to low shrinkage and successful shipping of a quality product.

Changing climate, changing economics: Global market integration of US-Canada American lobster in the emerging Chinese market
Sun, Jenny; Chiang, Frank; Le Bris, Arnault
Gulf of Maine Research Institute, Portland, ME 04101
alebris@gmri.org

This study analyzes the timing of Maine and Canadian lobster landings and how prices have responded to the landings anomalies caused by abnormally warm ocean temperatures in 2012. The Gulf of Maine Heatwave (GOMH) in 2012 caused the fishing season to start three weeks earlier than normal and high landings to occur during a compressed time period. As a result, boat price dropped by more than 30% in the summer in the US and business viability considerations have become a concern for lobstermen and fishery managers. Through global market integration, U.S. and Canadian lobster export value to the emerging Chinese market reached $245 million in 2014, which accounted for 21% and 11% of the export value from U.S. and Canada, respectively. The increasing demand in the Chinese market and the competition between the U.S. and Canada has affected lobster boat prices and is stretching the supply for live lobster, creating the need for a better management scheme that aims to produce high quality products for diversified global markets.

In this study, the monthly landings, prices, and trade of live and processed lobster between the U.S. and Canada are compiled. An inverse demand system is specified to evaluate the impacts associated with the supply shocks caused by the 2012 GOMH, and the price transmissions between countries caused by the integrated global market. The study provides an example of the resilience and adaptation of a coastal ecological-economic system in response to increasing ocean temperature and its consequences for fishery stakeholders.

Panelists: ‘The Business of Lobstering’

Beth Casoni
Executive Director
Massachusetts Lobstermen’s Association
beth.casoni@lobstermen.com

Stewart Lamont
Managing Director
Tangier Lobster Company
stewart@tangierlobster.com

Marc Lanteigne
Manager
Aquatic Resources Division
Gulf Region Fisheries and Oceans Canada
Marc.Lanteigne@dfo-mpo.gc.ca

Jeff Malloy
President
Lobster Council of Canada
jeffm@acadianfishcooop.com

Annie Tselikis
Executive Director
Maine Lobster Dealers’ Association
annie@mainelobsterdealers.org
POPULATION DYNAMICS

P1 Lobster Recruitment Index from Standard Traps
Scott-Tibbetts, S.L.
Fisherman and Scientists Research Society, PO Box 25125, Halifax, NS B3M 4H4
Shannon.Tibbetts@fsrs.ns.ca

The Lobster Recruitment Index from Standard Traps project began in the spring of 1999. The goal of the project is to provide an index of the number of lobsters that will moult into the legal sizes in the coming seasons. The project was initiated by the Fishermen and Scientists Research Society (FSRS) in cooperation with the Population Ecology Division, DFO at the Bedford Institute of Oceanography (BIO). The initial phase of the project was planned for five years but after reviewing the project’s usefulness, it is scheduled to continue for the foreseeable future. In 2014, this project involved 133 volunteer fishermen from LFAs 27-35 who fish standardized traps and take measurements of the lobster caught. There were 14,738 trap hauls and 61,626 lobsters measured. These measurements are recorded in a logbook using a specially designed gauge with 15 different size increments. Participating fishermen also monitor bottom temperatures with a minilog temperature gauge in one of the standard traps. These bottom water temperatures are forwarded to oceanographers at BIO and are a great addition to their coastal temperature monitoring database. The lobster information gathered has been used by Fisheries and Oceans Canada (DFO) in their lobster stock assessments and has helped to greatly understand the lobster populations around the Scotian Shelf area of Nova Scotia.

P2 Quantifying the density and size of early benthic phase lobsters on mud seafloor: Experiments with the Devisme otter trawl
Dinning, Kristin M.; Rochette, Rémy
University of New Brunswick, Saint John, NB E2K4K2
k.dinning@unb.ca

Young-of-the-year (YOY) and early benthic phase (EBP) lobsters prefer structurally complex seafloor, particularly cobble, but this habitat is relatively rare and its scarcity may limit benthic recruitment and population growth of lobsters. In a recent study in Maces Bay (southwest Bay of Fundy), YOY and EBP lobsters colonized cobble-filled collectors on isolated mud seafloor, more than 400m from cobble reefs, suggesting mud habitat may play a role in lobster benthic recruitment. How meaningful this role is will depend on mud’s availability (generally high) and on the density of juveniles using mud. We are conducting trials with a Devisme otter trawl to develop a tool to quantify the abundance and size of juvenile lobsters on mud bottom. The Devisme trawl is a small benthic otter trawl used in northern France to catch shrimp (Crangon crangon) which can burrow into sandy seafloor. The trawl has previously been used in Canada to catch EBP and adult lobsters (17-74 mm carapace length) in sandy eelgrass. We are modifying the original trawl, particularly in regards to net arrangement, mesh size, and lead lines (to entice burrowed lobsters to leave sediments) to capture YOY and small EBP lobsters. The Devisme trawl, unlike collectors, samples an area of known size, and, unlike suction-sampled quadrats and visual transects, can quickly cover a large area without being affected by poor visibility on easily-disturbed sedimentary substrates. This work is the first step in developing the Devisme trawl as a tool to support assessing the importance of mud seafloor towards the benthic recruitment of lobsters.
P3 Relationship of American lobster year-class strength to fishery recruitment in Massachusetts Gulf of Maine coastal waters
Whitmore, Kelly A.1, Pugh, Tracy L.1, Glenn, Robert P.2
Massachusetts Division of Marine Fisheries, 130 Emerson Ave., Gloucester, MA 01930; 21213 Purchase St., New Bedford, MA 02740
kelly.whitmore@state.ma.us

Indices of young-of-the-year (YOY) lobster settlement derived from air-lift/suction sampling have been maintained for 21 years along the coast of Massachusetts. Sites span Buzzards Bay, Cape Cod Bay, the South Shore, and Massachusetts Bay. One long standing objective of the survey is to assess the utility of the index in forecasting commercial fishery recruitment. Recent explorations of the predictive power of this long-term dataset have been promising for Gulf of Maine waters (i.e. sites north of Cape Cod). Robust associations were found between year-class strength and several fishery-dependent and fishery-independent indices, including commercial landings from the Massachusetts inshore portion of the Gulf of Maine, trawl survey lobster abundance, and ventless trap survey adolescent lobster abundance. Temperature factors will be examined in light of the recent warming trend and observed declines in the YOY index to elucidate differences north versus south of Cape Cod. Development of predictive capabilities to link life-history phases observed in the various surveys (e.g. suction sampling, ventless trap) to ultimate landings represents an important advancement towards improving stability and sustainability of the lobster fishery and resource.

P4 Thermal histories and migration of ovigerous lobsters, Homarus americanus, from Grand Manan, N.B. revealed using satellite tags
Hanley, Patricia; Morse, Bryan; Sigurdsson, Gudjon; Rochette, Remy
University of New Brunswick, Saint John, NB E3L 4L5
Patricia.Hanley@unb.ca

It has been hypothesized that ovigerous lobster, Homarus americanus, undertake seasonal migrations to maximize the temperature experienced by their embryos, to accelerate their development. In October 2013 we attached satellite tags to two ovigerous lobster in coastal waters off Grand Manan, N.B., which we programmed to release in July 2014. Tags recorded depth and temperature experienced by the lobster, in addition to start and end coordinates, which can be used to estimate lobster movements. The tags surfaced near Beaver Harbour and Minas Basin, approximately 33 and 123 km from the tagging location, respectively. The tagged lobsters remained in waters at temperatures between 5 and 12°C during the brooding period, suggesting inshore to-offshore movements in winter months to avoid lower inshore temperatures; this conclusion was supported by the depths recorded. In fall 2015, 10 ovigerous lobsters will again be tagged with satellite tags off Grand Manan, and tracked for 10 months during the brooding period. Bottom water temperature data will be collected and used in conjunction with an existing temperature model (DFO) to compare thermal regimes experienced by the lobsters in relation to those potentially available throughout the region. We hypothesize that ovigerous lobster will experience the highest temperatures available assuming realistic movement rates, to optimize egg development of their embryos. This study will expand our knowledge of the nature and extent of movement made by ovigerous lobster as well as the consequences of these movements, including timing and location of larval release and connectivity between lobster populations.
P5 Developing a fishery independent survey to assess lobster abundance and reproductive potential
Denton, Cheryl1; Gaudette, Julien2; Tremblay, John3; Hubley, Brad3
1Fisheries and Oceans Canada, Digby, Nova Scotia, Canada;
2St Andrews Biological Station, Fisheries and Oceans Canada, St Andrews, NB, Canada;
3Bedford Institute of Oceanography, Fisheries and Oceans Canada, Dartmouth, NS, Canada
Cheryl.Denton@dfo-mpo.gc.ca

Developing a fishery independent index of lobster abundance has been identified as a necessity for the management of the Lobster Fishing Areas (LFAs) 34-38. In 2013, the DFO Lobster Unit took over the leadership of the Individual Transferable Quota (ITQ) trawl survey. This survey was developed in collaboration with the fishing industry to monitor groundfish stock based on a fixed design. Some information on lobster were collected (size, sex, shell hardness, and blood protein and molt stage on few selected stations) but the sampling coverage nearshore was limited. The survey is undergoing a transition to make it more relevant to lobster and the design and gear type are being reconsidered. In the meantime, additional information is now collected to better understand the reproductive capacity and the health of the broodstock. This includes recording mating success on all females larger than 70mm CL, clutch fullness, egg stages and shell disease. A summary of data collected and methodologies adapted since the lobster group took over the survey as well as future plans for the survey is provided.

P6 Temporal trends (1989-2013) in the onset of hatch in American lobster, Homarus americanus, in relation to water temperature in the Southern Gulf of St. Lawrence, Canada
Haarr, Marthe Larsen1; Comeau, Michel2; Chassé, Joël3; Rochette, Rémy1
1University of New Brunswick Saint John, Saint John, NB, Canada;
2Gulf Fisheries Centre, Fisheries and Oceans Canada, Moncton, NB, Canada;
3Maurice Lamontagne Institute, Fisheries and Oceans Canada, Mont-Joli, QC, Canada
marthe.haarr@unb.ca

Water temperatures in the North Atlantic have been increasing steadily since the 1970s, which may be having widespread consequences in coastal ecosystems. One organism whose life history is likely affected by shifts in thermal regime is the American lobster, Homarus americanus, as development and growth rates of embryo, larvae and benthic stages are all temperature-dependent. Female lobsters spawn eggs in the summer or early fall and carry them on their abdomen for 9-12 months before the larvae hatch. It is likely that faster seasonal increases in temperatures and warmer waters in the spring and early summer will result in more rapid embryonic development and earlier hatch of larvae. The timing of hatch dictates the temperature and currents experienced by the larvae, which in turn affects the duration of the pelagic phase, survival probability as well as drift distances. The timing of hatch will also influence food availability. The time at which larvae are released into the water column may therefore have significant impacts on both connectivity and benthic recruitment of lobster. This study utilises annual fishery-dependent data collected by Fisheries and Oceans Canada on ovigerous females and the degree of development of their clutches throughout the Southern Gulf of St. Lawrence from 1989-2013 to assess whether there is evidence that females are hatching their larvae earlier in years with higher water temperature. Lobster constitutes the most valuable fishery in Canada, and understanding factors that impact the timing of hatch is important in managing this fishery.
P7 Reproduction and recruitment of American lobsters in the Great Bay Estuary, New Hampshire, USA
Morrissey, Elizabeth M.1; Goldstein, Jason S.2; Watson, Winsor H.1
1 University of New Hampshire, Durham, NH 03824; 2 Eastern Connecticut State University, Willimantic, CT 06226
Emz4@wildcats.unh.edu

It is generally accepted that American lobsters (Homarus americanus) seasonally utilize estuaries throughout most of their range. However, a recent tracking study in the Great Bay Estuary (GBE), New Hampshire revealed that some lobsters remain in the estuary year round, including ovigerous females. The possibility that there is a self-sustaining resident population of lobsters in GBE has never been rigorously addressed, and the objective of this study is to test this hypothesis. First, we conducted a series of sea sampling trips to quantify the abundance and distribution of ovigerous lobsters in GBE. In addition, we determined the stage of the eggs they were carrying in the spring and early summer. Second, we conducted a series of neuston tows to determine if the lobster larvae obtained were likely to have originated from females residing in the estuary, due to the timing of their appearance and developmental stage. Third, we deployed passive surface drifters (n = 23) to determine if estuarine currents have the potential to retain lobster larvae in GBE. Finally, a trap study was conducted to examine the distribution of juvenile lobsters (<60 mm) that might have originated from larvae that settled in GBE. All of the data obtained so far support our original hypothesis that the GBE contains a self-sustaining lobster population.

P8 Characteristics of recent increases of epizootic shell disease in the American Lobster for the inshore Gulf of Maine
Reardon, Kathleen; Wilson, Carl
Maine Department of Marine Resources, West Boothbay Harbor, ME 04575
Kathleen.Reardon@maine.gov

The epizootic shell disease (ESD) that has plagued southern New England since the mid-nineties appears to be creeping northward with higher incidences observed in recent years in the Gulf of Maine. The Maine Department of Marine Resources Sea Sampling Program has been monitoring for shell disease since 2003 in the commercial catch. Until 2010, the observed levels of ESD have been consistently below 0.1 percent, but, in the last few years of data collection, the observed incidence has increased to nearly 2.5 percent in certain areas. We explore the spatial and biological characteristics of the affected catch in the Gulf of Maine.
THE INDIVIDUAL LOBSTER

L1 Do agricultural pesticides impact the recruitment success of American lobster (Homarus americanus) larvae?

Taylor, Laura1,2; Blackburn, Philippa1,2; Daoud, Dounia3,4; Clark, K. Fraser1,2; van den Heuvel, Michael R.5; Greenwood, Spencer J.1,2

1Department of Biomedical Sciences, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown PE, Canada; 2AVC Lobster Science Centre, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown PE, Canada; 3Homarus Inc., Shediac, NB, Canada; 4EcoNov Inc., Moncton NB, Canada; 5Canadian Rivers Institute, Department of Biology, University of Prince Edward Island, Charlottetown PE, Canada

lataylor@upei.ca

There is substantial literature to show that crustaceans are exquisitely sensitive to many classes of compounds used for agriculture making these species the marine equivalent of the canary in the coal mine. The Northumberland Strait lobster population, adjacent to considerable agricultural landuse, has had reduced landings for some time and has not responded to fisheries adjustment measures, hence the hypothesis that contaminants may contribute to this problem is likely. Lobster larvae, like other crustaceans, are known to be more susceptible to contaminants than adults. Laboratory exposures have revealed major effects on larval survival, behaviour, development and immunity. Determining these endpoints is useful, however they may not provide reliable quantifiable indicators of contaminant exposure and furthermore, lack the ability to assess the risk that sub-lethal contaminant exposures may impose on lobster health. Several pesticides used regionally have been identified (including the organophosphate chlorpyrifos) and will be used to monitor endpoints including global gene expression and metabolic scope. Objectives and initial findings will be presented in relation to the long term aim of developing indicators of contaminant impacts on the American lobster that can be used within a monitoring program as well as to study causality in the Northumberland Strait lobster collapse.

L2 Environmental contaminants from aquaculture practices: impacts on American lobster (Homarus americanus) larvae

Blackburn, Philippa1,2 Taylor, Laura1,2; Daoud, Dounia3,4; Clark, K. Fraser1,2; van den Heuvel, Michael R.5; Greenwood, Spencer J.1,3

1Department of Biomedical Sciences, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown PE, Canada; 2AVC Lobster Science Centre, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown PE, Canada; 3Homarus Inc., Shediac, NB, Canada; 4EcoNov Inc., Moncton NB, Canada; 5Canadian Rivers Institute; Department of Biology, University of Prince Edward Island, Charlottetown PE, Canada

Pblackburn@upei.ca

In Atlantic Canada two economically important resources, aquaculture and fisheries, share the same aquatic ecosystem and each contributes environmental costs. For this reason, it is important that the practices of these essential economic drivers do not impede or impair the viability and sustainability of the other. A major concern for the lobster industry is the pesticides used in the treatment of Atlantic salmon infested with the crustacean parasite, sea lice (Lepeophtheirus salmonis) and the subsequent impact on lobster health. Not surprisingly, lobsters have been shown to be susceptible to many of the same pesticides used to treat sea lice. Laboratory exposure studies indicate that for several pesticides, larvae show an increased sensitivity and that survival, behaviour, development and immunity are differentially impacted by the exposure regimen. Determining reliable quantifiable indicators of contaminant exposure that can be used to assess the risk that sub-lethal contaminant exposures may impose on lobster health is important. We will monitor several endpoints including global gene expression and metabolic scope to explore the impact of aquaculture pesticides (including azamethiphos, Salmosan® and deltamethrin, AlphaMax®) and to identify relevant indicators. The study objectives and preliminary findings will be presented in relation to the goal of developing indicators of contaminant impacts for the American lobster that can be incorporated into a regional monitoring program.
L3 Temperature effects on length-at-maturity in American lobster

Le Bris, Arnault; Pershing, Andrew J.
Gulf of Maine Research Institute, Portland ME
alebris@gmri.org

It has long been acknowledged that temperature affects length-at-maturity in American lobster. Studies on temperature and length-at-maturity have however focused on local scales, impeding the development of tools for long-term and continental forecasts of the dynamics of lobster populations and fisheries under climate change. In this study, we present a synthesis of maturity patterns in relation to temperature over the species distribution range. Data on ovigerous and V-notched females from commercial sea-sampling are used to estimate yearly maturity ogives for management zones from Rhode Island to Newfoundland. Regression between the parameters of the maturity ogive and sea-surface temperature (SST) showed high correlation between the 7-year mean SST and length at 50% maturity at both local (management area) and large (distribution range) scales. At the large scale, a change of one degree in the 7-year mean SST led to an about 5 mm CL decrease in lobster mean maturation size. The results of this study will facilitate the development of coupled climate-population models to forecast the dynamics of the American lobster fishery.

L4 Performance and survival of lobster larvae at high temperatures: What is known, and implications in the context of climate change

Quinn, Brady K.; Rochette, Rémy
1University of New Brunswick, Saint John, NB E2L 4L5
bk.quinn@unb.ca

Warming generally improves performance of life processes (moultning, growth, metabolism, etc.), but excessive (in magnitude and/or duration) warming can reduce performance and cause death, which in turn affects demography. Previous studies of American lobster have considered warming impacts on benthic adults, for which temperatures above 20°C are known to be stressful (e.g., 50-100% mortality after 48-72 hours at ≥ 25°C; McLeese, 1956). Less attention has been paid to performance of larvae at “extreme” high temperatures. However, water column temperatures are expected to increase faster than bottom temperatures, so warming may compromise physiological performance of larvae sooner than that of adults. It is thus important to identify stressful and upper lethal temperatures for lobster larvae, and include these in estimates of climate change impacts. As a first step toward this end, we reviewed 9 studies that observed survival, development, growth, and/or physiological performance of lobster larvae at extreme temperatures. Mortality following short-term (few minutes to 1-6 hours) exposure to 28-36°C has been reported, but more ecologically-relevant long-term (1+ days or weeks) high-temperature exposures have not been tested for larvae. Sub-lethal indicators of stress (irregular heartbeat, reduced growth) were reported in short-term exposures between 20-26°C, suggesting that long-term exposures to these temperatures could be lethal; however, this needs confirmation. Over the next 10-50 years, larvae may experience prolonged temperatures ≥ 26-30°C, which could negatively impact lobster populations if these temperatures are indeed stressful and/or lethal to them. These results highlight the need for further research into tolerance of lobster larvae to high temperatures.
L5  The effect of temperature on feeding activity and digestion in the lobster *Homarus americanus*

McGaw, Iain J.; Wang, Guoqiang; Robertson, Leah M.; Wringe, Brendan F.
Department of Ocean Sciences, Memorial University, St John’s, NL Canada, A1C 5S7
jmcmgaw@mun.ca

The effect of temperature change on foraging activity and digestive processes was investigated in the American lobster, *Homarus americanus*. Lobsters consumed approximately 3%, 4% and 5% of their body mass of mussel flesh in water of 5°C, 10°C and 15°C respectively. Foraging behaviour and activity outside of a shelter was recorded over a 7 day period. The lobsters spent significantly longer periods foraging outside of the shelter with increasing temperature and foraging activity was greater during the hours of darkness. Lobsters fed on mussels approximately every 16 h in 5°C, every 8 h in 10°C and at 5 h intervals in 15°C water. A fluoroscope was used to follow the transit rate of food through the digestive system. Transit rates decreased with increasing temperature, with Q10 values of 3.7. There was a correlation between feeding interval time and food evacuation rates from the foregut; at each temperature approximately 20% of the food had to be evacuated from the foregut before the lobsters would feed again. The transit times recorded here for lobsters were considerably longer compared with other decapod crustaceans. The consumption of subsequent meals may be needed to assist in movement of food through the midgut and hindgut regions. Despite changes in the amount and frequency of food consumption and differences in transit rates, water temperature did not have any significant effect on the digestive efficiency of a meal.

L6  Ocean acidification and warming effects on lobster development in Atlantic Canada

Menu-Courey, Kayla E.; Calosi, Piero; Daoud, Dounia; Cooper, Andrew; Azetsu-Scott, Kumiko
1Université du Québec à Rimouski, Rimouski, QC; 2Homarus Inc, Shediac, NB; 3Saint-Andrews Biological Station, Saint-Andrews, NB; 4Bedford Institute of Oceanography, Halifax, NS.
kmencourey@gmail.com

There are many gaps in our current knowledge about future combined impacts of ocean acidification (OA) and ocean warming (OW) on the American lobster (*Homarus americanus*). Acidic conditions have been seen to slow developmental rates in lobster larvae, but appear to exert no significant effect on adults. The general aim of this study is to explore the independent and combined effects of OA and OW on lobster development, life history and physiology. The objective in the summer of 2015 was to investigate the effect of OA on the development and physiology of 840 juvenile lobsters reared under 7 different pH levels which were controlled by pumping CO2 in the seawater at 400, 600, 800, 1000, 1200, 1500, and 5000 ppm. After two molt cycles, stage 6 lobsters were sampled in three sections that were immediately frozen in liquid nitrogen: the tail, for tissue analysis, the carapace, for mineral analysis, and the gut content, in case of further testing. Energy reallocation and trade-offs were expected to occur to compensate for the effects of OA and be most prominent in molting periods. The main results about development, survival rates, and intermolt periods will be described at the conference, as well as further objectives for following experiments.
L7  
**Physiological and developmental impacts of acidified seawater on larvae of the American lobster (Homarus americanus)**

Jones, Ian T.1; Hall, Joshua J.2; Bowden, Timothy J.2

1School of Marine Science, University of Maine, 5706 Aubert Hall, Orono, ME 04469-5706
2School of Food & Agriculture, University of Maine, 5735 Hitchner Hall, Orono, ME 04469-5735

ian_jones@umit.maine.edu

Increasing anthropogenic CO₂ emissions entering our oceans are increasing water acidity and might reduce the ability of lobsters to precipitate their CaCO₃ cuticles. Larval lobsters are thought to be more susceptible to CO₂-induced acidification than adults due in part to a relatively high molting frequency. *Homarus americanus* larvae were raised in separate systems at low, mid, and high pH levels to determine whether CO₂-induced acidity impacts their growth, cuticle mineralization, and development rate throughout their four larval stages. Neither carapace length nor dry carapace mass significantly differed among pH treatments, and dry body mass of stage III and IV larvae was significantly lower at low and mid pH relative to that of larvae at high pH. Percent calcium of larval carapaces was generally lower at decreased pH and significantly so for stage II larvae, whereas the same trend of percent phosphorous among pH treatments was not significant. Larvae in low and mid pH treatments also had delayed development to each larval stage. These physiological changes may impact *H. americanus* stocks by increasing larval susceptibility to predation, disease, and time until maturity is reached.

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L8  
**The implementation of ultrasound technique as a method to evaluate gastroliths development in American lobsters, Homarus americanus**

Potocka, Marta; Bayer, Robert; Bowden, Timothy

University of Maine School of Food and Agriculture, Orono, ME 04469

marta.potocka@twarda.pan.pl

Lobsters, like other arthropods, must periodically shed their exoskeleton and form a new bigger one to grow. To harden this skeleton by a calcification process they need calcium ions. Minerals, removed from the old exoskeleton in a pre-molt stage are deposited in a calcium storage structures in stomach wall, gastroliths, and are transported back to the cuticle during post-molt. We used ultrasound technique to determine gastrolith development in American lobsters. This non-invasive method provides baseline information for further studies to investigate changes in gastrolith formation. Ultrasound procedure was used directly in a water tank without taking animals out and without exposing them to radiation, as in case of using X-ray. Lobsters are tested in the tank environment and are less stressed which give more reliable results. This technique is being used to evaluate the effects of acidification on this component of the molt cycle.
THE BUSINESS OF LOBSTERING

B1 Lobster claw strength as a measure of viability
Hodgkin, Matthew¹; Bayer, Robert¹; Peterson, Michael²; McKay, Thomas²
¹University of Maine School of Food and Agriculture, Orono, ME 04469
²University of Maine Department of Mechanical Engineering, Orono, ME 04469
matthew.hodgkin@gmail.com

Presently the viability of lobsters is evaluated by drawing a hemolymph (blood) sample via syringe and reading the sample with a refractometer (Leavitt and Bayer, 1977). This is a simple, but invasive procedure. The research done in this study has developed an alternative non-invasive procedure to evaluate viability of lobsters for shipping. The prototype device for this study measures claw strength by using a load cell to measure closing strength of lobster claws. Both serum protein and closing strength of the American Lobster (Homarus americanus) were measured to examine this correlation. Lobsters of uniform size from various locations in New England and Canada were tested in this study. The preliminary data showed that closing strength of the crusher claw is correlated with serum protein (P=.64). The claw strength can be influenced by variables encountered in the study such as water temperature and air temperature. Additional research is required to understand the effect of temperature on the ability of lobsters to interact with the device and to further develop the process to make it commercially viable.
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