

10th International
Conference and Workshop
on Lobster Biology and Management



PROGRAM AND ABSTRACTS
Cancún, Q.R., México

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**10th International
Conference and Workshop on Lobster Biology and Management**
“Lobsters in a Changing Climate”

Cancún, Q.R., México
18–23 May, 2014

Dear participants,

On behalf of the Organizing Committee we are pleased to welcome you to the **10th International Conference and Workshop on Lobster Biology and Management (10th ICWL) “Lobsters in a Changing Climate”**, hosted by the Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México (Institute of Ocean Sciences and Limnology, National Autonomous University of Mexico) in beautiful Cancún, the most important tourist resort in Mexico.

This ICWL, the tenth in a row, promises to be an exciting week of science, presentations and discussions on the latest advances on lobster biology, ecology, fisheries, aquaculture, and management. We thank you all for attending this conference and invite you to enjoy the renowned Mexican hospitality. We hope that, in addition to immerse yourself in the technical program, with 200 submissions accepted, you will also find time to immerse in the crystal clear Caribbean waters and to visit some of the famous Mayan archaeological sites close to Cancún in order to make your visit to Mexico a memorable experience.

¡Bienvenidos a México!

Patricia Briones Fourzán & Enrique Lozano Álvarez
Conveners

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GENERAL INFORMATION

Registration/Hospitality Desks

The Registration/Hospitality Desks will be located at the entrance of the Convention Center (Peninsula Lobby) in the Iberostar Cancún Hotel and will be open the following times:

Sunday:	4:00pm–6:00pm
Monday:	8:00am–4:00pm
Tuesday:	8:00am–4:00pm
Wednesday:	8:00am–11:30pm
Thursday:	8:00am–4:00pm
Friday:	8:00am–10:00am

Name badges

A name badge will be supplied to the registered delegates that will enable them to attend the sessions. Only those wearing their name badge will be entitled to participate in the daily catering. Registered companions will be supplied with tickets to those events which they have registered for. Those not registered as delegates for the conference are not entitled to the daily catering.

Presentation preview

Technical assistance will be available for both conference rooms (Miramar 1 and Miramar 2) and for uploading the presentations. Your presentation must be uploaded preferably the day before it is scheduled and at least 15 minutes before the corresponding session.

Conference T-shirts and additional tickets for conference social events

Pre-ordered conference T-shirts can be picked up at a special stand in the Miramar Foyer (cash only). A limited additional number of conference T-shirts will be available at this stand, but sizes are not guaranteed for those purchasing onsite. Additional tickets for the conference social events will be available also in this stand (cash only; for prices, see next page).

Lunch (Buffet) tickets for delegates not staying at the conference venue

Delegates staying at the conference venue (Iberostar Cancún Hotel) have all their meals included. However, those delegates not staying at the conference venue may purchase lunch (buffet) tickets for the hotel's restaurant at 250 Mexican pesos (or US \$20) per lunch. Lunch tickets will be available at the Hotel's registration desk (not the conference registration desk).

Mid-conference free afternoon special activity

Tickets for the Coral Reef Snorkeling and Lobster Sunset Meal (mid-conference free afternoon special activity, Wednesday 21) will be available at the Snorkeling Adventure stand in the Miramar Foyer (cash or credit card).

Tours and Transportation

Tickets for tours to Chichen Itzá, Ek Balám, Tulúm, etc., and for private transportation to the airport will be available at DMC-Cancún's hospitality desk at the entrance of the Convention Center (Peninsula Lobby)

Accommodation accounts

All accommodation accounts must be settled at check-out. The Organizing Committee will not be responsible in any way for accommodation accounts.

SOCIAL EVENTS SCHEDULE

Sunday, May 18

Meet & Greet

7:00pm – 9:00pm

Red & white wine, sodas, hors d'oeuvre

Cost: Inclusive for Full Registrants and Registered Companions

Additional tickets: US \$50 per person

Tuesday, May 20

Poster Session

7:00pm – 9:00pm

Red & white wine, sodas, hors d'oeuvre

Cost: Inclusive for Full Registrants and Registered Companions

Additional tickets: US \$50 per person

Wednesday, May 21

Mid-conference special activity

Coral Reef Snorkeling and Lobster Sunset Meal

Pick-up by special buses at 1:00pm. Return by 7:00pm

Tickets will be sold onsite at the Snorkeling Adventure stand

Cost: US \$55 per person

Thursday, May 22

Conference Dinner

7:00pm – 10:00pm

A four-course dinner with a lively Mexican folkloric ballet

Cost: Inclusive for Full Registrants and Registered Companions

Additional tickets: US \$100 per person



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PROGRAM

Sunday, May 18, 2014

4:00-6:00 pm	Registration
7:00-9:00 pm	Meet & Greet

Monday, May 19, 2014

8:00am-4:00pm	Registration	
8.45am	Announcements (posters can start being put up)	
9:00-9:30am	Official opening and welcome	
9:40-10:40am	Keynote: Lobsters in a changing climate. Bruce F. Phillips , M. Pérez-Ramírez	
10:40-11:00am	Health Break	
	Stream 1	Stream 2
	Climate Change <i>Chair: Nick Caputi</i>	Aquaculture, Nutrition and Population Enhancement <i>Chairs: Andrew Jeffs, Carly Daniels & Greg Smith</i>
11:00-11:20am	Factors affecting the low puerulus settlement in the western rock lobster fishery of Western Australia.- S. de Lestang, Nick Caputi , M. Feng, A. Denham, J. Penn, D. Slawinski, A. Pearce, E. Weller, J. How	Suspension feeding by larvae of American lobsters (<i>Homarus americanus</i>).- S. K. Vigue, Jan Robert Factor
11:20-11:40am	American lobster nurseries of southern New England recede in the face of climate change.- R. A. Wahle, L. Delinger, S. Olszewski, Phoebe Jekielek , C. Bergeron	New developments in lobster resource enhancement in Atlantic Canada through stage IV larvae release.- R. Haché, Dounia Daoud , Y. Hébert, A. Dumas
11:40-12:00pm	Is settlement and early survival of southern rock lobster affected by climate change-driven declines in kelp forests?- Ivan A. Hinojosa , B. Green, A. Jeffs, C. Gardner	Development of formulated feeds for intensive farming of European lobster <i>Homarus gammarus</i> .- Ingrid Lupatsch
12:00-12:20 pm	Shift from bottom-up to top-down control of the algal community due to climate change: impacts on the Japanese spiny lobster in southwestern Japan.- Taku Yoshimura , K. Yatsuya, T. Taneda, S. Kiyomoto, G. Yoshida	An overview of the American lobster (<i>Homarus americanus</i>) stock enhancement program in southern Gaspé, QC, Canada.- Jean Côté , O. Cloutier
12:20-12:40pm	Thermal tolerance of the nektonic puerulus stage of spiny lobsters and implications of ocean warming.- Quinn P. Fitzgibbon , N. Ruff, S. R. Tracey, S. C. Battaglione	Stocking density of European lobster (<i>Homarus gammarus</i>), implications for restocking and sea ranching.- A-L. Agnalt, Ellen Sofie Grejsrud , E. Farestveit, K. E. Jørstad
12:40-1:00pm	European lobster (<i>Homarus gammarus</i>) develop deformities when exposed to ocean acidification: larvae and juveniles.- Ann-Lisbeth Agnalt , E. S. Grejsrud, E. Farestveit, M. Larsen, F. Keulder	Sea based container culture: potential for use in rearing <i>Homarus gammarus</i> in South West England.- Carly L. Daniels
1:00-2:00pm	Lunch	
2:00-2:20pm	The future of <i>Nephrops</i> : the effect of climate change drivers on early development in the Norway lobster.- Hannah L. Wood , H. K. Styf, S. P. Eriksson	Culturing the European spiny lobster, <i>Palinurus elephas</i> .- David J. Fletcher , I. T. Fletcher
2:20-2:40pm	Combinational effects of climate-derived ocean acidification, hypoxia and manganese on food search behavior and CO ₂ avoidance in the economically and ecologically important marine crustacean <i>Nephrops norvegicus</i> .- Anna-Sara Krång , J. Mattsson, F. Jutfelt	Improving feed reception and larval survival through use of scyphozoan medusae as feed in scyllarid larviculture.- Joe K. Kizhakudan , V. Jayasankar, P. Vijayagopal, S. Krishnamoorthi, B. Jasper
2:40-3:00pm	Revisiting the <u>Lobster Gangs of Maine</u> amid ecosystem and climate change.- Carla Guenther	Can larval culture vessel surfaces influence the diversity of bacterial biofilms in spiny lobster culture?- Greg G. Smith , A. J. Poole, P. King, R. de Nys, Q. Fitzgibbon, S. Powell, S. Battaglione

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3:00-3:20pm	Temporal variability in population parameters of the Caribbean spiny lobster (<i>Panulirus argus</i>) in Cuba.- <u>María Estela de León</u> , R. Puga, R. Piñeiro, O. Morales, R. Alzugaray, L. S. Cobas	Impact of technology transfer on development of lobster farming in Indonesia using Vietnamese practices.- <u>Clive M. Jones</u> , B. Priyambodo
	Behavioral Ecology Chair: Michael J. Childress	
3:20-3:40pm	Seasonal movements of American lobsters in the Great Bay Estuary, NH, USA.- <u>Thomas G. Langley</u> , J. S. Goldstein, W. H. Watson III	The effect of trap type and depth on catch rate of puerulus collectors in the spiny lobster aquaculture industry of Indonesia.- <u>Bayu Priyambodo</u> , J. Sammut, C. Jones
3:40-4:00pm	Health Break	
4:00-4:20pm	Are juvenile Caribbean spiny lobsters becoming less social?- <u>Michael J. Childress</u> , K. A. Heldt, S. D. Miller	Potential environmental impacts from sea-cage aquaculture of tropical spiny lobster (<i>Panulirus ornatus</i>).- <u>Soxi Lee</u> , N. D. Hartstein, A. Jeffs
4:20-4:40pm	Aggressive behavior of spotted spiny lobsters (<i>Panulirus guttatus</i>) in different social contexts.- <u>Patricia Briones-Fourzán</u> , R. Domínguez-Gallegos, E. Lozano-Álvarez	Rearing, ongrowing and harvesting of Caribbean spiny lobster (<i>Panulirus argus</i>) in a marine farm in Cuba.- <u>Gerardo Suárez-Álvarez</u>
4:40-5:00pm	Pulse magnetization indicates Magnetite-based magnetoreceptors in the Caribbean spiny lobster.- <u>Dave A. Ernst</u> , K. Gentry, K. J. Lohmann	The New Zealand scampi (<i>Metanephrops challengeri</i>): A new aquaculture challenge.- <u>Kevin Heasman</u> , S. Ogilvie, G. Paine, R. Paine, S. Connor, G. Connor, D. Taylor, C. Batstone, H. Mussely, A. Jeffs
5:00-5:20pm	The in situ swimming and orientation behavior of spiny lobster (<i>Panulirus argus</i>) postlarvae.- <u>Andrew S. Kough</u> , C. B. Paris, E. Staaterman	

Tuesday, May 20, 2014

8:00am-4:00pm	Registration	
8:15am	Announcements	
8:20-9:20am	Keynote: The American lobster: Poster child of a changing ecosystem.– Richard A. Wahle	
	Stream 1	Stream 2
	Diseases and Parasites <i>Chairs: Don Behringer & Grant Stentiford</i>	Fisheries and Fisheries Technology <i>Chairs: Tom Matthews & Win Watson</i>
9:20-9:40am	The curious case of PaV1 in adult Caribbean spiny lobsters.– Donald C. Behringer , M. J. Butler IV, J. Moss, J. D. Shields	New approaches to fishing for Scampi (<i>Metanephrops challengeri</i>) in New Zealand.– Shaun Ogilvie , G. Paine, R. Paine, S. Connor, G. Connor, D. Taylor, C. Batstone, H. Mussely, K. Heasman, A. Jeffs
9:40-10:00am	A scent of death? Caribbean spiny lobsters equally avoid lethally injured and clinically PaV1-infected conspecifics.– Rebeca Candia-Zulbarán , P. Briones-Fourzán, E. Lozano-Álvarez	The development and deployment of GIS based, Electronic Logbook (eLog) in the South African south coast rock lobster fishery (<i>Palinurus gilchristi</i>).– Amos Barkai , K. Flanagan
10:00-10:20am	Detection and prevalence of <i>Panulirus argus</i> Virus 1 (PaV1) in tails of Caribbean spiny lobsters from two fishing cooperatives in Yucatan, Mexico.– Ruth Pérez-Campos , J. A. Pérez-Vega, N. Kantún-Moreno, S. Salas-Marquez, C. Pascual-Jiménez, R. Rodríguez-Canul	Long-term spatial and temporal variability in catches of common spiny lobster <i>Palinurus elephas</i> (Fabricius, 1787) in Corsica (NW Mediterranean): fisheries trends, biological trends or both?– Anthony Pere , A. Astrou, M. Patrissi, L. Michel, C. Pelaprat
10:20-10:40am	Does the importation of live American lobster (<i>Homarus americanus</i>) pose a threat to native European (<i>H. gammarus</i>) populations? Shell disease susceptibility.– Charlotte E. Davies , M. M. A. Whitten, A. Kim, E. C. Wootton, T. G.G. Maffei, M. Tlusty, C. L. Vogan, A. F. Rowley	Health risk associated to the lobster fishery in coastal communities of Yucatan, Mexico.– Oswaldo Huchim-Lara , S. Salas, C. Walter, J. Fraga
10:40-11:00am	Health Break	
11:00-11:20am	Infestation by metacercariae of the trematode <i>Cymatocarpus solearis</i> in Caribbean spiny lobsters from Bahía de la Ascensión, Mexico.– Rubén Muñoz de Cote-Hernández , P. Briones-Fourzán, F. Negrete-Soto, C. Barradas-Ortiz, E. Lozano-Álvarez	Redesigning the lobster trap for efficiency: Development of a better escape vent for lobster, <i>Homarus americanus</i> .– Kathleen Castro , B. Somers, L. Dellinger
11:20-11:40am	Immune response to <i>Panulirus argus</i> Virus 1 (PaV1) in naturally and experimentally infected juveniles of <i>Panulirus argus</i> .– Cristina Pascual-Jiménez , R. Rodríguez-Canul, Patricia Briones-Fourzán, Enrique Lozano-Álvarez, J. P. Huchin-Mian, N. Herrera-Salvatierra, M. Mascaró- Miquelajáuregui	Ghost fishing lobster traps in the Florida Keys.– Casey B. Butler , Thomas R. Matthews
11:40-12:00pm	Differential susceptibility to <i>Panulirus argus</i> Virus 1 (PaV1) between experimentally infected juvenile and adult Caribbean spiny lobsters.– Juan Pablo Huchin-Mian , R. Rodríguez-Canul, E. Lozano-Álvarez, P. Briones-Fourzán, N. Herrera-Salvatierra, C. Pascual-Jiménez	Catch me if you can: Factors influencing the catch of American lobsters in ventless traps.– Win Watson , A. Clark, J. Goldstein, E. Morrissey, T. Langley
12:00-12:20pm	Nutritional condition and digestive activity of juvenile spiny lobsters, <i>Panulirus argus</i> , naturally infected with PaV1.– Nancy Herrera-Salvatierra , J. P. Huchin-Mian, R. Rodríguez-Canul, C. Pascual-Jiménez	Scottish lobster fisheries and environmental variability.– Héctor A. Lizárraga-Cubedo , I. Tuck, N. Bailey, G. J. Pierce, A. F. Zuur, D. Bova
12:20-12:40pm	Experimental infections with <i>Panulirus argus</i> Virus 1 (PaV1) from <i>Panulirus argus</i> lobsters in the white shrimp <i>Litopenaeus vannamei</i> could lead to a putative reservoir host for PaV1.– Rossanna Rodríguez-Canul , E. T. Ruz-Ruiz, Y. Cruz-Quintana, J. P. Huchin-Mian, J. A. Pérez-Vega, R. A. A. Pérez-Campos, S. Guillén-Hernández, C. Pascual-Jiménez	Cost-effective puerulus settlement monitoring in deep, remote, and exposed waters utilizing the commercial lobster fleet.– Graeme Ewing , S. Frusher

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		Marine Protected Areas <i>Chair: Raquel Goñi</i>
12:40-1:00pm	The relationship between environmental DNA and invertebrate disease: ground-truthing an emerging technology.- Grant D. Stentiford , K. S. Bateman, S. W. Feist, H. Hartikainen, B. Okamura, D. Bass	Performance evaluation of No Take Marine Reserves in the Florida Keys National Marine Sanctuary for spiny lobsters, <i>Panulirus argus</i> .- Kerry E. Maxwell , R. D. Bertelsen, J. H. Hunt
1:00-2:00pm	Lunch	
2:00-2:20pm	Can we help lobsters beat shell disease? - Kathleen Castro , M. Gomez-Chiarri, K. Carria	Population recovery in a newly protected area adjacent to a well-established marine reserve.- Raquel Goñi , S. Mallol, D. Díaz
2:20-2:40pm	Characteristics of recent increases of epizootic shell disease in the American lobster (<i>Homarus americanus</i>) for the inshore Gulf of Maine.- Kathleen Reardon , C. Wilson	Evaluating the use of an MPA as a management tool for the Juan Fernández rock lobster fishery.- Billy Ernst , J. Porobic, C. Parada
2:40-3:00pm	Geospatial analysis in the prevalence of PaV1 in the lobster fishery of the eastern coast of Yucatan, Mexico.- Oswaldo Huchim-Lara , R. Pérez-Campos, S. Salas, H. Hernández-Nuñez, M. Liceaga-Correa, R. Rodríguez-Canul	Fisheries effect on mating behavior and mate choice in wild European lobster (<i>Homarus gammarus</i>).- Tonje Knutsen Sørtdalen , H. Knutsen, E. M. Olsen, A. Vøllestad
		Habitat and Ecosystem Issues for Fisheries Management <i>Chairs: Lynda Bellchambers & Renae Hovey</i>
3:00-3:20pm	Prevalence and genetic diversity of <i>Panulirus argus</i> virus I throughout the Caribbean Sea.- J. Moss, Donald C. Behringer , J. D. Shields, M. J. Butler IV	Addressing habitat and ecosystem issues in fisheries management: a case study with western rock lobster (<i>Panulirus cygnus</i>).- Lynda Bellchambers , M. Pember, R. Hovey
3:20-3:40pm	Swimming with sickness: A theoretical model of disease dispersal.- Andrew S. Kough , C. B. Paris, M. J. Butler IV, D. C. Behringer	Socio-economic evaluation of a California lobster fishery in the context of ecosystem.- A. Chávez-Hidalgo, Ernesto A. Chávez , J. M. Borges-Souza
3:40-4:00pm	Health Break	
		Population and Community Ecology <i>Chair: Kari Lavalli</i>
4:00-4:20pm	Facilitating coexistence: Dietary partitioning between two sympatric spiny lobsters in a Caribbean coral reef system.- Iris Segura-García , P. Briones-Fourzán, S. de Lestang, E. Lozano-Álvarez	Spiny lobster fishing and maerl conservation: short-term losses and long-term benefits of modifying <i>Palinurus elephas</i> trammel net material.- Sandra Mallol , J. Mora, D. Díaz, R. Goñi
4:20-4:40pm	Patterns in demographics of American lobster (<i>Homarus americanus</i>) in coastal waters - Massachusetts Bay - USA.- Tracy L. Pugh , R. E. Glenn	Complex effects of casitas on spiny lobsters in the Florida Keys, FL (USA).- Benjamin C. Gutzler , M. J. Butler IV, D. C. Behringer Jr.
4:40-5:00pm	Higher correlation of <i>Palinurus elephas</i> settlement with regional versus global environmental forcing.- David Díaz , A. Muñoz, S. Mallol, R. Goñi	Does large scale harvesting of the spiny lobster, <i>Jasus edwardsii</i> , affect their subsequent recruitment into reefs? - Jan Hesse , A. Jeffs, J. Stanley
5:00-5:20pm	Patchiness in American lobster settlement at a hierarchy of spatial scales.- Gudjon Mar Sigurdsson , M. J. Tremblay, R. Rochette	Upscaling habitat data to understand the spatial arrangement of lobster habitat across its geographic range: the effect of spatial scale on the predictability of lobster habitat.- Renae K. Hovey , L. Bellchambers, M. Pember, K. van Niel
5:20-5:40pm	Investigating European lobster (<i>Homarus gammarus</i>) populations in Northumberland, UK, via acoustic telemetry (AT)- Movement & habitat utilisation.- Daniel J. Skerrett , C. Fitzsimmons, N. V. C. Polunin	An unfished area enhances a <i>Panulirus argus</i> fishery: Implications for management and conservation within a Biosphere Reserve in the Mexican Caribbean.- Kim Ley-Cooper , S. de Lestang, B. F. Phillips, E. Lozano-Álvarez
7:00-9:00pm	Poster Session (with light refreshments)	

Wednesday, May 21, 2014

8:00-10:00am	Registration	
8:15am	Announcements	
8:20-9:20am	Keynote: History of utilization of lobsters by humans.– <u>Ehud Spanier</u> , <i>Kari Lavalli</i>	
	Stream 1	Stream 2
	Lobsters in Antiquity <i>Chairs: Ehud Spanier, Kari Lavalli & Jason Goldstein</i>	Habitat and Ecosystem Issues for Fisheries Management (continues) <i>Chairs: Lynda Bellchambers & Renae Hovey</i>
9:20-9:40am	Aspects of the history of lobster utilization in the Central and Eastern Mediterranean and Red Sea.– <u>Ehud Spanier</u> , <i>M. L. Bianchini, J. S. Goldstein, R. D Kibler</i>	Delousing chemicals containing teflubenzuron will affect European lobster (<i>Homarus gammarus</i>) juveniles.– <u>Ann-Lisbeth Agnalt</u> , <i>E. S. Grefsrud, B. T. Lunestad, E. Farestveit, R. Hannisdal, B. Holmelid, T. Tjensvoll, O. B. Samuelsen</i>
9:40-10:00am	The European spiny lobster <i>Palinurus elephas</i> : A species for understanding the ancient history of Mediterranean fisheries.– <u>David Díaz</u> , <i>S. Mallol, R. Goñi</i>	Effects of pesticide-spiked sediment exposure on stage V juvenile lobster <i>Homarus americanus</i> .– <u>Dounia Daoud</u> , <i>P. Jackman, S. Greenwood, S. Reeb, M. Comeau, M. Mallet, K. Benhalima, B. Bruneau</i>
10:00-10:20am	History of utilization of lobsters by humans in Australia.– <u>Clive M. Jones</u> , <i>B. F. Phillips</i>	Settlement delay and growth of postlarval American lobsters on different seafloor substrates, and juvenile use of mud seafloor.– <u>Kristin Dinning</u> , <i>R. Rochette</i>
10:20-10:40am	Nga Koura o Aotearoa: The history of lobsters in New Zealand.– <u>Andrew Jeffs</u>	Does fishing for Western rock lobster impact benthic ecosystems?– <u>Matthew B. Pember</u> , <i>L. Bellchambers, R. K. Hovey, N. Konzewitsch, S. de Lestang</i>
10:40-11:00am	Health Break	
11:00-11:20am	The long and winding history of the fishery, management and culture of European lobster (<i>Homarus gammarus</i>) in Norway.– <u>Gro L. van der Meeren</u> , <i>E. Moland, A.-L. Agnalt, A. R. Kleiven, E. M. Olsen, E. S. Grefsrud</i>	Habitat characterization of juvenile lobsters <i>Panulirus argus</i> in central coast of Yucatan, Mexico.– <u>Gloria Verónica Ríos-Lara</u>
11:20-11:40am	Usage of lobsters in the Americas.– <u>Kari L. Lavalli</u>	Habitat complexity: A key factor in spatiotemporal fluctuation of abundance of spiny lobster <i>Panulirus gracilis</i> in Manabí, Ecuador.– <u>Juan Figueroa</u> , <i>R. Castillo, D. Mero, C. Erazo</i>
11:40-12:00pm	A historical overview of lobster use by pre- and post-Columbian cultures in the Caribbean and Mesoamerica.– <u>Jason S. Goldstein</u> , <i>D. C. Behringer, W. F. Keegan</i>	
12:00-12.30pm	Group Photography	
1:00-7:00pm	Mid-conference free afternoon special activity: Coral reef snorkeling and Lobster sunset meal	

Thursday, May 22, 2014

8:00am-4:00pm	Registration	
8:15am	Announcements	
8:20-9:20am	Keynote: Research for management of lobster fisheries: its history, recent developments and future challenges.- Jim Penn	
	Stream 1	Stream 2
	Population and Community Ecology (continues) Chair: Adolfo Gracia	Stock Assessment Chair: Nelson Ehrhardt
9:20-9:40am	An analysis of spiny lobster movement patterns: A comparison of two <i>Panulirus argus</i> populations residing in the lower Florida Keys, Florida, USA.- Rodney D. Bertelsen , T. R. Matthews	Growth of juvenile lobster, <i>Homarus americanus</i> , in a changing environment.- Marissa D. McMahan , D. F. Cowan, Y. Chen, J. H. Grabowski, G. D. Sherwood
9:40-10:00am	Interspecific shelter competition as a driver of juvenile spiny lobster abundance and distribution.- Elliot Hart , D. C. Behringer	A new forecasting model for the American lobster fishery using the American Lobster Settlement Index.- Noah G. Oppenheim , R. A. Wahle, D. C. Brady, P. Lawton
10:00-10:20am	Natural ecological traps in Caribbean spiny lobster nurseries.- Mark Butler , D. Behringer	Has exploitation caused a downward shift in size-at-maturity of female American lobster <i>Homarus americanus</i> in Atlantic Canada?- Marthe Larsen Haarr , R. Rochette
	Reproduction, Development & Physiology Chair: Jason Goldstein	
10:20-10:40am	American lobster mating system: Limited mating opportunity and possible male preference for larger females.- Julien Gaudette , J. Tremblay, V. Burdett-Coutts	Scampi (<i>Metanephrops challengeri</i>) emergence patterns and catchability.- Ian Tuck , D. Parsons, B. Hartill
10:40-11:00am	Health Break	
11:00-11:20am	Overwhelming odds? Male mating success when dwarfed or outnumbered by female partners.- Tracy L. Pugh , W. Watson III	Assessment of maximum economic yield of the western rock lobster fishery of Western Australia under quota control.- Nick Caputi , S. de Lestang, C. Reid, A. Hesp, J. How, P. Stephenson
11:20-11:40am	Robbing the cradle: Evidence of mating in immature, pre-reproductive, female American lobsters.- Jason S. Goldstein , E. Morrissey, W.H. Watson III	Depletion analysis of spiny lobster (<i>Panulirus argus</i>) at Glover's Reef Marine Reserve, Belize, incorporating estimates of in-season recruitment.- Elizabeth A. Babcock , R. Coleman, J. Gibson, W. Harford
11:40-12:00 pm	Resistance to starvation of first-stage juveniles of the Caribbean spiny lobster, <i>Panulirus argus</i> .- Alí F. Espinosa-Magaña , P. Briones-Fourzán	On the recruitment dynamics of <i>Panulirus argus</i> .- Nelson Ehrhardt , J. A. Aragão, M. Pérez, M. Fitchett
12:00-12:20pm	The effects of cardio-ventilatory activity on the control of acute environmental thermal variations in immersed lobsters, <i>Homarus americanus</i> .- John J. Garland , R. F. Uglow	Numerical age-length key algorithm applicable to species when direct aging is not possible: The case of the Caribbean spiny lobster, <i>Panulirus argus</i> .- Mark Fitchett , Nelson Ehrhardt
12:20-12:40pm	Gastrolith development in European lobster <i>Homarus gammarus</i> juveniles during a moult cycle.- Ellen Sofie Grefsrud , A.-L. Agnalt, E. Farestveit	Environmental effects associated with cold fronts increase catch rates of <i>Panulirus argus</i> in a Mexican Caribbean Biosphere Reserve.- Kim Ley-Cooper , S. de Lestang, B. F. Phillips, E. Lozano-Álvarez, P. Briones-Fourzán, R. Fotedar
12:40-1:00pm	The association behavior of phyllosomas with jellyfish.- Kaori Wakabayashi , Y. Tanaka	Local dynamics of spiny lobster <i>Panulirus argus</i> resource under contrasting exploitation patterns in two fishing banks of the Mexican Caribbean.- Eloy Sosa-Cordero , C. Alvarez, J. C. Seijo, A. Ramírez-González
1:00-2:00pm	Lunch	

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	Connectivity and Larval Studies <i>Chair: Mark Butler</i>	
2:00-2:20pm	Settlement behavior of American lobster (<i>Homarus americanus</i>) postlarvae: effect of stock origin and incubation temperature.- Léo Barret , G. Miron, P. Ouellet, R. Tremblay	Estimating survival from long-term tagging data sets – how does time and duration of study influence survival estimates?- Ziya Kordjazi , S. Frusher, C. Buxton, C. Gardner
2:20-2:40pm	The effect of sedimentation on the settlement behavior of the American lobster (<i>Homarus americanus</i>).- Benoît Bruneau , G. Miron, D. Daoud, M. Mallet	Handle with care: an analysis of the effects of appendage damage on the growth and productivity of the southern rock lobster (<i>Jasus edwardsii</i>).- Timothy J. Emery , K. Hartmann, B. S. Green, C. Gardner, J. Tisdell
2:40-3:00pm	The effect of temperature, light and flow condition on the swimming ability of American lobster (<i>Homarus americanus</i>) larvae.- Ryan R. E. Stanley , P. V. R. Snelgrove, E. J. Pedersen	Population dynamics of the Baja California spiny lobster (<i>Panulirus interruptus</i>) and biological reference points of a sustainable and well-managed fishery.- Armando Vega-Velázquez , A. Vega-Bolaños, G. A. Jiménez-Llano
		Management <i>Chair: Jim Penn</i>
3:00-3:20pm	First estimates of potential large-scale spatial connectivity of American lobster fisheries in eastern North America via larval drift.- Brady K. Quinn , J. Chassé, R. Rochette	Comparing MSC certification process and obtained benefits for lobster fisheries.- Mónica Pérez-Ramírez , B. F. Phillips
3:20-3:40pm	Connectivity patterns in six lobster species at remote islands, seamounts and shelf habitats in the SW Indian Ocean and South Atlantic.- Johan C. Groeneveld , C. A. Matthee, S. von der Heyden, A. Macdonald, L. Zacharias	Microsatellite DNA profiling: a viable tool for the conservation and long-term sustainability of European lobsters (<i>Homarus gammarus</i>) stocks.- Paulo A. Prodöhl , D. Bailie
3:40-4:00pm	Health Break	
4:00-4:20pm	Hot n' hungry lobster larvae: Can a warming ocean explain a decline in spiny lobster recruitment?- Andrew Jeffs , M. Wang, R. O'Rorke, A. Waite, L. Beckley, P. Thompson	Fishing for revenue: how leasing quota can be hazardous to your health.- Timothy J. Emery , K. Hartmann, B. S. Green, C. Gardner, J. Tisdell
4:20-4:40pm	Caribbean spiny lobster larval connectivity: the "Holy Grail" for management of an iconic species.- Mark Butler , A. Kough, C. Paris	The use of management procedures in New Zealand rock lobster fisheries.- Kevin Sullivan
4:40-5:00pm		The pathway from research on lobster translocation into an industry-funded commercial enterprise.- Caleb Gardner , B. Green, K. Hartmann
5:00-5:20pm		Spatial management of a rock lobster resource under a quota system: biological, fishery and economic considerations.- Adrian Linnane , R. McGarvey
7:00-10:00pm	Conference dinner	

Friday, May 23, 2014

8:00-10:00am	Registration. All posters to be removed before 11:00am	
8:15am	Announcements	
8:20-9:20am	Keynote: Individual fishing grounds in the community co-managed spiny lobster fishery of Punta Allen, México: Lessons learned.- Juan C. Seijo	
	Stream 1	Stream 2
	Genetics <i>Chair: Johan Groeneveld</i>	Management (continues) <i>Chair: Jim Penn</i>
9:20-9:40am	Evidence for population structure of the southern rock lobster, <i>Jasus edwardsii</i> , around southern Australia.- Cecilia Villacorta-Rath , J. Strugnell, B. Green, K. Miller	Pressure for co-management and certification of Brazil lobster (<i>Panulirus argus</i>) fishery – Fisheries Improvement Program FIP.- René Schärer
9:40-10:00am	Genomics as a powerful tool in the management of the American lobster fishery.- Laura Benestan , R. Rochette, L. Bernatchez	The Caribbean spiny lobster (<i>Panulirus argus</i>) fishery management system in Cuba.- Rafael Puga , R. Alzugaray, M. E. de León, R. Piñeiro, O. Morales, L. S. Cobas
10:00-10:20am	Using genetic markers to investigate population ecology for lobster stock enhancement.- Charlie D. Ellis , A. Teacher, D. J. Hodgson	Effects of changing the commercial strategy of lobster capture and sales at Banco Chinchorro, Mexico.- Ernesto A. Chávez , K. Ley-Cooper, J. M. Borges-Souza
10:20-10:40am	The presence and role of Cryptochrome in the CNS of the American lobster.- Win Watson , M. Parks, C. White, J. Ramsdell, K. Chesmore, C. Chabot	The Bahamian spiny lobster fishery: Current status and the ongoing journey.- Lester Gittens
10:40-11:00am	<i>Homarus</i> hybrids detected in Norway – First evidence for interbreeding between introduced <i>Homarus americanus</i> and the local species, <i>Homarus gammarus</i> .- Knut E. Jørstad , A.-L. Agnalt, E. Farestveit, D. Bailie, P.A. Prodöhl	Solving the lobster diving paradox: Closing the Honduran dive fishery without collapsing the rural economy.- Stephen Box
11:00-11:20am	Health Break	
11:20-1:00pm	Awards for best student oral & poster presentations, Closing remarks, 11th ICWL Announcement.	

POSTER PRESENTATIONS

Climate Change

P1. Interactive effects of ocean warming and acidification on aspects of the developmental eco-physiology of the European lobster, *Homarus gammarus* (L.).- *D. Small, P. Calosi, J.I. Spicer, D. Boothroyd, S. Widdicombe*

Behavioral Ecology and Neurobiology

P2. Into a rhythm: Diel activity patterns and behavior in Mediterranean Slipper lobsters, *Scyllarides latus*.- *Jason S. Goldstein, Elizabeth A. Dubofsky, Ehud Spanier*

P3. Does aggression influence denning behavior of gregarious spiny lobsters in shelter limited habitats?- *Katherine A. Heldt, Michael J. Childress*

Diseases and Parasites

P4. Shell disease in American lobster: Identification of infection-promoting agents and projections for an expanding epizootic.- *Kisei Tanaka, Samuel Belknap, Jared Homola*

P5. A new conceptual model for Shell Disease in the American lobster (*Homarus americanus*).- *Anita Kim, Kathy Castro, Michael Tlusty*

P6. The polychaete *Histiobdella homarus* and other epibionts on the European lobster.- *Vidar Øresland*

P7. A theoretical basis for the occurrence of gynandromorphy and ovotestes in clawed lobsters.- *Grant D. Stentiford, A.T. Ford*

P8. Testing for the presence of PaV1 in oceanic phyllosomata and nektonic pueruli of *Panulirus argus*.- *Enrique Lozano-Álvarez, Patricia Briones-Fourzán, Juan P. Huchin-Mian, Iris Segura-García, Rossanna Rodríguez-Canul*

P9. Rickettsia-like organisms in Caribbean spiny lobsters: a putative concomitant infection associated to *Panulirus argus* Virus 1 (PaV1).- *Miriam Camelo-Marrufo, Juan P. Huchin-Mian, Juan A. Pérez-Vega, Rossanna Rodríguez-Canul*

P10. Prevalence and genomic variations of *Panulirus argus* Virus 1 (PaV1) in spiny lobsters from some Caribbean sites.- *Yanis Cruz-Quintana, Juan Pablo Huchin-Mian, Víctor M. Vidal-Martínez, Rossanna Rodríguez-Canul*

P11. Development of a qPCR assay for analyzing variability in viral load of *Panulirus argus* Virus 1 (PaV1) across lobster size scales.- *Abigail S. Clark, Donald C. Behringer, Thomas B. Waltzek*

Population and Community Ecology

P12. Evaluation of *Palinurus elephas* settlement at deep water by artificial lobster's collectors.- *David Díaz, Sandra Mallol, Anabel Muñoz, Javier Llorente, Raquel Goñi*

P13. Settlement of *Panulirus interruptus* postlarvae in Bahía Tortugas, B.C.S., Mexico and its relationship to the ocean environment.- *Jorge Carrillo-Laguna, Magdiel A. Bravo-Gómez, Sergio A. Guzmán del Prío*

P14. Stomach content of early juvenile spiny lobster *Panulirus interruptus* in Bahía Tortugas, BCS, Mexico.- *Jorge Carrillo-Laguna, Nallely Martínez-Sánchez, Sergio A. Guzmán del Prío*

P15. Variability in condition factor of recently settled pueruli and first-stage juveniles of the spiny lobster *Panulirus argus*.- *Rogelio Martínez-Calderón, Patricia Briones-Fourzán, Enrique Lozano-Álvarez*

P16. Population biology of the blue spiny lobster (*Panulirus inflatus*) from the Pacific south coast of Mexico.- *Rogelio Martínez-Calderón, Vicente Anislado-Tolentino, Samuel Ramos-Carrillo*

P17. Population biology of painted spiny lobster (*Panulirus echinatus*) in the São Pedro and São Paulo Archipelago, Brazil.- *Françoise D. de Lima, Lorena C. A. Andrade, Tatiana S. Leite, Jorge E. Lins Oliveira*

P18. Why do young Japanese spiny lobsters aggregate in sea anemone colonies?- *Taku Yoshimura, Tomeharu Todaka, Rumiko Kajiwara, Hisami Kuwahara, Yasushi Nakajima*

P19. Fauna caught in collectors for spiny lobster postlarvae (*Panulirus* spp.) in the southeastern Gulf of California.- *David Becerra-Arroyo, Raúl Pérez-González*

P20. A mark-recapture study with natural marks in juvenile Mexican lobsters, *Panulirus inflatus*.- *Jesús R. García-Paredes, Raúl Pérez-González, Guillermo Rodríguez-Domínguez*

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- P21.** Lobster in a Bottle – A novel technique for predation observation.– Jan Hesse, Andrew Jeffs
- P22.** Distribution and abundance of Family Nephropidae in the southern Gulf of Mexico.– Ana Stephanie del Ángel, Ana Rosa Vázquez-Bader, Adolfo Gracia
- P23.** Population traits of the flatback lobster *Stereomastis sculpta* in the Gulf of Mexico.– Mariana López Robles, Ana Rosa Vázquez Bader, Adolfo Gracia
- P24.** Lobsters from the deep: Nephropidae and Polychelidae from the continental slope of the Yucatan peninsula.– Patricia Briones-Fourzán, Enrique Lozano-Álvarez, Adolfo Gracia, Ana Rosa Vázquez-Bader

Lobsters in Antiquity

- P25.** History of utilization of Cape rock lobster *Jasus lalandii* by humans along the west coast of South Africa from pre-historic times to the present.– Johan Groeneveld

Reproduction, Development and Physiology

- P26.** Spermatophores produced by electro-stimulation of male lobsters (*Homarus americanus*) vary in size and content.– Tracy L. Pugh, Michel Comeau, Kadra Benhalima, Winsor H. Watson III
- P27.** Temperature accurately predicts fecundity in a regional lobster population.– Charlie D. Ellis, David J. Hodgson
- P28.** Mapping and navigating the reproductive anatomy in Mediterranean Slipper lobsters, *Scyllarides latus*.– Jason S. Goldstein, Marco L. Bianchini, Ehud Spanier
- P29.** The effect of size on spermatophore production and fertilization success in the Caribbean spiny lobster, *Panulirus argus*.– Mark J Butler IV, Alison MacDiarmid, Gaya Gnanalingam
- P30.** Mate choice, mate competition, and the contrasting reproductive biology of temperate and tropical spiny lobsters.– Mark Butler, Alison MacDiarmid, Rodney Bertelsen
- P31.** Use of jellyfish as the sole food for rearing phyllosomas of the scyllarid lobster *Ibacus ciliatus*.– Kaori Wakabayashi, Satomi Nagai, Yuji Tanaka
- P32.** Metabolic adjustments of *Panulirus argus* to thermal maxima limits.– Miriam Palestina-Martínez, Viridiana Gómez-Vázquez, Natali Casanova-Salazar, Cristina Pascual-Jiménez, Carlos Rosas-Vázquez
- P33.** Effects of temperature and salinity in dark and light condition on QO₂ of phyllosoma larvae of *Panulirus interruptus*.– Antonio Silva, Eugenio Díaz-Iglesias, Eitelberto Serrano-Flores, Armando Vega-Velázquez

Connectivity and Larval Studies

- P34.** Canadian Fishery Research Network, Project 1.3: Factors influencing recruitment and early survival of lobsters.– Gilles Miron, Michel Comeau, Dounia Daoud, Martin Mallet, Patrick Ouellet, Rémy Rochette, Bernard Sainte-Marie, Réjean Tremblay
- P35.** Light traps as a tool to sample pelagic larvae of American lobster (*Homarus americanus*).– Gudjon Mar Sigurdsson, Bryan Morse, Rémy Rochette
- P36.** Spatial variation and abundance of *Panulirus* spp. phyllosomas off the coast of Quintana Roo, Mexico.– Ashanti Canto-García, Eloy Sosa-Cordero, Jason S. Goldstein
- P37.** Effect of temperature on development rate of larvae from cold-water American lobster (*Homarus americanus*).– Brady K. Quinn, Rémy Rochette, Patrick Ouellet, Bernard Sainte-Marie
- P38.** Potential importance of interactions between mean and variability of water temperatures to realized development times of American lobster larvae.– Brady K. Quinn, Rémy Rochette
- P39.** Settlement of postlarvae of the spiny lobster *Panulirus inflatus* in the southeastern Gulf of California.– David Becerra-Arroyo, Raúl Pérez-González, Guillermo Rodríguez-Domínguez
- P40.** Hitching rides and stealing bites? Phyllosomas and large gelatinous zooplankton.– Richard O'Rorke, Shane Lavery, Miao Wang, Anya M. Waite, Lynnath E. Beckley, Peter A. Thompson, Andrew G. Jeffs
- P41.** Seasonal variation in size of nektonic pueruli of *Panulirus argus* and *P. guttatus*.– Patricia Briones-Fourzán, Enrique Lozano-Álvarez, Alí F. Espinosa-Magaña, Rogelio Martínez-Calderón
- P42.** Pueruli settlement of red spiny lobster (*Panulirus interruptus*) at Bahía Asunción, Baja California Sur, México, and its relationship with

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oceanographic factors.– **Armando Vega-Bolaños**, Armando Vega-Velázquez, Fernando López-Salas, Rigoberto Luna-Villalobos

P43. How puerulus behavior affects settlement success: interactions between settlement cues and oceanographic processes in southern rock lobster.– **Ivan A. Hinojosa**, Bridget Green, Caleb Gardner, Rafael León, Andrew Jeffs

Genetics

P44. Improving the stocking and sea-ranching practices for *Homarus gammarus* through the application of next-generation genetic-sequencing and transcriptomic analysis.– **Adam H. Bates**

P45. Genetic evidence from the spiny lobster fishery supports international cooperation among Central American marine protected areas.– N. K. Truelove, K. Ley-Cooper, J. Azueta, I. Majil, **Stephen Box**, S. Canty, S. Griffiths, R. Mansfield, A. Medina, A. Aguilar-Perera, D. Behringer Jr, M. J. Butler IV, R. F. Preziosi

P46. Genetic analyses reveal population structure among discrete size classes of Caribbean spiny lobster within two Biosphere Reserves in Mexico.– Nathan K. Truelove, **Kim Ley-Cooper**, Iris Segura-García, Patricia Briones-Fourzán, Enrique Lozano-Álvarez, Richard F. Preziosi, Bruce F. Phillips

Aquaculture, Nutrition and Population Enhancement

P47. Growth rate of juvenile Caribbean spiny lobster, *Panulirus argus*, fed a semi-humid diet.– **Pedro Gallardo-Espinosa**, Miriam Palestina-Martínez, Viridiana Gómez-Vázquez, Natali Casanova-Salazar, Carlos Rosas-Vázquez, Cristina Pascual-Jiménez

P48. Physiological condition of juvenile *Panulirus argus* fed diets containing by-catch from shrimp fisheries.– Aurora Ramírez-Estévez, Ariadna Sánchez-Arteaga, Pedro Gallardo-Espinosa, Francisco Aguilar-Salazar, Lucía Huchin-Cahum, **Cristina Pascual-Jiménez**

P49. On the occurrence of juvenile spiny lobsters, *Panulirus inflatus* and *P. gracilis*, in niester plastic baskets for oyster culture in the Ceuta lagoon complex, Sinaloa, Mexico.– **Luis Miguel Valadez-Manzano**, Martín Ignacio Borrego, Raúl Pérez-González, Jesús R. Galindo-Soto

Fisheries and Fisheries Technologies

P50. From nets to bottom traps: is exploitation of Norway lobsters a suitable option for Corsican common spiny lobster fishermen?– Michela Patrissi, Adèle Astrou, Corinne Pelaprat, Pierre Lejeune, Loïc Michel, **Anthony Pere**

P51. Common trends in two Scottish lobster populations.– **Héctor A. Lizárraga-Cubedo**, Ian Tuck, Nick Bailey, Graham J. Pierce, Alain F. Zuur

P52. Assessing the use of traps versus hook and diving method in the spiny lobster fishery of the Mexican Pacific.– **Víctor H. Martínez-Magaña**, Eduardo Ramos-Santiago, Ignacio Méndez-Gómez-Humarán

P53. The status of lobster fisheries in Rio Grande do Norte, Brazil.– Leocledna F. de Oliveira, Lorena C. A. Andrade, Françoise D. de Lima, Tatiana S. Leite, José A. de Vasconcelos, **Jorge E. Lins Oliveira**

P54. Diving accidents with lobster fishermen in the Northeast of Brazil.– Maria Isabel B. de Souza Mendes, Sérgio de Souza Mendes, **Jorge E. Lins Oliveira**, Hellyson R. Costa, Moaldecir Freire D. Junior

P55. Monitoring the catch of red spiny lobster *Panulirus interruptus* in Baja California, Mexico.– **José Julián Castro-González**, Rigoberto Sánchez Medina

P56. Remote, real-time monitoring of puerulus settlement using an underwater camera system.– Chris Sharman, **Graeme Ewing**, Stewart Frusher

Habitat and Ecosystem Issues for Fisheries Management

P57. Investigating lobsters and their habitat maps through the eyes of robots.– **Renaë K. Hovey**, Matt Pember, Lynda Bellchambers, Stefan Williams, Gary A. Kendrick

P58. An industry-based approach to regional-scale monitoring of benthic ecosystems.– **Matthew B. Pember**, Simon de Lestang, Dirk Slawinski

P59. Demersal assemblages of crustacean fishing grounds off the Portuguese South coast.– Aida Campos, Paulo Fonseca, Bárbara Teixeira, Manuel Afonso-Dias, **Margarida Castro**

P60. Effects of mosquito control pesticides on spiny lobster (*Panulirus argus*) pueruli.– **Thomas R. Matthews**, Gabrielle F. Renchen, Richard H. Pierce

P67 (Late submission). Size-at-age and body condition of juvenile American lobster (*Homarus americanus*) living on cobble and mud in a mixed-bottom embayment in the Bay of Fundy.– **Feng Tang**, Taryn Minch, Kristin Dinning, C. J. Martyniuk, Raouf Kilada, Rémy Rochette

Stock Assessment

P61. Spatial patterns in productivity of American lobster *Homarus americanus* in Atlantic Canada.– **Marthe Larsen Haarr**, Rémy Rochette, Michel Comeau, Bernard Sainte-Marie, John Tremblay

P62. Developing Southeast US spiny lobster stock assessment in a meta-population model.– **Nan Yao**, Yuying Zhang

P63. A stock evaluation model for future management of Caribbean spiny lobsters in Banco Chinchorro (México) with the use of casitas.– **Kim Ley-Cooper**, Enrique Lozano-Álvarez, Patricia Briones-Fourzán, Simon de Lestang, Bruce F. Phillips, Maria del Carmen García-Rivas

P64. Tag-induced mortality and tag retention in the European lobster *Palinurus elephas*.– Aline do Vale Barreto, **Margarida Castro**

P65. Estimation of age and growth of the spiny lobster *Panulirus inflatus*, using a matrix of transition and growth simulation.– **Karem Francely Castro-Gutiérrez**, Enrique Morales-Bojórquez, Raúl Pérez-González

Management

P66. Passive management vs Active management: the lobster fishery in Mexico.– **Enrique Morales-Bojórquez**

Keynote Presentations

Abstracts

Lobsters in a changing climate [K1]

Bruce F. Phillips¹, Mónica Pérez-Ramírez²

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The reports of the Intergovernmental Panel on Climate Change and the results of many other studies have confirmed the reality of climate change. Changes in the ocean include increases in sea temperature, changes in ocean circulation patterns and weather. Sea level is increasing worldwide; the ocean is becoming more acidic; increasing UVR levels will affect plankton production in the future, and an increased spread of diseases may occur. Some of the identified changes that have already occurred to lobsters include movements to deeper water in response to increasing water temperature; changes in growth rates; differing sizes at maturity, increases in catchability; increased abundance of some species and reduced abundance of others. Another change is the seasonal timing and the level of settlement of final stages from the plankton, although the manner in which these changes are brought about is uncertain. This presentation examines the latest information on climate change studies as they affect lobsters and considers case studies of five lobster species: *Panulirus cygnus* and *Jasus edwardsii* in Australia; *Homarus americanus* in the USA and Canada; *Panulirus interruptus* in the USA and Mexico, and *Panulirus argus* in Mexico, USA, and Cuba. Likely scenarios for lobster fisheries affected by climate change in the future will also be examined.

The American Lobster – Poster child of a changing ecosystem [K2]

Richard A. Wahle

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By far the largest lobster fishery in the world, the American lobster of eastern US and Canada has become a poster child for the impacts of environmental change on coastal ecosystems, and the coastal economies that depend on them. This talk will recap the four themes of a recent US-Canada Science Symposium on the American Lobster in a Changing Ecosystem: climate change, altered foodwebs, population connectivity, and coupled human-natural systems. With a geographic range spanning the steep north-south thermal gradient of the Northwest Atlantic, the American lobster straddles both sides of climate change story. As its populations and associated fisheries recede from the south, they expand to cooler waters in the north. Widespread commercial depletion of predatory groundfish, including Atlantic cod, has diminished the foodweb and further promoted the unprecedented lobster boom northern areas are now experiencing. But as the range of southern predators also expands northward, foodweb dynamics are in flux. Southern New England has been rocked by episodes of local mass mortality and disease brought on by summer heat stress and hypoxia. These deteriorating conditions have promoted the spread of shell disease leading to a more gradual but widespread collapse of the region's fishery. Further north, the historic ocean heat wave of 2012 triggered an early molt in Maine and Atlantic Canada, exacerbating the glut in lobster supply, and causing price to continue its downward spiral. This, in a fishery only just recovering its value after the global financial collapse of 2008, the one crisis in recent memory unrelated to climate change. With the price of the American lobster now at a 50-year low, and the cost associated with fishing higher than ever, the future of the region's iconic, lobster-based coastal economy is uncertain and in peril.

History of utilization of lobsters by humans [K3]

Ehud Spanier¹, Kari L. Lavalli²

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Did early humans utilize lobsters? If so, what species did they fish? How did they catch them? Did they preserve them, trade with them? What was the relative importance of lobsters to humans' nutrition and economy? Did human civilizations utilize lobsters, or parts of them, for purposes other than food? How were lobsters expressed in the culture and art of ancient civilizations? To answer these questions the authors examine various human civilizations in different coastal regions around the world from ancient times up to the first half of the 20th century. There is evidence of consumption of lobsters by prehistoric societies; however, presence of lobster remains in middens found in prehistoric sites depends on environmental conditions. Lobsters appeared in carvings in the ancient era and later in classical writings, mosaics, and arts works in various civilizations. The amount of information available on lobster utilization, fisheries and economic importance increased in the Middle Ages and the New Era and there are indications that in some areas lobsters were more abundant than they are today.

Research for management of lobster fisheries, its history, recent developments and future challenges [K4]

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The early research on lobsters was focused on biology and behaviour to better understand their then poorly known life histories and where they could be caught, with little thought given to the impact of fishing. With the rapid development of lobster fisheries in the 1960s and 1970s, concerns were first raised about the sustainability of the stocks and some early attempts to manage these expanding and largely uncontrolled fishing activities were undertaken. These initial management attempts immediately raised questions about the dynamics of lobster populations and led to increasing demands for research and data on the fisheries themselves. This resulted in the development of cooperative fishery logbook programs and an increased research focus on measuring stock abundance to address the new management questions being raised by both Governments and fishing industries. While stock assessments to ensure biological sustainability of wild fisheries remains an underlying objective for many lobster research projects today, the objectives of management and the resulting literature on lobster fisheries has become increasingly diverse. In many cases where wild stocks are fully exploited, alternative methods to enhance lobster production have included stock enhancement, translocation of lobsters within fisheries, harvesting of juveniles for grow-out, and the development of aquaculture technology, all of which have added complexity to the traditional management approaches. More recently, the management research process has extended to developing biological and economic performance criteria, measuring lobster fishing impacts on marine ecosystems, through to fishery environmental certification of fisheries to meet market initiatives. A review of the historical development of lobster fisheries management systems and related research will be used to highlight some of the successes and lessons that can be usefully applied to meet the expanding array of questions now being raised by lobster fishery and industry managers. The presentation will also consider the management questions that lobster scientists and their traditional fishermen partners are likely to face in the future.

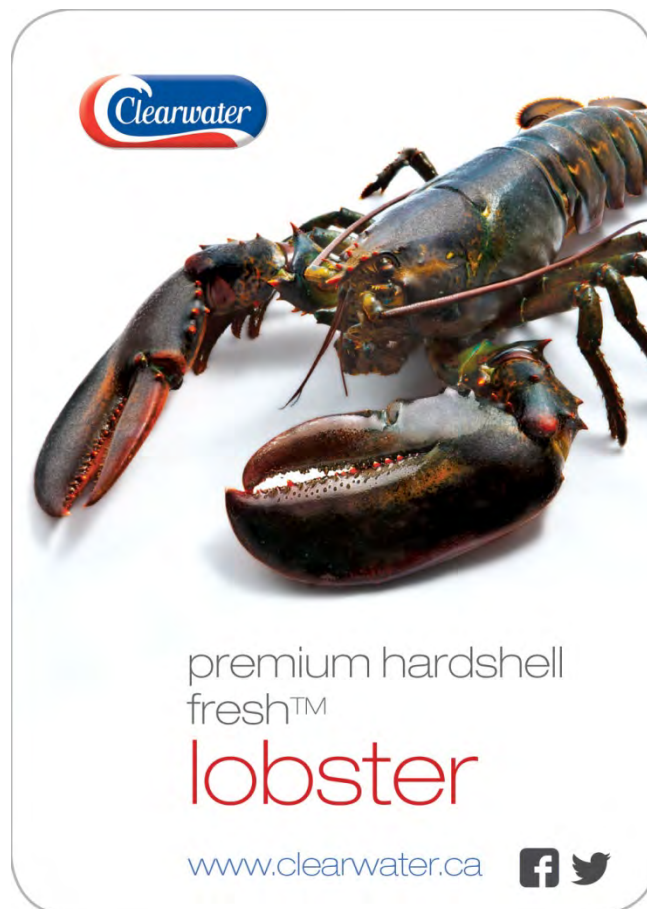
Individual fishing grounds in the community co-managed spiny lobster (*Panulirus argus*) fishery of Punta Allen, México: Lessons learned [K5]

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Management and conservation of the Caribbean spiny lobster (*Panulirus argus*) fisheries of the Western Central Atlantic involve the following complexities: (i) it is a trans-boundary resource, (ii) it is characterized by a metapopulation with source-sink configuration, (iii) gears and fishing methods are heterogeneous with differing effects on population structure, and (iv) there is heterogeneity in management strategies, regulations (including differing legal sizes and trade restrictions), and enforcement. The metapopulation connectivity imposes management difficulties because not all of the countries involved in the Caribbean ecosystem implement the same regulatory strategies for responsible use of this resource over time. Within this complex context, the Punta Allen fishing community has co-managed the resource with a history of sound decision making. The local fishing cooperative has exclusive rights to harvest spiny lobsters using 'casitas' (artificial shelters) in Bahía de la Ascensión, Mexico. Currently there is a limited entry policy with no new licenses being issued to fishermen cooperatives, a closed season, minimum size restrictions, and prohibition on the harvest of egg-bearing females. As a co-managed fishery, the community has implemented additional local rules, and community enforcement mechanisms. Punta Allen cooperative members (56) have granted among themselves exclusive individual fishing rights of 150 fishing lots ranging in size from 0.5 to 3.0 km². Factors identified to explain the relative success of the Punta Allen spiny lobster fishery will be presented and discussed.



Oral Presentations

Abstracts

Climate Change

Factors affecting the low puerulus settlement in the western rock lobster fishery of Western Australia [O1]

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The puerulus settlement of the western rock lobster fishery has remained below average for seven consecutive years (2006/07 to 2012/13) with 2008/09 being the lowest in over 40 years. This has occurred despite a strong Leeuwin Current in 2008 and 2011 and high breeding stock levels in most areas of the fishery since 2010/11. A strong Leeuwin Current (increased water temperatures) has historically been associated with above-average settlement. However this relationship has broken down since 2007. Examination of the timing of the start of spawning using fishery-independent data has indicated that in recent years this has been occurring earlier. It appears to be related to higher water temperatures at the time of the onset of spawning (October) since the mid-2000s. When the timing of spawning is combined with a measure for autumn and spring storms (i.e. May, September and October rainfall) that affect water conditions and onshore water movement, these combined indices describe 72% of the variation in puerulus settlement. These two variables provide a plausible hypothesis to explain the decline in puerulus settlement in recent years, including the recruitment failure of 2008/09. They also predict a marked improvement in settlement for 2013/14 based on a later start to spawning in 2012 and above-average rainfall in 2013. Preliminary indications are that the 2013/14 puerulus settlement will be well above average and the largest since 2000/01. Further verification with additional years is required to see whether this relationship is maintained. There may be climate change implications for the environmental factors (water temperature and storm activity) affecting the spawning and larval period as both these variables are showing long-term trends.

American lobster nurseries of southern New England recede in the face of climate change [O2]

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Historically southern New England has supported one of the most productive American lobster (*Homarus americanus*) fisheries of the US northeast. Over the past two decades, however, the region has seen dramatic declines in its lobster population that are related to excessive summer warmth and shell disease. This two-year fisherman-scientist collaboration compares current population of juvenile lobsters in cobble nurseries of Rhode Island's Narragansett Bay and outer coast to densities reported at the same sites in 1990 during a period of historically high abundance. Diver-based visual surveys and suction sampling used in 1990 and again in 2011-2012 indicate significant declines in the abundance, distribution and size composition of juvenile lobsters in Narragansett Bay since 1990. In 1990 juvenile lobsters extended from the outer coast well into the mid-sections of the bay, but in 2011 and 2012 they were largely restricted to the outer coast and deeper water at the mouth of the bay. Hydrographic surveys in 2011 and 2012 indicate shallow water temperatures (<5m) at all locations sampled exceeded the 20°C thermal physiological threshold for lobsters during at least several weeks of the summer, even on the outer coast. Levels of dissolved oxygen, pH and introduced crabs further suggest semi-enclosed embayments are becoming increasingly inhospitable to lobsters in this region. Because juvenile and adult lobsters appear to be increasingly restricted to deeper and outer coastal waters of southern New England, further monitoring of settlement and nursery habitat in deep water is warranted.

Is settlement and early survival of southern rock lobster affected by climate change driven declines in kelp forests? [O3]

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Kelp forests provide food, refuge, and significantly enhance the recruitment of invertebrate species associated with this habitat. The southern rock lobster (SRL), *Jasus edwardsii*, supports valuable fisheries in Southern Australia and New Zealand. In recent years most areas of the Australian fishery have suffered declines in recruitment. In Tasmania, one Australian jurisdiction, declines in settlement have occurred at the same time as climate change-driven loss of giant kelp forests (*Macrocystis pyrifera*) which previously provided dense cover across large areas of the east coast. We investigated the effect of kelp on settlement and survival of the early benthic phase (EBP). Using crevice collectors, with either natural *M. pyrifera* or artificial kelp, we evaluated the settlement magnitude over 5 months. Additionally, we evaluated the survival of the EBP under kelp and barren habitats using artificial shelters. Collectors with either natural kelp or plastic kelp had higher catches than control collectors without either, although there was no difference between plastic and natural kelp. This suggested that the structure of kelp helps increase settlement but this is a physical process and not affected by any chemical produced by kelp. In predation experiments, survival of the EBP was higher (40%) in kelp environments compared with barrens where kelp was absent (10%). These results suggest that kelp forests provide an important nursery habitat for lobsters and that decline in kelp habitat could contribute to the decline in lobster recruitment.

Shift from bottom-up to top-down control of the algal community due to climate change: impacts on the Japanese spiny lobster in southwestern Japan [O4]

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In recent years, large brown algae communities have changed dramatically, probably because of climate change that has warmed the ocean, for example, in the northwestern Pacific and in the eastern East China Sea. Along the southwestern coast of Japan, in particular around Kyushu Island, perennial macroalgal beds composed of *Sargassum* and/or Kelp regulated by a bottom-up control system have been declining, and the area of the algal beds regulated by top-down herbivory has been expanding. Even though the algal community is composed of perennial species, in recent years, the macroalgae form a dense bed only for a relatively short period in spring, and from summer to early winter almost of the algae's branches and leaves are lost as a main result of high grazing/browsing pressure from herbivores. Therefore, the algal landscape now changes dramatically from dense bushy growth to essentially barren in summer. Beds of large brown algae are the most important habitat for the Japanese spiny lobster (*Panulirus japonicus*) during its early benthic development stage, because they provide post-larval settlement and juvenile nursery sites. The shortening of the bush season of the algal bed by top-down control systems, therefore, is likely to be detrimental to the juvenile lobsters. Our field research and experiments conducted during five years showed that this shift from bottom-up to top-down control of the algal community probably due to climate change negatively affects recruitment and survival of early benthic stages of the Japanese spiny lobster.

Thermal tolerance of the nektonic puerulus stage of spiny lobsters and implications of ocean warming [O5]

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Climate change has great potential to affect the functioning of marine ecosystems through its influence on the complex and little understood larval processes. Recent recruitment declines in important spiny lobster fisheries worldwide have triggered conjecture about negative impacts of anthropogenic induced environmental change on their long-lived planktonic larval life stages. Puerulus larvae may be particularly sensitive to environmental change due to immature cardiorespiratory capacity and exceptional energy demands associated with shoreward migration. We employed measurements of *Sagmariasus verreauxi* pueruli energy metabolism to define their thermal tolerance which are considered against wild coastal recruitment data and spatially explicit ocean warming scenarios. Upper threshold of the thermal optimum window (upper *pejus* temperature) was defined by the temperature optimum for aerobic scope. Beyond the upper *pejus* temperature pueruli had diminished aerobic capacity for physiological performance, used more of their finite lipid reserves to support an amplified metabolism and had a greater reliance on anaerobic energy production to support activity. Maximum water temperatures at the northern extent of their natural range already exceed the upper *pejus* and monitoring settlement data from the wild show that fewer puerulus successfully recruit during hot seasons in this area. Our study provides evidence that physiological thermal tolerance constraints are already limiting post-larval recruitment. Further increases in water temperatures predicted for their rapidly warming habitat will likely result in large shifts in lobster distribution and abundance which may lead to significant re-shuffling of species assemblages, and create challenges for sustainable natural resource management.

European lobster (*Homarus gammarus*) develop deformities when exposed to ocean acidification: larvae and juveniles [O6]

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Ocean acidification is considered one of the major threats to marine biodiversity, and may especially have impact on calcifying organisms. Larvae and juveniles of European lobster (*Homarus gammarus*) were exposed to ambient, 750 μ atm (pH=7.79) or 1200 μ atm (pH=7.62) p CO₂ at temperatures 10°C or 18°C. At 18°C development from stage I to IV lasted 14-16 days, as predicted under optimal conditions, while growth was slow at 10°C resulting in three stage IV larvae. There were no clear effects of p CO₂ treatment on size. All larvae exposed to ambient conditions of pH>7.9 developed normally, while deformities were observed in larvae and juveniles in treatment groups. Proportion of larvae with deformities increased with increasing p CO₂ exposure, independent of temperature. At 750 μ atm 23% of the larvae had deformities and 43% at 1200 μ atm. Deformities of carapace were most commonly observed, but also the tail fan was affected. After long-term exposure of juveniles for five months at 18°C, 44% of the juveniles kept in 750 μ atm and 21% in 1200 μ atm developed deformities. Damages were found in chelae, pereopods and carapace, and antennae were lost. In a recent experiment, juvenile lobster raised in pH>7.9 for one year were exposed to elevated p CO₂ of 1000 μ atm or 1500 μ atm at 14°C, 18°C or 22°C. Deformities developed after six weeks of exposure and continued evolving. After 12 weeks 63% of the juveniles had developed deformities. At 14°C, survival was highest and fewer deformities occurred. Some deformities may affect respiration (carapace), ability to find food (pereopods, chelae and antenna) and ability to swim (tail-fan damages).

The future of *Nephrops*: the effect of climate change drivers on early development in the Norway lobster [O7]

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Climate change has led to a significant change in the intensities of a number of abiotic factors, such as salinity, temperature, oxygen availability and ocean acidification. The Norway lobster (*Nephrops norvegicus*) fishery is the most valuable crustacean fishery in Europe with a recent capture rate of around 60 000 tons per year. How the Norway lobster responds to future climate change will have a large economic as well as biological impact. Historic episodes of hypoxia on the west Swedish coast lead to local extinctions, however these areas have been repopulated from surrounding areas. Global changes will not leave unaffected populations to repopulate affected areas such as with hypoxia. While invertebrate early life stages are generally considered to be more vulnerable to ocean acidification, there has been little research carried out on brooding species such as the Norway lobster where the parent is able to offer some regulation of the environment, nor of the ecologically relevant interactive effects with other climate change linked abiotic factors. Here we present the results of predominantly physiological investigations into the impacts of climate change drivers on the development of *Nephrops norvegicus*.

Combinational effects of climate derived ocean acidification, hypoxia and manganese on food search behavior and CO₂ avoidance in the economically and ecologically important marine crustacean *Nephrops norvegicus* [O8]

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Marine ecosystems face several environmental changes in the future. Rising atmospheric CO₂ levels increase the ocean CO₂ concentrations by a process known as ocean acidification. This is of great concern for marine organisms and yet we know very little about the combined effects of ocean acidification and other stressors such as spreading of oxygen depleted (hypoxic) areas. The Norway lobster, *Nephrops norvegicus*, is one of the commercially most important shellfish species in Europe. It is found on coastal soft bottom sediments that are subjected to periodic hypoxia. Hypoxia may in turn lead to release of manganese from the sediment, which is accumulated in benthic organisms. Here we investigated behavioral effects on *N. norvegicus* after long-term exposure to elevated CO₂ at concentrations postulated for year 2100, but also the combinational effect of elevated CO₂ and hypoxia and manganese. We show several behavioral disturbances, including effects on food recognition, food search and CO₂ avoidance. Our results are compared with CO₂ induced behavioral disturbances previously found in fish.

Revisiting the Lobster Gangs of Maine amid Ecosystem and Climate Change [O9]

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In 1988, Anthropologist Jim Acheson penned his seminal book about lobster fishermen's stalwart territoriality and its role in conserving the state's iconic crustacean. Twenty-six years later, lobsters in the Gulf of Maine are more abundant, ocean temperatures are warmer, and lobster's natural predators are functionally extinct- thus bottom that was previously unsuitable for trapping lobsters is now productive for Maine's nearly 5000 lobstermen. As a result, Maine's lobster landings are five times greater than the decades-long average experienced when Acheson studied in mid-coast Maine. Lobster Gangs still exist, but territoriality has evolved, where the benefits of such highly defended inshore areas are challenged as the density of lobsters moves offshore where there are no long-established territories. I examine the manifestations of harbor gang evolution and explore the longer-term conservation consequence of this coupled natural human systems shift.

Temporal variability in population parameters of the Caribbean spiny lobster (*Panulirus argus*) in Cuba [O10]

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Modifications in life-history traits are often concomitant with prolonged periods of exploitation or changes in the environment, producing changes in population abundance. Both of them act as selective forces and can affect patterns in population parameters such as growth rate, reproduction output, natural mortality rate and size at first maturity. Because of the economic importance of Caribbean spiny lobster (*Panulirus argus*) for Cuba and other countries of western central Atlantic, it is necessary to make a careful study on its life cycle processes and any changes in population parameters over time. A consistent, monthly biological monitoring program in Cuban fishing grounds conducted for over 40 years has allowed obtaining annual population parameters and their relationship with sea surface temperature, biomass and recruitment. Time-series analyses of growth parameters showed a decadal behaviour with significant cycles of 16 years for the asymptotic length, and 16 and 20 years for the growth rate. Estimates of annual size at first maturity indicate a significant increment over time. Across the study period, annual natural mortality rates obtained had an average value of 0.36 year⁻¹ with variations between 0.33 and 0.38 year⁻¹, with same standardized anomalies of the growth coefficient. These analyses reveal the plasticity of the species in different conditions, using a periodic strategy in its life history traits as it faces density-dependent processes and/or climatic changes. The consideration of these results will improve catch forecast and management decisions to obtain a sustainable use of the stock.

Behavioral Ecology

Seasonal movements of American lobsters in the Great Bay Estuary, NH, USA [O11]

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The seasonal movements of American lobsters (*Homarus americanus*) are often attributed to changes in environmental conditions, especially water temperature. Moreover, in estuaries, lobsters have been shown to move in response to drops in salinity, which typically occur at least once each year. However, in this study, during which seasonal fluctuations in salinity were moderate, lobsters moved only short distances (2.32 ± 2.53 km, per year; $n = 31$), with mature lobsters ($CL_{avg} = 83.4$ mm) moving shorter distances than juveniles ($CL_{avg} = 74.9$ mm) (1.94 km vs 2.85 km, respectively). Unlike in previous studies in this estuary, limited net movement (0.03 km down estuary) occurred in the fall of the first year of the study and moderate movement took place in the spring and summer. In the fall in the second year, lobsters moved further (net 0.44 km down estuary), but they were tagged and released further up the estuary, and most of them moved closer to the location where animals were tagged and released in the first year. SCUBA surveys in this area indicated that it was an optimal habitat for lobsters, compared with other areas in the estuary, with lots of shelters, deep holes, and little turbulence from storms. These data suggest that many factors, besides fluctuations in temperature and salinity, strongly influence the movements and distribution of lobsters in estuaries.

Are juvenile Caribbean spiny lobsters becoming less social? [O12]

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Caribbean spiny lobsters are known to be highly gregarious due to attraction to conspecific odors. This leads to aggregation of individuals in crevice shelters and coordinated movements during migration. The success of their commercial fishery relies heavily on exploiting this behavior either through aggregation at artificial structures (casitas) or the use of juveniles as bait in lobster traps. Over the past twenty-five years, we have studied the ontogeny and adaptive significance of juvenile conspecific attraction in the nursery of Florida Bay, FL, USA. During this time period, sudden losses of seagrass and sponge communities have dramatically reduced the availability of natural structure essential to juvenile lobster survival. Juvenile lobsters now show significantly less response to conspecific odor cues than they did twenty years ago. The reasons for this decline in behavioral response to odor cues are unknown, but there are several intriguing possibilities. First, lobsters may learn to avoid conspecific odor cues if shelters are limited and they currently have suitable shelter. Second, increases in disease such as PaV1, may increase the risks associated with aggregation. Third, declining water quality, especially lowered pH, may impair the signal, reception, or ability to respond to odor cues. Fourth, intensive fishing effort that systematically removes those individuals most responsive to odor cues may be selecting against this behavior. Although there is some evidence that each of the first three explanations play a role in reducing the attraction of conspecific cues, none of these are sufficient to explain the widespread loss of conspecific attraction.

Aggressive behavior of spotted spiny lobsters (*Panulirus guttatus*) in different social contexts [O13]

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Panulirus guttatus is a sedentary spiny lobster that exhibits cryptic behavior and a low degree of gregariousness. Because these lobsters are obligate coral reef-dwellers and avoid sandy/vegetated areas, they are potentially distributed in relatively small, discrete populations with variable social contexts, which can strongly influence the expression of aggression. This study examined the relative importance of lobster sex and size in the shelter-related aggressive behavior of replicated groups of four lobsters that differed in social context (i.e. same-sex and mixed-sex groups). Each group was held in a seawater tank with a single artificial cave. The behavior of lobsters was video recorded for 72 h and the number of aggressions performed by each individual over 10 min per hour was quantified. Most aggressions were related to occupancy of the shelter space and tended to end when individuals became sufficiently spaced. In general, per-capita rates of aggression were higher at night. Aggressiveness increased with size in individuals of the same sex, but males were overall more aggressive than females. In mixed-sex groups, fewer aggressions occurred when the males were larger than the females than the other way around, suggesting that it takes longer for smaller males to assert themselves. Maternal state did not affect degree of aggressiveness in females, but the number of missing limbs significantly impacted degree of aggressiveness in males. Since spacing is important for these lobsters, our results provide insight into potential consequences of the ongoing loss of structural complexity of Caribbean reefs for populations of *P. guttatus*.

Pulse magnetization indicates Magnetite-based magnetoreceptors in the Caribbean spiny lobster [O14]

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Understanding animal navigation is critical to developing effective management plans and predicting migratory patterns or geographic distributions. The Earth's magnetic field plays an important role in guiding diverse taxa by providing both directional (compass) and positional (map) information. The commercially-important Caribbean spiny lobster (*Panulirus argus*), an animal known for coordinated migrations and an impressive homing ability, is the only invertebrate known to possess both a magnetic compass and map. However, the transduction mechanisms underlying magnetic field detection have not been clearly established in any animal. One hypothesis proposes that crystals of the magnetic mineral magnetite function as magnetoreceptors; by twisting into alignment with the geomagnetic field, single-domain magnetite crystals may activate secondary receptors or open ion channels. Magnetic material thought to be magnetite has previously been detected in spiny lobsters. To determine if these particles are associated with magnetoreception, lobsters were subjected to strong, pulsed magnetic fields capable of re-aligning the dipole moment of biogenic magnetite. Lobsters were subjected to a pulse directed either parallel or antiparallel to the geomagnetic field's horizontal component. An additional control group was handled but not pulsed. Lobsters were subsequently tethered within a water-filled arena at the capture location and allowed to walk in any preferred direction. While control lobsters oriented randomly, parallel pulsed lobsters oriented west ($\theta = 259^\circ$) and the antiparallel pulse group oriented northeast ($\theta = 47^\circ$). Orientation of the two pulsed groups was significantly different. These results imply that spiny lobsters possess magnetite based magnetoreceptors and provide insight into lobster navigation.


The *in situ* swimming and orientation behavior of spiny lobster (*Panulirus argus*) postlarvae [O15]

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Larval dispersal is common in benthic marine organisms, but the environmental cues guiding the final larval stages to settlement habitat remain largely unknown. The Caribbean spiny lobster (*Panulirus argus*) spend 5 to 12 months at sea as pelagic phyllosome larvae before transitioning into rapidly swimming and non-feeding puerulus postlarvae. Spiny lobster postlarvae are specialized to seek settlement habitat, making them an ideal model for studying orientation behavior during the transition to benthic environments. We observed the swimming orientation of *P. argus* in the open ocean during all hours of the day and across tidal phases using a circular behavioral arena deployed at sea. Contrary to laboratory observations of only nocturnal activity, swimming and orientation occurred during both the day and the night in open waters ca. 6-8 km offshore in the Florida Straits. Individual postlarvae swam directionally with similar accuracy in all hours. The mean orientation direction was significantly different with tidal phase. Postlarvae oriented to the southeast (163.5°) during flood tide, and to the southwest during ebb flow (225.2°), placing them on a shoreward trajectory. Postlarval behavior was circatidal, and during ebb tide innate swimming behavior beneficial to finding settlement habitat was triggered. Postlarvae also oriented relative to the wind, potentially using the sea breeze to orient towards the coast. A change in behavior tied to ubiquitous coastal signals is a strategy likely used by other pelagic larvae searching for a benthic home.



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Diseases and Parasites

The curious case of PaV1 in adult Caribbean spiny lobsters [O16]

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The pathogen PaV1 (*Panulirus argus* Virus 1) exacts a heavy toll from juvenile Caribbean spiny lobsters with an estimated 24% in Florida dying of it before they reach maturity and recruit to the fishery. Prevalence is also high among adult populations, especially in the northern Caribbean (e.g., Puerto Rico – 17%). However, PaV1 manifests differently in adults. They may act as “carriers” because adults rarely develop visible infections and do not seem adversely affected by the pathogen. Infected adults are not avoided by healthy conspecifics, as occurs among juveniles. Moreover, adult females with subclinical PaV1 infections are often captured from the wild with a spermatophore or fertilized eggs, indicating that males are willing to mate with them. Adults with subclinical infections of PaV1 are not infectious to other adults or to the more susceptible juveniles. Although postlarval lobsters infected with PaV1 occur in the nearshore waters of Florida, experiments indicate that vertical transmission of PaV1 from females to embryos is not the mode of transmission. Instead, postlarvae acquire PaV1 shortly after arriving inshore from the oceanic plankton. These recent results suggest that PaV1 may be of little consequence to adult lobsters in contrast to its major effect on juvenile ecology and population dynamics. Just how adult lobsters retain subclinical infections of PaV1 remains a mystery.

A scent of death? Caribbean spiny lobsters equally avoid lethally-injured and clinically PaV1-infected conspecifics [O17]

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Caribbean spiny lobsters commonly share shelters, a gregarious behavior mediated by conspecific chemical cues released with urine. Previous studies revealed that these lobsters avoid shelters emanating scents from lethally injured conspecifics (“alarm odors”, which signal predation risk), whereas other studies found that they avoid scents from conspecifics with overt signs of the *Panulirus argus* Virus 1 (PaV1) disease. However, all those studies utilized different experimental protocols and devices, making comparisons difficult. In the present study, we conducted a controlled experimental series using a set of 2m-long Y-mazes to examine and contrast the response of *P. argus* lobsters to shelters emanating scents from conspecifics in four different conditions: uninfected, subclinically PaV1-infected (infected but not diseased and presumably non-infectious), clinically PaV1-infected (i.e. diseased and infectious), and lethally injured. Each treatment was replicated at least 17 times. All lobsters were pre-tested for PaV1 by PCR and all focal lobsters were uninfected and in intermolt. Focal lobsters equally avoided shelters emanating scents from clinically infected (80% avoidance) and from lethally injured conspecifics (85%), whereas their response to subclinically infected and to uninfected conspecifics did not differ significantly from random. These results indicate that scents from PaV1-diseased lobsters trigger a similar avoidance response in healthy lobsters as conspecific alarm odors do, potentially increasing fitness. It remains to be determined whether lobsters avoid diseased conspecifics to reduce their risk of exposure or they simply discriminate against the potentially decaying odor of PaV1-diseased conspecifics, which undergo massive tissue degradation as the infection becomes systemic.

Detection and prevalence of *Panulirus argus* Virus 1 (PaV1) in tails of Caribbean spiny lobsters from two fishing cooperatives in Yucatan, Mexico [O18]

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The spiny lobster *Panulirus argus* supports one of the most important fisheries in the Caribbean region and provides an important income to local fishermen. It is estimated that around 48% of the lobster production in Mexico is from two states in the Yucatan peninsula: Yucatan and Quintana Roo. *Panulirus argus* Virus 1 (PaV1), a virus that is particularly lethal to juveniles, has been reported in the Caribbean sea, including Quintana Roo, but not in Yucatan, where there is concern about its presence in subadult and adult lobster tail landings from two main local fishing cooperatives. Thus, from June to February 2012 we collected 496 tails maintained in ice cold (4° C) from two locations in the state of Yucatan: Río Lagartos (n = 169) and Progreso (n = 327). Based on their size, subadults (n = 206) and adults (n = 290) were analysed by PCR to detect PaV1. We found 13 samples positive to PaV1 (Río Lagartos = 9; Progreso = 4) providing a prevalence of 2.62%. The PaV1 prevalence in Río Lagartos was higher (5.32%) than in Progreso (1.53%). Also, the prevalence was higher in subadult individuals than in adults (4.3% and 1.37%, respectively). The present study documents the first report of PaV1 in spiny lobster from the state of Yucatan and the first evidence of PaV1 in commodities maintained in ice cold for local marketing and for the international seafood industry.

Does the importation of live American lobster (*Homarus americanus*) pose a threat to native European (*H. gammarus*) populations? Shell disease susceptibility [O19]

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The crustacean cuticle is the first-line defence against invasion of parasites and pathogens. Once damaged, it can be subject to colonisation by microbial agents from the surrounding environment, often leading to shell disease syndrome. A progressive condition whereby the outer cuticle becomes pitted and eroded and in extreme cases is compromised, leaves lobsters susceptible to septicaemia. A form of shell disease, termed epizootic shell disease, has hampered southern regions of the North American lobster fishery for over a decade; however, there are recent signs of the syndrome spreading farther North. It is feared that this increasing prevalence of shell disease, plus American lobsters being found in European waters, could have serious implications for the health of native European lobster populations. Our study examined the susceptibility of American (*Homarus americanus*) and European (*H. gammarus*) lobsters to shell disease. Scanning electron microscopy was used to identify differences between the cuticle structure of both species, as well as subsequent structural modifications of the cuticle after induced damage. In summary, the carapace and claws of American lobsters were found to be thinner and more vulnerable to abrasion damage than their European counterparts. In addition, the number and distribution of setal pits and pore canal openings differed between the two species, with Americans harbouring more setal pits. The induced damage resulted in the formation of shell disease lesions on the claw and carapace of both species; however, American lobsters, unlike their European counterparts, had extensive bacterial colonisation on the margins of these lesions. Overall, it is concluded that the cuticle of the European lobster may be less susceptible to damage and resulting microbial colonisation.

Infestation by metacercariae of the trematode *Cymatocarpus solearis* in Caribbean spiny lobsters from Bahía de la Ascensión, Mexico [O20]

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Caribbean spiny lobsters (*Panulirus argus*) are second intermediary hosts for *Cymatocarpus solearis*, a digenean trematode whose final hosts are sea turtles (which prey on lobsters). Encysted metacercariae of *C. solearis* were previously reported in abdominal muscles of *P. argus* lobsters from Bahía de la Ascensión, a large bay on the Caribbean coast of Mexico where a highly productive casita-based fishery for *P. argus* exists. As lobsters may be important in transmission of parasites to higher trophic levels, we sampled 3,956 lobsters over a wide size range (9.5–111.0 mm carapace length, CL) from three separate bay zones in three different seasons, to examine prevalence of infestation by metacercariae cysts, which are visible to the naked eye. The probability of finding infested lobsters significantly increased with lobster size and varied widely between zones and seasons. However, prevalence of infestation was consistently higher in one particular zone (21.5% on average) relative to the other zones (5.1% and 6.0%), suggesting that the first intermediary host of *C. solearis* (which remains unknown but is likely a mollusk) may be more abundant in the former zone. Intensity of infestation in three lobsters (74.7–84.7 mm CL) varied from 58 to 70 cysts, with more cysts in cephalothoracic than in abdominal muscles. There was a negative relationship between infestation by metacercariae and clinical infection with PaV1, but this result may simply reflect that probability of infection with PaV1 decreases with increasing size of lobsters while the opposite occurs for probability of infestation with metacercariae.

Immune response to *Panulirus argus* Virus 1 (PaV1) in naturally and experimentally infected juveniles of *Panulirus argus* [O21]

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Since the discovery of PaV1 most research has focused on understanding viral infection and its ecological implications. In this study, we compared the immune response between juvenile lobsters *Panulirus argus* naturally and experimentally infected with PaV1 by comparing wild lobsters (54 uninfected, 56 infected) and lobsters from an experimental challenge (56 uninfected, 43 infected). The challenged lobsters were injected with a viral inoculum and time course infection was evaluated during 6 months. Hemocyte counts, hemagglutination, and phenoloxidase activity were evaluated. PaV1 was confirmed by PCR and infection severity was analyzed by histology (uninfected: 0; lightly infected: 1; moderately infected: 2; severely infected: 3). Dissimilarity amongst measures in lobster samples was calculated using the reciprocal of Gower. Samples were then ordered using non-metric dimensional scaling. A permutational MANOVA was used to establish whether differences in the ordination of samples were influenced by the type and severity of infection, and their interaction. Carapace length was used as covariate. Type and severity of infection contributed significantly to explain the variation of the immunological response in *P. argus*. The non-significant interaction term indicated that differences in immune response among levels of infection severity were similar in naturally and experimentally infected lobsters. Variation in immune response by type of infection could be associated with intensity of the initial viral load, suggesting that observations during controlled immunological challenges should be taken with caution, especially if data are extrapolated to the ecological level.

Differential susceptibility to *Panulirus argus* Virus 1 (PaV1) between experimentally infected juvenile and adult Caribbean spiny lobsters [O22]

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Panulirus argus virus 1 (PaV1) is a highly pathogenic virus that infects *Panulirus argus* spiny lobsters. In experimental infections, juveniles of *P. argus* are highly susceptible to PaV1, but this issue has not been previously addressed for larger lobsters. A time-course experimental challenge with PaV1 was carried out to examine the progression of infection in lobsters within three size groups: juveniles (20–45 mm CL), subadults (45.1-80 mm CL), and adults (>80 mm CL). Viral inocula from heavily infected lobsters were injected into 30 uninfected individuals of each size group. Hemolymph was collected from 3 individuals per group at intervals of 15, 36, 57, 81, 105, 132, 159, and 187 days post-injection (dpi) to compare their immunological (hemocyte counts, lysozyme, hemagglutination) and physiological (proteins, glucose, cholesterol, acylglycerides) response variables vs those of control groups. Severity of infection was analyzed by histology of hepatopancreas, gills, muscle, midgut, gonad, and heart tissues. The presence of PaV1 was confirmed by PCR. Viral inclusions in tissues, especially from the hepatopancreas, were observed at 15 dpi in juveniles, 36 dpi in subadults, and 105 dpi in adults. Infected juveniles had significantly lower counts of total hemocytes, hyalinocytes, and semigranulocytes than control juveniles, and nine juveniles became heavily infected. In contrast, subadults and adults became only lightly infected and their hemocyte counts did not differ significantly from their respective controls. Our results corroborate a higher susceptibility of juvenile lobsters to PaV1 and suggest that resistance in large lobsters could be regulated by cellular hemocytes responses.

Nutritional condition and digestive activity of juvenile spiny lobsters, *Panulirus argus*, naturally infected with PaV1 [O23]

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The spiny lobster *Panulirus argus* has been affected by a highly pathogenic virus known as *Panulirus argus* Virus 1 (PaV1). Little is known about the physiological responses of naturally infected *P. argus*. In this study we evaluated the effect of the viral infection on the enzymatic activity and metabolites from the digestive gland (hepatopancreas) of lobsters from the Mexican Caribbean naturally infected with PaV1. Sixty six juvenile lobsters, 28 visibly healthy and 38 diseased, were collected by Scuba diving in Puerto Morelos, Mexico. After dissection, the digestive gland was removed and the activity of glucosidase, amylase, trypsin and chymotrypsin was evaluated. The levels of glycogen, proteins, glucose, cholesterol and acylglycerol were also determined. The presence of the virus was confirmed by PCR and histology. The presence and amount of Cowdry type A inclusion bodies were used to grade severity of infection: uninfected (0), lightly infected (1), moderately infected (2) and severely infected (3). Using metabolic variables, a principal component analysis (PCA) yielded 2 separate clusters: one corresponding to the uninfected group and the other corresponding to the infected group. One-way ANOVAs were used to analyze the behavior of some variables individually. Relative to uninfected lobsters, severely infected lobsters showed a significant decrease in enzymatic activity (glucosidase, amylase, trypsin and chymotrypsin), and in glucose and glycogen concentration. The significant alteration in enzymatic activity of infected lobsters reflects damage of the tissues leading to a failure of digestive capacity as the infection with PaV1 progresses.

Experimental infections with *Panulirus argus* Virus 1 (PaV1) from *Panulirus argus* lobsters in the white shrimp *Litopenaeus vannamei* could lead for a putative reservoir host for PaV1 [O24]

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Panulirus argus Virus 1 is considered a threat to Caribbean spiny lobsters *Panulirus argus*. Apparently, this virus is specific to *P. argus* because putative species that could serve as PaV1 reservoirs have not been identified. Previously, for instance, three decapods that co-occur with *P. argus* (the crabs *Mithrax spinosissimus* and *Menippe mercenaria*, and spotted lobsters *Panulirus guttatus*) were experimentally infected with hemolymph of PaV1-infected lobsters but did not acquire the virus. We evaluated the infectivity and pathogenicity of PaV1 in penaeid shrimps *Litopenaeus vannamei* to explore their role as putative paratenic host for PaV1. 120 shrimps were allocated (n=30) among four aquaria (3 experimental groups, and 1 control group). Experimental shrimps were injected with 50 µl of inoculum from the hepatopancreas of an infected juvenile *P. argus*. Control shrimps (n=30) were injected with 50 µl of hepatopancreas of an uninfected lobster. Time course infection was evaluated by PCR, total and differential count of hemocytes, histology, and oxihemocyanine determination. No differences were observed in hemocyte counts. In experimental shrimps, oxihemocyanine levels were lower but histology revealed no Cowdry viral inclusions in gills, muscle and hepatopancreas. The hepatopancreas of 5 experimental shrimps showed infiltration of hemocytes and enlargement of the hepatopancreatic tubules, vast amount of blood vessels, and spongy connective tissue. The PCR detected PaV1-DNA from 12 h to 648 h post-infection. Infected shrimps were exposed to 5 uninfected juvenile *P. argus*, which after 20 days were positive to PaV1. The DNA sequence of positive infected shrimps and spiny lobsters had 100% of homology.

The relationship between environmental DNA and invertebrate disease: ground-truthing an emerging technology [O25]

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The increasing deployment of deep sequencing technologies (DSTs) to environmental samples (water, sediment, whole animals etc.) has enormous potential for the detection of known, novel and otherwise cryptic pathogen lineages. Our laboratory is applying such approaches for the detection of invertebrate pathogens of potential significance to fisheries and aquaculture. Utilising primers targeted at specific pathogen groups of interest (e.g. Haplosporidians, Mikrocytids), we have revealed a previously unknown hyper-diversity with the potential to impact upon the health status of important host groups. The approach can also be utilised to generate the first sequences from highly divergent organisms that may not be detected by other methods and to investigate life cycle strategies of important pathogens (e.g. which may pass through previously unchecked hosts). However, despite the potential, care must be taken when analysing environmental datasets and particular, in assigning biological relevance (in terms of infection/disease) to detection of DNA in environmental matrices. We predict a re-emergence in the importance of classical approaches to disease investigation (e.g. histopathology, electron microscopy) to enable meaningful links to be drawn between presence within the matrix and outcomes in hosts. DSTs should therefore be considered as a 'tool in the box', rather than *the* toolbox *per se*, for investigating pathogens of concern to aquatic hosts.

Can we help lobsters beat Shell Disease? [O26]

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As part of the New England Shell Disease Initiative, a general hypothesis was proposed relating shell health to vulnerability to attack by shell disease agents. Researchers found a protective, basic hydroxyl boundary layer on the external surface of the epicuticle that provides significant antimicrobial function. The loss of this biofilm provides an entry for the bacteria to begin shell degradation. The use of probiotics for biocontrol of diseases has shown to be effective for protection of larvae and juvenile oysters against bacterial pathogens. These candidate probiotics, *Phaeobacter* sp. and *Bacillus pumilus* are being tested for effectiveness for controlling *Aquimarina homari*, *Pseudoalteromonas gracilis* and *Thalassobius* sp. (all thought to be involved in epizootic shell disease). *In vitro* plate assays are currently being conducted. After testing for effectiveness in *in vitro* plate interactions, 10 non-symptomatic lobsters or lobsters with scars will be treated with a probiotic bath for 10-15 minutes. A control set of 10 lobsters will not be treated. After 1 month, lobsters will be assessed for development of epizootic shell disease. If successful, we will pursue developing a bacterial dip that fishermen can apply to clean sublegal or v-notched lobsters when fishing.

Characteristics of recent increases of epizootic shell disease in the American lobster (*Homarus americanus*) for the inshore Gulf of Maine [O27]

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Epizootic shell disease in the American lobster (*Homarus americanus*) has plagued southern New England since the nineties and appears to be creeping northward with higher incidences observed in recent years in the inshore 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 2011, the observed levels of shell disease have been consistently below one percent, but, in the last two years of data collection, the observed incidence has increased to nearly 5% in some areas. We explore the spatial and biological characteristics of the affected catch in the inshore Gulf of Maine and compare to the patterns of onset of shell disease in Southern New England.

Geospatial analysis in the prevalence of PaV1 in the lobster fishery of the eastern coast of Yucatan, Mexico [O28]

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The lobster fishery is an important source of income for many fishermen along the Yucatan coast, Mexico. However, in the last decade wild populations of *P. argus* have been infected by a pathogenic virus, *Panulirus argus* virus 1 (PaV1). Much has done to understand about the disease, but limited information exists regarding environmental factors that could be associated with the disease and its distribution using geospatial analysis. From July 2012 to February 2013, fieldwork was undertaken in two communities of the eastern coast of Yucatan. During fishermen journeys, onboard observers recorded geographical coordinates, depth and water temperature of each fishing site visited. The tail length (TL) was measured and a sample of the gills was taken from each individual to be analyzed by PCR to detect PaV1. Sea bottom landscape where determined employing a geospatial analysis. From the 357 lobsters obtained, 4 were positive to PaV1. Positive lobsters had an average of 13.77cm TL, three were females and one male, and they were caught on three different fishing sites. Landscape characteristics were determined for two of those sites. For fishing site I depth and temperature were 12.66m and 25.08°C and for fishing site II 17.14m and 21.9°C, respectively; for both sites the sea bottom was mainly patches of sea grass. Prevalence for fishing site I was 28% and for fishing site II 0.9%. It is discussed the potential use of geospatial analysis to understand the physical characteristics of the lobster habitat and environmental conditions that favor PaV1.

Prevalence and genetic diversity of *Panulirus argus* virus I throughout the Caribbean Sea [O29]

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Panulirus argus virus I (PaV1) is a pathogenic virus that infects the Caribbean spiny lobster, *Panulirus argus*. PaV1 was first identified in the Florida Keys where its prevalence in juvenile lobsters has remained steady at ~8% for more than a decade, although there are localized "hotspots" where prevalence can reach 60%. In 2010-2011, we collected tissue samples from ~100 adult *P. argus* from each of 26 locations in 13 countries and used PCR-based molecular diagnostics to determine the prevalence of the virus around the wider Caribbean. In samples where PaV1 DNA was amplified, we used DNA sequencing to explore viral diversity within individual lobsters and among Caribbean locations. The prevalence of the virus in adult lobsters ranged from 0-17% around the Caribbean, with low or zero prevalence in the Bahamas, Lesser Antilles, southern Caribbean, and Bermuda. PaV1 was most prevalent in the central Caribbean (Cuba, Puerto Rico), western Caribbean, and Florida. Viral diversity was high with at least 61 viral alleles observed from 9 areas. The sharing of viral alleles from distant locations suggests high genetic connectivity of the pathogen in the Caribbean. However, our experimental results indicate that vertical transmission of PaV1 from infected adults to larvae is unlikely, as is waterborne transmission of the pathogen over long distances.

Swimming with sickness: A theoretical model of disease dispersal [O30]

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Throughout the Caribbean, a lethal virus is killing juvenile spiny lobsters (*Panulirus argus*) before they can mature. The pathogen may not be vertically transmitted and has not been found in phyllosoma larvae, but appears subclinically in postlarvae that metamorphose at the shelf edge and settle near the coast. Modeled and genetic results indicate panmixia in lobster populations, yet similar work with the virus suggests that there are multiple unique and unshared strains across the Caribbean. We couple Lagrangian modeling with a flexible matrix model of dispersal, using repeated random iterations to describe long-term patterns. With the Caribbean basin as a testing ground, we can now ask questions about how a large area with complex hydrology influences the theoretical spread of disease. If the virus is waterborne and becomes non-viable within a few days, as laboratory experiments indicate, it is unlikely to impact both the Central/Eastern and Northern Caribbean. However, if it can be transported between locations by infected postlarvae, the Caribbean becomes linked with higher prevalence in the North. Based on our results we identify possible regions where disease is likely to spread from.



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Population and Community Ecology

Facilitating coexistence: Dietary partitioning between two sympatric spiny lobsters in a Caribbean coral reef system [O31]

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In the Caribbean region, the Caribbean spiny lobster (*Panulirus argus*) and the spotted spiny lobster (*P. guttatus*) co-occur. *Panulirus argus* undergoes ontogenetic habitat shifts during its benthic life, whereas *P. guttatus* is a habitat specialist that dwells exclusively in the coral reef habitat after settlement. Competition for food resources between these two species is thought to be minimal given that (1) all *P. guttatus* are highly sedentary and tend to forage on the reef itself, (2) juvenile *P. argus* both dwell and forage in reef lagoon habitats, and (3) larger reef-dwelling *P. argus* lobsters tend to forage in adjacent habitats rather than on the reef itself. In this study the diet composition of reef-dwelling *P. guttatus* and *P. argus* and lagoon-dwelling *P. argus* from the Puerto Morelos coral reef system (Mexico) were examined using carbon and nitrogen stable isotopes. Bivariate ellipses were used to delineate isotopic niche space of the three lobster groups. The estimation of the contribution of food sources to the diet of lobsters showed that *P. guttatus* fed mostly on carnivores and reef-dwelling *P. argus* on herbivores. Lagoon-dwelling *P. argus* also fed mostly on herbivores but showed an important contribution of producers to their diet, which might be ingested while feeding on invertebrates that live on macroalgae. Dietary overlap between the three lobster groups was negligible. These results suggest that, in addition to a differential use of habitat resources, a differential use of food resources facilitates the local coexistence of these closely related species.

Patterns in demographics of American lobster (*Homarus americanus*) in coastal waters - Massachusetts Bay – USA [O32]

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Many factors influence lobster distribution and habitat use, including ontogenetic changes in shelter requirements and movement tendencies, molt-related behaviors, and competitive interactions. We have documented demographic information for lobsters in the Massachusetts Bay region using a fishery-independent ventless trap survey. The Massachusetts Bay Ventless Trap Survey (MassBAY VTS) was originally designed as a pilot survey to develop methods for measuring lobster relative abundance. The survey stratification scheme was based on both bottom type and depth, making it a useful survey design not only for population monitoring, but also as a means to examine lobster habitat use. The MassBAY VTS study area encompassed approximately 700 km² in Massachusetts Bay. Bottom sediments ranged from mud to boulders and were generally classified as “complex” or “featureless.” Depth ranged from ~3 m to a maximum of 50 m. Seventy seven randomly selected stations were sampled from May through November in 2005 and 2006, providing opportunity for both seasonal and annual comparisons. More than 96,000 lobsters were sampled, over 12,385 trap hauls. Depth was generally the main habitat variable related to size structure and relative abundance; the shallow strata had the smallest size distribution of lobsters, as well as the highest average catch rates. The percent of lobsters that were culls or newly-molted was higher on featureless than complex bottom, suggesting that competitive ability may have influenced what bottom type a lobster inhabited. This relatively high resolution survey has served not only as a model for future population monitoring surveys, but also as a resource for documenting habitat-related patterns in lobster demographics.

Higher correlation of *Palinurus elephas* settlement with regional versus global environmental forcing [O33]

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Palinurus elephas is the most economically and socially important decapod crustacean in the Mediterranean. Proper management requires understanding population dynamics, of which recruitment is the most influential process due to its high variability of complex causality. In the case of the European spiny lobster, studying recruitment at the larval stage is not approachable due to extremely low densities of phyllosomas in the plankton. However, a practical and reliable indicator of recruitment strength is the density of post-larvae settled in the bottom (early benthic juveniles). We know now that *P. elephas* in the northwestern Mediterranean has a meta-population structure of "common larval pool". In this study we relate settlement rates with various environmental variables in order to assess our ability to predict recruitment strength. The study uses series of settlement indices, of 10 to 14 years duration depending on the location, from 13 locations in the northwestern Mediterranean, along with series of global (NAO, AMO) and regional (WEMO, IDEA) climate indices and environmental variables (Zonal Wind, South wind, SST, SST Gulf of Lions, precipitation). By correlation and principal component analyses we observed a significant correlation between the trend of lobster settlement indices and IDEA index and Zonal Wind. Moreover, at the spatial scale settlement was not significantly correlated with any of the climatic indices or environmental variables studied, suggesting that settlement is determined by local physiographic factors.

Patchiness in American lobster settlement at a hierarchy of spatial scales [O34]

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The objective of this study was to quantify the abundance and spatial pattern of lobster settlement in select coastal habitats of the Bay of Fundy. A spatially nested design comprising of two large regions in Atlantic Canada, south New Brunswick (300 km²) and southwest Nova Scotia (1200 km²), 11 sampling areas within the regions (0.3-10 km²), 2-3 sampling sites (0.3-3 km²) within each area, 2 sub-sites within each site (0.15-1.5 km²), and finally 5-13 settlement collectors within each sub-site (0.00000055 km²). Lobsters found in the collectors were classified as settlers (≤ 13 mm CL) or juveniles (≥ 13 mm). In order to assess patchiness, we conducted a variance component analysis, followed by a new method designed for this project, where we calculated variance in the number of settlers (or juveniles) at different spatial scales, and then compared these values to a theoretical distribution obtained by Monte-Carlo simulation and assuming random settlement across sampling units as an index of patchiness. This project has so far discovered important nursery areas for lobster that hold regardless of inter-annual variation in settlement, identified significant patchiness in settlement at the scale of 1-10 km² and much lower variability at larger and smaller spatial scales, and identified important processes that can be used when predicting what areas might be good for American lobster settlement.

Investigating European lobster (*Homarus gammarus*) populations in Northumberland, UK, via acoustic telemetry (AT)– Movement & habitat utilization [O35]

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European lobster, *Homarus gammarus*, supports one of the most valuable UK fisheries, but stocks are considered fully exploited, and research lags behind other commercial species, particularly given increased reliance on the continued productivity of shellfish in light of reported failures of finfish stocks. Knowledge gaps exist regarding habitat-use and movements; influencing our ability to determine distribution and design management plans. Data is required to support the current plan to implement a network of reserves around the UK coast. This paper presents results from a small-scale AT tracking study, using a network of VR2W receivers, covering an area >1km². In 2013, 43 lobsters of varying sizes (65-98mm CL), were tagged and high resolution positions gained every 5 minutes, for 42 days during the summer (May-June) and 35 days during winter (Oct-Nov). Results of site fidelity, home-range size and habitat-utilization will be presented; analyzed by sex, size, and season. Initial data show lobsters cluster along the edge of rocky habitat; females had restricted home-range sizes (20-40m diameter), and were less-likely to move away from hard substrate. Male movement was more variable with a larger home-range (30-60m) and increased movement into surrounding soft substrate. This research is the first of its kind in the UK; the technology offers novel insights into the behaviour of the cryptic *H. gammarus*, that trapping studies cannot provide. Elucidating sex-, size- and season-specific patterns of movement, and habitat-utilization for *H. gammarus*; vital for the basis of regional management plans and determining the impact of reserves on stocks, and the potential for spillover.

Lobsters in Antiquity

Aspects of the history of lobster utilization in the Central and Eastern Mediterranean and Red Sea [O36]

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The Mediterranean and the adjacent Red Sea host a variety of clawed (2 species), spiny (6 species), and slipper lobsters (4 species) that are commercially significant to the region. Although historical information is patchy, evidence indicates that the utilization of lobsters in ancient times was variable ranging from the prohibition of lobster consumption by the Jewish religion, to that of Epicurean status in the Roman world. One of the earliest known illustrations of a (spiny) lobster was a wall carving in the Deir el Bahri temple in Egypt depicting the Queen Hatshepsut expedition to the Red Sea in the 15th century BCE. Lobsters were known by the ancient Greeks and Romans as was expressed in art forms and writings. Lobsters (mainly spiny) also appeared in ancient mosaics and coins. In *Historia animalium*, Aristotle (ca 350 BCE) gave mostly accurate biological descriptions of clawed and spiny lobsters including their reproduction and spawning. He, as well as Pliny the elder (ca 78 AD), also referred to the migration and molting of lobsters. The writings of naturalists and philosophers from the Roman-Hellenistic period, together with illustrative records indicate that lobsters were a well-known food and there was considerable knowledge of their classification, biology and fisheries. The popularity of lobsters as a gourmet food increased with time followed by an expansion of the scientific knowledge of these large crustaceans.

The European spiny lobster *Palinurus elephas*: A species for understanding the ancient history of Mediterranean fisheries [O37]

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In the Mediterranean Sea the European spiny lobster *Palinurus elephas* (Fabricius, 1787) has been fished and consumed by coastal communities for thousands of year. As evidence of its importance, Aristotle (s IV, b.C.) devoted a chapter in his book *Historia Animalium* where he assembled the knowledge on the biology and behavior available at the time. An indication of the prevalence of the species are the faithful depictions present in Roman mosaics where it is possible to discern the capture methods, which included catch by hand from the shore hinting at its great abundance. Since the time of the Greeks (2500 years ago) little has been written about *P. elephas* or its fisheries in the Mediterranean, preventing even a superficial appraisal of their evolution since ancient times. During the past century, interest on the species grew impelled by the growth of coastal populations and later on also of the tourist industry along the Mediterranean shores. We present information from various sources that help to understand the dramatic effect that the growing economic importance of *P. elephas* has meant for its population. We also document events that have shaped the way in which *P. elephas* fisheries have been pursued during the last century, highlighting their consequences for the viability and current status of *P. elephas* fisheries today.

History of utilization of lobsters by humans in Australia [O38]

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Australia is an island with almost 60,000km of coastline, spanning tropical to temperate, and with well established fisheries for spiny (Palinuridae) and slipper (Scyllaridae) lobsters. Although Australia has a long history of human settlement dating back more than 40,000 years, records of lobster utilisation are only available for the past 150 years, since European settlement. The native mainland and Tasmanian inhabitants, the Australian Aborigines, and those of the Torres Strait between Australia and New Guinea, the Torres Strait Islanders, have lived in Australia for millennia and many communities had and continue to have a close association with the sea and fishing. They are known to have fished for lobsters, which are abundant in inshore rocky and coral reefs throughout Australia, although evidence of this prior to European settlement is based on hearsay. The history of native Australians has been passed through the generations by stories, art and dance, and in recent times some documentation of this history has been recorded, including scant references to lobsters. Recent documented history of lobster utilisation by European settlers and their descendants indicates that fishing for lobsters began in earnest in the late 1800's. There are four species of Palinurid lobsters of significance, *Panulirus cygnus*, *Jasus edwardsii*, *Panulirus ornatus* and *Sagmariasus verreauxi*, and two genera (multiple species) of Scyllarid lobsters, *Thenus* and *Ibacus*. All commercial lobster fisheries are managed through various output or input controls, and are sustainable. The total catch of lobsters exceeds 10,000 tonnes per year, and markets are primarily in Asia and the USA.

Nga Koura o Aotearoa: The history of lobsters in New Zealand [O39]

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Two species of spiny lobster are found in New Zealand/Aotearoa waters, the packhorse lobster (*Sagmariasus verreauxi*) and the red rock lobster (*Jasus edwardsii*). Both species of lobster have been extensively harvested since the first arrival of human-kind in the island chain that makes up New Zealand. For the indigenous Maori people, lobster became to hold special significance as an important coastal food item (kaimoana), as a trading item, and as an animal with spiritual values associated with it. Following European colonization in New Zealand there was some delay before the value of lobsters was fully recognized and commercial fishing expanded rapidly and dramatically reduced lobster populations throughout their natural range. This talk will share some of the history of lobster utilization in New Zealand and a few traditional recipes as well.

The long and winding history of the fishery, management and culture of European lobster (*Homarus gammarus*) in Norway [O40]

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The European lobster (*Homarus gammarus*) is found in Norwegian coastal waters from southeast at the Swedish border, north to near the Arctic Circle. Historically lobster has been important for the coastal culture. Originally it was described as sea monsters and utilized as fertilizer. Fishing commenced in the early 1600s, for export first to the Netherlands and then to England. A trial over prices and property rights of lobster ended in 1725 in a regulation making fishing in sea water common property rights. Since 1850 annual landings has varied from about 300 to 600 metric tons (t) until it peaked at 1 300 t in 1932, possibly partly driven by benign climate and increased market opportunities due to relax of the sales monopoly around 1920. Since the late 1960s, official landings have dramatically declined, and leveled out at 30 to 50 t since 1985. Nowadays unreported landings are estimated to be ten to 14 times higher than the official landings, mostly due to a widespread recreational fishery. Fishing regulation was introduced in 1848/9 with a closed summer season. In 1879, minimum legal size (MLS) was introduced, set to 21 cm total length (TL). MLS increased twice until set to 25 cm TL in 2008, along with protection of berried females. Substantial increase in landings has still not been observed. However, CPUE increased in small scale marine protected areas since implementation in 2006. To enhance depleted stocks, larvae and juveniles have periodically been cultivated and released locally since 1880. Experimental releases of one-year old juveniles resulted in substantial increase (up to 50 %) in landings in the release area.

Usage of lobsters in the Americas [O41]

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The continental shelves of the Americas host a very rich variety of lobster species, many of which are fished in some manner, though not necessarily commercially. These include 12 species of clawed lobsters, only one of which is shallow enough to be taken by ancient peoples; 13 species of spiny lobster, 11 of which are shallow; and 8 species of slipper lobster, 2 of which are shallow. Because the peopling of the Americas is relatively recent compared to Europe and Asia, there are few written records of ancient use of lobsters. Most of the written records come from European visitors and/or colonialists from the 1600's onward. Nevertheless, archaeological records demonstrate that lobsters may have been used very early by native peoples that occupied coastlines or nearshore islands. For example, lobster remains in middens on Block Island off the coast of Rhode Island show that local people were feeding on clawed lobsters nearly 2,500 year before present and many native peoples have a word for lobster (sometimes several words) in their language. Via both midden analyses, oral histories, artwork and written histories, it is likely that on the northeastern seacoast of North America the ancestors of the Manisseeans, the Mi'kmaq, and Wampanoags fished for clawed lobster while the Chumash on the west coast of North America and the Calusa and other southeastern tribes in the Gulf of Mexico fished for spiny lobster. Similar records exist for the variety of peoples occupying coastlines of South and Central America.

A historical overview of lobster use by pre- and post-Columbian cultures in the Caribbean and Mesoamerica [O42]

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The waters of the Caribbean Sea and Mesoamerica are home to several spiny and slipper lobster species that were of cultural significance to the economies and livelihoods of pre- and post-Columbian maritime civilizations. Mesoamericans, defined as a mosaic of pre-Columbian indigenous cultures including the Maya and Aztec, incorporated lobster as part of their diet and often in their material culture. Despite the patchy nature of information from other parts of the Caribbean, archeological evidence including mouth grinding plates, antennae, and other shell fragments excavated on the islands of present-day Turks and Caicos and Jamaica indicate the Caribbean spiny lobster (*Panulirus argus*) was a target species. These indigenous cultures (e.g., Tainos, Arawaks, Caribs, ~200-400 BCE) appear to have used a variety of fishing techniques to collect lobsters. The earliest reports for this are found at sites in both Montserrat (400-200 BCE) and Nevis (900-1200 AD). In the Turks and Caicos, it is likely that native cultures designed and constructed traps specifically for lobsters while the native Carib may have harvested lobsters from boats. Saladoid (Ceramic-age, ~500 BCE) peoples who radiated from present-day Venezuela maintained a variety of subsistence strategies including the fishing and consumption of spiny lobsters. Europeans, who began colonization in the 17th and 18th centuries, sought to further exploit marine resources and set the foundation for more intense lobster fishing in a pre-industrial society.



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Population and Community Ecology (2nd Part)

An analysis of spiny lobster movement patterns: A comparison of two *Panulirus argus* populations residing in the lower Florida Keys, Florida, USA [O43]

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We tracked the movements of adult and sub-adult lobsters in two locations in south Florida using acoustic technology. The first location is Western Sambo Ecological Reserve (WSER) south of the Florida Keys which contains many natural shelters. Over 100 lobsters were acoustically tagged from summer of 2003 to spring of 2007. The second location is in the Gulf of Mexico (GOM) north of the Florida Keys. We tagged 32 lobsters (summer 2011). This location is natural-shelter poor but contains numerous artificial shelters (casitas) used by lobster fishers. We found that the probability of lobsters shifting their denning location and distance moved was virtually the same in both locations. For example, the probability of a lobster shifting its denning location greater than 300 m was 10% in the GOM and 10% for similar sized lobsters in WSER. Although daily emigration rates were nearly identical, emigration directions were markedly different. All GOM lobsters migrated to the west (between 225 and 295 degrees) whereas in WSER, emigrations occurred in all directions except shoreward. Reproductive migrations which are nearly universal with egg bearing females in WSER were not present in two egg bearing females tagged in GOM. These results when integrated with earlier 1970's traditional tag recapture studies for growth and movement, suggest that lobster movement patterns observed in the GOM may be a consequence of much higher growth rates of juveniles in the northern half of Florida Bay resulting in large sub-adult lobsters migrating through the GOM location.

Interspecific shelter competition as a driver of juvenile spiny lobster abundance and distribution [O44]

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Interspecific competition can strongly influence the population dynamics of competing species. Observations have pointed to an inverse relationship in abundance between juvenile stone crabs (*Menippe mercenaria*) and juvenile spiny lobsters (*Panulirus argus*) in the hard-bottom habitat of the Florida Keys. It is primarily during their vulnerable juvenile stages that these species have similar shelter requirements. We explored this relationship using mesocosm experiments to determine competitive dominance and field experiments to determine the effect of stone crabs on lobster abundance and distribution. Our results showed that stone crabs are the dominant competitors regardless of the number of lobsters present, the presence of co-sheltering species such as the spider crab (*Mithrax spinosissimus*), or the order in which the competitors were introduced to the mesocosm. We also found that lobsters use chemical cues from stone crabs to detect and avoid them. Our manipulations of stone crabs in the field demonstrated that increased crab abundance resulted in decreased lobster abundance and increased aggregation. The opposite occurred on stone crab removal sites. Our study suggests that stone crabs can limit the availability of shelter to lobsters, potentially increasing lobster mortality or driving them to emigrate from the area. If shelter is extremely limited or stone crab recruitment is high, competition may contribute to a population bottleneck for adult lobster populations that could reduce recruitment into the fishery.

Natural ecological traps in Caribbean spiny lobster nurseries [O45]

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First described by terrestrial ornithologists in the 1970's, "ecological traps" are now a well-known phenomenon in terrestrial and freshwater ecosystems but are rare in the sea. The term refers to situations in which the evolved behavior of an animal that is normally advantageous becomes disadvantageous under another set of circumstances. It was first used to describe a situation in which the choice of nesting habitat by birds led to their reproductive failure because of anthropogenic changes in the environment. Although many ecological traps are anthropogenically induced, they need not be. Among the social spiny lobsters, the chemical odors produced by conspecifics are an irresistible siren's call that draws individuals together in dens for protection from predators. But in nursery areas, large dens occupied by large lobsters are a death trap for juvenile lobsters. Adult and subadult lobsters congregate in large dens, and their scent entices juvenile lobsters to join them from the surrounding nursery habitat. However, large fishes that are predators of juvenile lobsters are also attracted to those dens. Our field, mesocosm, and laboratory research demonstrates that small lobsters are absent near natural ecological traps because of increased mortality by piscine predators, which are undetectable by juvenile lobsters using chemoreception. An anthropogenic-induced parallel to this natural ecological trap exists when casitas are deployed in nursery habitats.

Reproduction, Development and Physiology

American lobster mating system: Limited mating opportunity and possible male preference for larger females [O46]

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Maintaining the reproductive capacity of any commercial stocks is a vital management objective to ensure sustainability. This implies knowing the size-at-50%-maturity (SoM50) and ensuring there are sufficient males to fulfill female reproductive potential. In the Bay of Fundy, lobster SoM50 was estimated at 108.1 mm CL in the early 1980s but the validity of this historical estimate has been questioned. Using unpublished data on ovary condition, cement gland development and presence of spermatophore from 1978-79 and 2011, we evaluate SoM50 for both periods, and estimate mating success among mature and immature females. We found that SoM50 in Grand Manan in 1978-79 was best estimated at 99.8mm CL, lower than the historical estimate. The SoM50 estimate for 2011 for Grand Manan (92.5 mm CL) was lower yet. SoM50 estimates for other areas of the Bay in 2011 were variable but greater than 92.5 mm CL. Mating ogives were shifted to smaller sizes compared to maturity ogives in both time periods and at all sampling sites. This provides persuasive evidence that immature females commonly mated. Mating rates were higher for mature females, but not all were mated. In 2011, mating success among mature females was considerably less than 100%, in contrast to the historical rates of 100%. A positive size-dependent relationship was also observed with mating success for both mature and immature females. These results raise questions about the lobster mating system, particularly the role of male choice. They highlight that low mating opportunities and/or male preference may limit egg production and affect SoM estimates.

Overwhelming odds? Male mating success when dwarfed or outnumbered by female partners [O47]

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Management measures in the U.S. American lobster (*Homarus americanus*) fishery include biological controls to conserve spawning stock biomass, such as protecting ovigerous females and v-notching. This differential protection for females ensures they experience higher survivorship than males once recruited to the fishery, resulting in increasingly female-skewed sex ratios particularly at larger sizes. This may affect reproductive output if females become sperm-limited due to insufficient appropriate mates. Two laboratory studies were conducted to examine male mating ability under certain conditions. The first study focused on whether males could successfully pass a spermatophore to larger females (males were $\leq 15\%$ smaller, 25-30% smaller, or $\geq 40\%$ smaller than their female partner). The second examined male mating success under the condition of female-skewed sex ratios (slightly skewed: 67% female; highly skewed: 86% female). Preliminary results suggest that both size discrepancies and female-skewed sex ratios might negatively impact reproductive success. In size trials, males $\geq 40\%$ smaller than their female partner only passed a spermatophore in 25% of trials. Those males $\leq 15\%$ smaller and 25-30% smaller successfully passed spermatophores to their partners (78% and 87% of trials, respectively), but males 25-30% smaller often did not completely fill the female's receptacle. Males mated with an average of 86% of females in the slightly female-skewed sex ratio trial, but only on average with 58% of females in the highly-skewed trial (density control trial average success was 93%). These data suggest that lobster management should consider both sexes if the goal is to conserve reproductive potential.

Robbing the cradle: Evidence of mating in immature, pre-reproductive, female American lobsters [O48]

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The American lobster (*Homarus americanus*) fishery is heavily dependent on female reproduction and an important metric used in management of this fishery is the size at which 50% of the females in the population reach sexual maturity. It is generally assumed that males defend mating dens, sequentially courting then mating with multiple females once they have molted. It is also generally assumed that the only females that mate are the ones that have mature ovaries capable of extruding fertilized egg clutches. However, recent data has suggested that some immature females might mate as well; this study was undertaken to test that hypothesis. We examined ~200 lobsters, ranging in size from 60-100 mm CL, collected from the Gulf of Maine, in New Hampshire coastal waters. Determination of sexual maturity was primarily based on ova size and color. As expected for animals from this area, 50% of the females examined were mature at ~83 mm CL. However, in every 5 mm size class more females were sperm positive (SP) (sperm in seminal receptacles) than were mature. This was due to immature females (small, white-yellow ovaries) in each size class being SP, and thus having mated. Interestingly, a higher percentage of immature females were SP in the larger size classes. The adaptive significance of mating by immature females, which does not yield successful reproduction, is not entirely clear. Moreover, given the potential for sperm limitation, it is odd that some mature females don't mate (~9% from this study), while their immature conspecifics do.

Resistance to starvation of first-stage juveniles of the Caribbean spiny lobster, *Panulirus argus* [O49]

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Non-feeding pueruli of *Panulirus argus* actively swim from the open ocean towards the coast to settle in shallow vegetated habitats, where they molt into first-stage juveniles after a few days. As pueruli presumably allocate most of their energy to swimming and preparing for the post-settlement molt, the survival of first-stage juveniles may greatly depend on resuming feeding as soon as possible. To test this hypothesis, we estimated the point of no-return (PNR₅₀: the time when 50% of initially starved juveniles lose the capability to recover even after subsequent feeding) of first-stage juveniles in the summer and winter. Experimental pueruli were obtained with collectors and transferred to seawater tanks. One day after molting into first-stage juveniles, 160 individuals were allocated among eight feeding treatments: daily fed, starved for 3, 6, 9, 12, 15, or 18 days but subsequently fed, and never fed. Intermolt periods increased with duration of initial starvation and were longer in winter than in summer. Irrespective of season, mortality increased sharply after 9 days of starvation and reached 90% after 18 days of starvation despite subsequent feeding. The PNR₅₀ did not vary with season, being 12.1 ± 1.0 days (mean ± 95% CI) in summer and 11.6 ± 1.5 days in winter. Results indicate that first-stage juveniles of *P. argus* can tolerate relatively long periods of starvation without suffering irreversible damage. The point of reserve saturation (PRS₅₀: the time when 50% of initially fed juveniles lose the capability to recover after subsequent starving) is currently being investigated.

The effects of cardio-ventilatory activity on the control of acute environmental thermal variations in immersed lobsters, *Homarus americanus* [O50]

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Ectotherms such as the lobster, *Homarus americanus*, that live in a constantly changing environment are subjected to variations in body temperature that can present metabolic and physiological challenges. Challenged with sudden or acute changes in ambient water temperature, the lobster has the capacity to change internal body temperature rapidly to match their environment using the efficient branchial heat exchange system. This research explores the extent to which *H. americanus* uses cardio-ventilatory activity to control the rate at which they change body temperature when exposed to acute changes in their ambient water temperature within the range of 2°C to 8°C, as experienced in the northwest Atlantic ocean during the Canadian lobster season. Comparisons between passive and active thermal equilibrium are reviewed and the implications on the thermal tolerance range of *H. americanus* in its natural environment and in the commercial environment are discussed.

Gastrolith development in European lobster *Homarus gammarus* juveniles during a moult cycle [O51]

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Gastroliths are calcium deposits found in some species of crayfish, lobster and terrestrial crabs. They are located in the cardiac stomach and are formed as paired semi-spherical discs between the epidermis and cuticular lining of the stomach wall. The calcium in these structures are secreted by the epidermis and stored as biogenic amorphous calcium carbonate, the most soluble form of calcium carbonate. In contrast to the solid calcium structures found in crayfish, gastroliths in lobsters consist of many small irregularly shaped milk-white crystals. The composition of the gastroliths is similar to the exoskeleton, but in different proportions. Components found in *Homarus americanus* gastroliths are magnesium, phosphate, aluminium, iron, silicon, chitin and proteins. In the freshwater crayfish *Orconectes virilis*, gastrolith development has been documented throughout the moulting cycle using X-ray radiography. To our knowledge no such study has previously been conducted in lobsters. In 2013, 30 juveniles (19-22 mm total length) were used to study gastrolith development throughout a moulting cycle of 28 days in European lobster *Homarus gammarus*. Juveniles were sampled at specific times in the moulting cycle (hours/days since moulting), stored in ethanol and gastrolith development was recorded by X-ray radiography. The radiographs showed that the gastroliths dissolved within 12 hours post ecdysis, reappeared at about day 17, and increased in size until next moulting. More research on gastroliths and their function in the moulting cycle is needed. Such knowledge can be significant when predicting if and how lobsters will adapt to pollution (e.g. louse treatment) and climate change (e.g. ocean acidification).

The associative behavior of phyllosomas with jellyfish [O52]

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Phyllosomas of slipper (scyllarid) lobsters are widely known to associate with gelatinous zooplankton such as jellyfish and salps in natural waters. It is suggested that phyllosomas may utilize gelatinous zooplankton as food, transport, and shelter; however, information concerning this association behavior is limited. In the present study, we observed the behavior of phyllosomas associating with jellyfish in two *Ibacus* species. Phyllosomas appeared to recognize jellyfish by the sense of touch. Although capable of attaching to any part of the jellyfish body, phyllosomas eventually positioned themselves on the exterior of the jellyfish bell. They then started feeding on the tentacles and oral arms of the jellyfish. This series of associative behaviors implies that phyllosomas are capable of rapidly identifying components of the jellyfish body and then deciding on the position that enables them to stay on the jellyfish. In addition, we observed that phyllosomas did not always feed on jellyfish, but sometimes only clung onto jellyfish as they drifted, suggesting that phyllosomas may utilize jellyfish for transport as well as for food. Phyllosomas demonstrated similar behaviors on several jellyfish, regardless of differences in size and species. To overcome the challenges of long-term planktonic life in the open ocean, phyllosomas may have evolved the ability to associate with jellyfish.

Connectivity and Larval Studies

Settlement behavior of American lobster (*Homarus americanus*) postlarvae: effect of stock origin and incubation temperature [O53]

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The settlement success of the American lobster postlarvae is a key factor in the study of population dynamics and stock management. Water temperature is a factor that could limit the establishment of postlarvae on the seafloor mainly with the presence of an important vertical stratification. The spatial distribution of this species allows its pelagic larvae to encounter heterogeneous thermal zones. However, very few information is available on the occurrence of a local adaptation for stocks and their ability to cope with temperature acclimation during larval development. The main objectives of the experiments are to characterize: 1) The settlement behavior of the larvae in relation to the incubation temperature and the origin of the stock; 2) The behavioral responses of larvae in the absence/presence of a thermocline. The resulting behavioral modifications will have ecological implications for larval dispersion and population connectivity. This will also provide relevant data for the lobster industry in relation to enhancement procedures.

The effect of sedimentation on the settlement behavior of the American lobster (*Homarus americanus*) [O54]

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Low recruitment of lobsters in the Northumberland Strait combined with an important commercial fishery contributed to the decline of existing populations. Questions were raised by stakeholders in eastern Canada on the effect of habitat modifications on recruitment processes. Most benthic invertebrates have a life cycle involving a pelagic dispersal phase followed by a benthic settlement phase. The transition between these phases is critical to the American lobster (*Homarus americanus*). Of the various factors that may affect larval deposition the effect of substratum modifications, due to sedimentation, on larval behavior is investigated. Sedimentary regimes can be severely affected and ultimately impede lobster recruitment. The main objective of this study is to quantify how different thickness of fine sediments over preferred substrate will affect the larval behaviors involved during settlement. Experiments carried out included behavioral observations over various types of substrates (single- vs multiple-choice experiments) and lipid measurements to standardize behavioral responses.

The effect of temperature, light and flow condition on the swimming ability of American lobster (*Homarus americanus*) larvae [O55]

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The planktonic larval phase of the American lobster is arguably the most complex and least understood of its life history stages. The relative paucity of larval behavioural data limits the capacity of biophysical models to predict dispersal accurately, particularly at small spatial scales. We investigated the behavioural capacities of larval *Homarus americanus* (stages I-IV), from two source populations, in vertical columns and horizontal flume chambers. Our nested experimental treatments varied temperature (10, 15 and 20 °C), light (0, 50 and 100% peak UV), and horizontal flow velocity (0-10 cm/s). Both temperature and light significantly affected rate of movement for all larval stages, but effects varied among stages and natal origin. We observed marked decreases in swimming activities in intermediate larval stages for both vertical and horizontal planes relative to early and late stages. Our data offers a new assessment of larval American lobster behavioural capacity and temperature dependence, thus providing a platform for the incorporation of behaviour into biophysical models. Accurately resolving pelagic dispersal represents a primary step towards understanding spatial linkages between adult spawning and larval recruitment.

First estimates of potential large-scale spatial connectivity of American lobster fisheries in eastern North America via larval drift [O56]

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American lobster (*Homarus americanus*) larvae are planktonic, drift with ocean currents for days to weeks before settling, and may end up settling in areas far away from where they originate. This means that different areas may depend on one another for their supply of lobster larvae, and may be parts of larger biological units. Potential spatial connectivity of lobster fisheries in eastern North America by larval drift has previously been investigated using bio-physical individual-based models coupled to regional hydrodynamic models. In the present study a new modeling system, incorporating the Atlantic Shelf of North America from Cape Cod, MA to the Strait of Belle Isle, Newfoundland, was used to investigate potential spatial connectivity of lobsters at a spatial scale larger than attempted previously. Drift of larvae between hatch and settlement across the model's domain was simulated, and then used to estimate proportional export and retention of larvae among and within different fisheries management areas. Model results, thus far based primarily on physical forcing (currents, temperatures, etc.), have demonstrated much connectivity between fisheries within and among different regions of eastern North America. The model also predicted that certain areas might retain most of their own larvae, while other areas may export a large portion of their larvae and depend on external sources for most of their larval supply. This information will be important to lobster fisheries management, as the amount and direction of connectivity between fisheries can be used to derive cooperative management strategies to ensure sustainability of interconnected fisheries.

Connectivity patterns in six lobster species at remote islands, seamounts and shelf habitats in the SW Indian Ocean and South Atlantic [O57]

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Lobsters are excellent models for studying the influence of ocean processes on gene flow, because they have restricted benthic distribution patterns, and drifting larval lifespans that range from a few hours or days in some clawed lobsters (Nephropidae) to many months at sea in spiny lobsters (Palinuridae). Recent studies of genetic connectivity of five spiny and one clawed lobster species in the SW Indian Ocean and South Atlantic, combined with life-history and oceanographic information, have suggested great contrast in inferred dispersal patterns, and also questioned the taxonomic status of previously-recognized species. An apparent lack of barriers to dispersal and gene flow over thousands of kilometres of southern waters indicates that *Jasus paulensis* (St Paul and Amsterdam Islands; SW Indian Ridge seamounts) and *J. tristani* (Tristan archipelago, South Atlantic) should be synonymised as *J. paulensis*. Three closely-related *Palinurus* species have evolved in the SW Indian Ocean; two occur along the continental shelf-edge of SE Africa, where panmictic (*P. gilchristi*) and genetically structured (*P. delagoae*) populations are maintained through the inter-relationship of strong directional currents, eddies, hydrographical boundaries, and life-history adaptations such as long-distance migrations. *Palinurus barbarae* appears to be widely distributed on SW Indian Ocean seamounts. The clawed lobster *Metanephrops mozambicus* (short larval development) exhibited genetically well-structured populations over short geographical distances along the coasts of Mozambique, Madagascar and South Africa. Based on genetic data, recent demographic expansion (<25,000y ago) was observed for most species, confirming that the last glacial maximum had a major effect on lobster taxa in southern waters.

Hot n' hungry lobster larvae: Can a warming ocean explain a decline in spiny lobster recruitment? [O58]

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Changes in the offshore oceanographic processes are suspected to be the cause of a recent dramatic decline in the settlement of post-larvae of the Western Australian spiny lobster (*Panulirus cygnus*), which has greatly reduced the productivity from the world's second largest spiny lobster fishery. This study assessed whether there are differences in the nutritional condition of the larvae of *P. cygnus* sampled from two pairs of anticyclonic and cyclonic eddies, that may provide new insights into the role of eddy systems in the subsequent survival and settlement of post-larvae. Morphometric and biochemical analyses were undertaken of the mid-late stage larvae sampled from two pairs of adjacent counter-rotating mesoscale eddies in the Leeuwin Current off Western Australia found marked differences in the nutritional condition of larvae between cyclonic versus anticyclonic eddies. On average this difference amounted to 53.0±8.7% more energy per larva (i.e., 80±10 J) which has the potential to make a large difference in the prospects for successful cross-shelf migration by the post-larvae. These differences could not be explained by differences in diet as assessed by examining larval gut contents using specialized molecular genetic methods. Warmer water temperatures associated with anticyclonic eddies may be exceeding the temperature optima required by the larvae to accumulate nutritional reserves. The results suggest that the larval physiology and ecology of spiny lobsters are vulnerable to changes in oceanic climate that are associated with recent marked declines in recruitment to valuable spiny lobster fisheries around the world.

Caribbean spiny lobster larval connectivity: the "Holy Grail" for management of an iconic species [O59]

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Predicting the oceanic dispersal of the planktonic larvae that connect disjunct marine populations is difficult, especially for species such as spiny lobster whose long-lived larvae do not recognize geopolitical boundaries. Yet, understanding the connectivity of lobster metapopulations among often far-flung regions is crucial to the sustainable management of lobster fisheries. For example, larvae of the Caribbean spiny lobster (*Panulirus argus*) dwell in the oceanic plankton for 6 - 8 months and potentially disperse throughout the Caribbean where fishers in 38 countries vie for this valuable species. We used multi-scale biophysical modeling coupled with empirical estimates of larval behavior and gamete production to predict and empirically verify the spatio-temporal patterns of larval connectivity throughout the Caribbean from Venezuela to Florida. We also explored how various spatial arrangements of marine protected area networks (i.e., random, stratified random, self-recruitment, long-distance dispersal, maximum export) influence the recruitment of lobsters in the Caribbean. MPA sites selected at random resulted in lower Caribbean-wide recruitment than those whose locations were chosen based on their merit as international or domestic larval exporters. Somewhat fortuitously, we discovered that certain supposed larval dispersal corridors actually lead to "larval oblivion", whereas other pelagic realms are larval nurseries worthy of protection. Our findings reveal the long sought sources, sinks, and dispersal corridors of *P. argus* in the Caribbean – information that represents the "holy grail" for the proper international management of this iconic Caribbean species.

Genetics

Evidence for population structure of the southern rock lobster, *Jasus edwardsii*, around southern Australia [O60]

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The southern rock lobster, *Jasus edwardsii*, is a species of economic importance in Australia and New Zealand. Due to the extended pelagic larval stage of *J. edwardsii*, there are predictions of extensive gene flow between sub-populations throughout its geographical distribution. Understanding the degree of gene flow and population structure is essential in determining population boundaries, as well as sources and sink of larvae and will ultimately help making managerial decisions about fishing effort. The aim of this study was to investigate connectivity of populations of *J. edwardsii* on the east coast of Tasmania, Australia, using next generation sequencing (NGS). Three locations, with 3 sites within location, were surveyed using a hierarchical sampling design. Baited pots were deployed at each site and left overnight. Pots were collected the following day and lobsters were removed manually from them. Carapace length of all lobsters was measured and a pleopod clip was cut for subsequent genetic analysis and preserved in ethanol. DNA was extracted from pleopod clips and subject to a double-digest RAD sequencing (ddRADseq) in order to prepare a nucleotide library. DNA was sequenced under MiSeq to obtain single nucleotide polymorphisms (SNPs). Genetic differentiation was determined by examining the proportion of variance in allele frequencies between locations relative to the total variance. Here I will present an overview of my PhD research as well as preliminary data evidencing population structure in *J. edwardsii* populations on the Tasmanian east coast.

Genomics as a powerful tool in the management of the American lobster fishery [O61]

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A major goal in fisheries management is to define demographically independent populations and assess their connectivity to delineate management units. However, most marine populations exhibit complex demographic patterns and pronounced potential for dispersal, making it difficult to decipher population structure with only a few genetic markers. To address this challenge, we performed an extensive genomic study on the American lobster (*Homarus americanus*). We genotyped 5859 single nucleotide polymorphism markers (SNPs) on 651 individuals from 19 sampling locations distributed along the North Atlantic coast. We found regional scale structure and signs of historical separation among northern and southern populations. We also discovered weak but highly significant genetic differentiation among sampling locations (P-value<0.0001) and were able to assign individuals to local populations with very high success, that is 89% on average. Our results provide strong evidence for genetic differentiation among sites at a relatively small geographic scale, which is in contrast with results obtained previously based on a small number of microsatellite markers. However, fine scale structure is in accordance with the homing behavior and the restricted movement of American lobsters (<70 km) observed by several tagging studies. Overall, our genomic data have provided important insights into lobster biology, which will aid in the creation of sustainable management practices. In addition, we found that assignment test can be used to estimate dispersal and will be a promising new approach to defining management units as well as potentially assessing the traceability of origins of lobsters sold on the market.

Using genetic markers to investigate population ecology for lobster stock enhancement [O62]

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Widespread stock enhancement for the European lobster (*Homarus gammarus*) is currently hampered by a lack of studies on the ecology of wild populations, and of comprehensive assessments into the impacts of stocking. Data for stocking impact assessments relies on identifying cultured individuals recaptured after release into the wild environment, but such evaluation of lobster stocking has been inhibited by largely unsuitable or unproven physical tagging methods. Parentage assignments via genetic markers have important benefits over established lobster tags, potentially eliminating the need for expensive hatchery on-growing, lethal sampling, and much of the error from tag loss. For other marine species, genetic markers have been used to provide multi-generational insights into the recruitment success of released individuals, as well as long-term genetic effects of hatchery stocking on the target population. Using 16 polymorphic microsatellite loci, a regional population of *H. gammarus* currently under enhancement in Cornwall, UK, has been surveyed to assess whether population genetic structure supports current rearing and release strategies. The same loci have also been used to estimate the extent of multiple paternities in Cornish lobsters, and preliminary findings from these ongoing studies are presented. These studies are not only significant to improving our knowledge of *H. gammarus* population biology, but can also facilitate evaluations of whether genotyping can enable the identification of cultured individuals in the wild, in order to better appraise the effectiveness of stocking in providing benefits to fisheries and conservation of lobster populations.

The presence and role of Cryptochrome in the CNS of the American lobster [O63]

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Adult American lobsters, *Homarus americanus*, express a circadian rhythm of locomotion, with a preference for nocturnal activity. Most, if not all, circadian rhythms of this nature can be entrained by light:dark cycles, and often the photoreceptors involved are not the same ones used for normal vision. One light sensitive molecule that is known to mediate the entrainment of daily rhythms is cryptochrome (CRY). Interestingly, in some species such as *Drosophila*, CRY is located in clock neurons, where it entrains rhythms by influencing the daily cycling of known clock proteins. Recently, we sequenced lobster homologs of a number of clock proteins, including CRY. As expected, lobster CRY is very similar in structure to the CRYs previously sequenced in other crustaceans, such as *Euphausia*, and it appears to fall into the CRY2 family. We also used antibodies against CRY to localize CRY-immunoreactive neurons throughout the CNS, including the ventral nerve cord. Finally, we tested the hypothesis that CRY neurons in the ventral nerve cord might be part of an extra-ocular photoreceptor system that could be used to entrain lobster activity to the light:dark cycle. While it is clear lobsters have at least one form of CYR, it remains to be seen whether lobster CRY is involved in both central and peripheral circadian clocks and/or if it serves as an extraocular photoreceptor to help lobsters entrain their activity to natural light:dark cycles.

Homarus hybrids detected in Norway – First evidence for interbreeding between introduced *Homarus americanus* and the local species, *Homarus gammarus* [O64]

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Live lobsters *Homarus americanus* have been imported into Europe for commercial purposes for many decades. Individuals are often kept in cages where escapes have been reported on a number of occasions. In Norway, *H. americanus* were first caught as part of the local European lobster *H. gammarus* fishery in 2000. Since that time, an annual monitoring program has been carried out in cooperation with local fishermen to measure the extent of the issue. Development of diagnostic microsatellite DNA profiling methods was necessary for correct identification to species, as some overlap occur in morphological characteristics. During the past ten years of monitoring, 93 lobster specimens with unusual morphology were caught, and 24 identified to the *H. americanus* species by DNA profiling. Of particular relevance was the presence of a berried (with fertilized eggs) *H. americanus* caught in the Larvik region in autumn 2009. This female was transported alive to the hatchery facilities at Institute of Marine Research in Bergen for closer examination (shell disease). Further DNA profiling of the female in addition to a sample consisting of her fertilized eggs, revealed surprising results: for all diagnostic marker loci examined, the male fragment sizes detected in the eggs have only been found in specimens of *H. gammarus*. Hatching of the additional eggs in the laboratory and further DNA profiling of larvae and juveniles confirm that the offspring were hybrids between the two species. This is the first report of successful interbreeding in the wild environment between an introduced *H. americanus* female and the local *H. gammarus* male. The *Homarus* hybrids are now raised under hatchery conditions for further comparative studies.

Aquaculture, Nutrition and Population Enhancement

Suspension feeding by larvae of American lobsters (*Homarus americanus*) [O65]

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American lobster larvae are thought of as raptorial feeders, which see their prey, capture it with the feeding appendages, and then ingest it. In this experiment, larvae in stages I and III, and postlarvae of stages IV/V were suspended for 23 hours in water containing microscopic 1 μm , 6 μm , and 10 μm fluorescent microspheres. Specimens were preserved and subsequently examined using fluorescence light microscopy and scanning electron microscopy. Microsphere clusters were found in the stomachs and intestines of the larvae examined, showing that the microspheres were removed from suspension, ingested, and concentrated in the digestive system. This research suggests that *Homarus americanus* larvae may possess a filtering mechanism and that they may not rely solely on raptorial feeding. It implies that they may be capable of feeding on suspended natural particles that are too small to see, such as single-celled algae and other microplankton in their environment.

New developments in lobster resource enhancement in Atlantic Canada through stage IV larvae release [O66]

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Our group has been working on American lobster (*Homarus americanus*) enhancement since 2002. At the last international conference in 2011, the results regarding the important first steps of the project that allowed us to now release more than 300,000 stage IV post-larvae every year in Atlantic Canada were presented. This initiative is led by Homarus Inc., a non-profit organization comprised of several partners from the public and private sectors, in collaboration with the Coastal Zones Research Institute (CZRI). In order to continue the development of a simple and cost-effective hatchery technology which would enable community-based fishermen groups to pursue their own stocking efforts, important and innovative R&D activities were held. This presentation will give an update of the R&D activities and outcomes of the project carried at the CZRI since 2011. Results associated with the development of specific rearing and transportation techniques, as well as results obtained from trials on light regime and green water will be presented and future research avenues will be discussed.

Development of formulated feeds for intensive farming of European lobster *Homarus gammarus* [O67]

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European lobster (*Homarus gammarus*) is one of the most valuable seafood in the world. The main obstacle for lobster aquaculture has been the high production costs due to their cannibalistic nature. While there have been promising developments towards land based farming, the lack of nutritionally balanced feeds is still one of the limiting factors. Studies were performed to quantify energy and protein needs in growing lobster (initial sizes 1g, 3g and 30g at 18°C) as the sum of maintenance plus growth. Requirement for maintenance is considered a function of lobster size and temperature and requirement for growth is dependent upon the weight gain and its energy and protein content; in addition, utilization efficiencies of energy and protein deposition have to be considered. The consequence of this approach is that daily protein and energy needs are expressed primarily in terms of absolute demand per body mass and anticipated daily weight gain and only secondary as inclusion level in the feed. Maintenance requirements and efficiencies of energy and protein deposition were determined by feeding groups of lobsters at increasing levels from zero to maximum feed intake. Maintenance requirement was determined at a level where energy and protein balance was zero. Energy and protein gains were measured by comparative body analysis and utilization efficiency established via the relationships between energy intake and gain and protein intake and gain respectively. Using these values together with a suitable growth prediction will allow set up of feeding tables for *Homarus gammarus* culture.

An overview of the American lobster (*Homarus americanus*) stock enhancement program in southern Gaspé, QC, Canada [O68]

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In 2010, after 2 years of small-scale production of American lobster (*Homarus americanus*) in hatchery, the RPPSG, a non-profit association of lobster fishermen, has undertaken a stock enhancement program to achieve higher release of hatchery-reared American lobster in southern Gaspé, Québec, Canada. Using the culture method developed in Maine (USA), lobster larvae were produced in strongly aerated 450 L conical tanks filled with green water and fed live *Artemia* (< 24 h). Larval growth was comparable from one year to another and larvae reached stage IV after 11-12 days at 18-20 °C. However, their survival differed considerably between years, even more between batches within the same year. Best batch showed a 76 % survival while no survival was often seen, for a yearly average going from 10.6 ± 1.2 % in 2012 to 16.1 ± 4.4 % in 2010. Still, using the Aquahive system (Shellfish Hatchery Systems Ltd, UK) to grow postlarvae, production has increased from 20 000 stage IV released in 2010 and 2011 to 60 000 lobsters released at stage V in 2012. The success of these releases was assessed using a Before-After-Control-Impact (BACI) approach. Results indicated a short-term pulse effect in 2010 and 2012, but no effect in 2011. Other methods are now considered to better evaluate the success of these stock enhancement efforts, such as marking larvae with ¹³C and genetic sequencing. Also, experimental trials are done to stabilize survival through a better diet and to achieve the goal of releasing annually 100,000 stage V lobsters.

Stocking density of European lobster (*Homarus gammarus*), implications for restocking and sea ranching [O69]

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The European lobster (*Homarus gammarus*) has traditionally been regarded a valuable marine resource, and has supported the Norwegian coastal fishery for several centuries. The collapse of the fishery along with sustained failure to recover renewed the interest in restocking and sea ranching. Knowledge of the early benthic stage of European lobster is limited, however crucial for restocking and sea ranching. During a period of four years a series of experiments were run to study juvenile stocking density under controlled conditions. Previous studies on the early benthic phase indicated preference to settle in a complex substrate of sand/cobble. Pelagic stage IV larvae were released at densities of 10 to 40 per m² into tanks with shell sand and shelter. Within a few days after release the larvae settled. In general only one juvenile was found inside a shelter. During the course of the observation period of eight months the juveniles changed shelter several times. Survival decreased the first 20 days, and thereafter stabilized. After eight months, the density varied from 8 to 20 juveniles per m². Highest mortalities were found in the experiments with highest stocking densities. There were indications that the carrying capacity had not been reached in the experiments with lowest stocking density. These results should be considered when designing restocking and sea ranching strategies.

Sea based container culture: potential for use in rearing *Homarus gammarus* in South West England [O70]

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This three year (2011-2013) field experiment consisted of three discrete investigations, considering six potential sites for rearing juvenile *H. gammarus* around the Cornish coast (U.K). Between May and August 2011 two sites off the South coast of Cornwall were selected to assess the effect of site and rearing depth on growth (CL - carapace length) and survival (%) of stage IV post larvae. One estuarine (River Fal) and one sea based (St Austell Bay) site were assessed with containers suspended at two depths from the surface (2m and 8m). Greatest survival was found at the St Austell site with containers suspended at 8m providing significantly greater survival and growth rates. Between May and August 2012 one estuarine (Fowey) and two sea-based (St. Austell Bay and St. Mawes) sites were selected to assess the effect of site and shelter on growth and survival of stage V post larvae. Sea rearing at St. Mawes showed the highest survival (93%), with St. Austell Bay and Fowey also producing good survival (66% and 76% respectively). Survival was also increased in experimental containers compartments with in-built shelter, though no significant differences in growth were found with either shelter availability or between sites. Between August 2013 and December 2013 a third investigation tested a sea bed based mooring system and assessed two sea based sites on the North coast of Cornwall (one onshore and one offshore) in comparison to the previously tested South coast St Austell Bay site. Survival was greatest at the St Austell Bay site (86%) with the suspended container mooring design, though growth at the onshore site was significantly greater than all other sites.

Culturing the European spiny lobster, *Palinurus elephas* [O71]

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Following decades of severe overfishing the European spiny lobster, *Palinurus elephas*, is considered as a residual species throughout much of its former range (Lock, 2010). Apart from its economic value, *P. elephas* is a top reef predator with high ecological significance. It is a key focus of the marine UK Biodiversity Action Plan (BAP) species list and in Wales it is important in the context of attaining Good Environmental Status for Welsh waters under the Marine Strategy Framework Directive. During 2013 pilot larval culture trials were performed with some financial support from Natural England, UK. Important progress was made in relation to broodstock management, larval tank design, water quality requirements and optimal culture conditions for the phyllosoma. A feeding strategy was identified to support phyllosoma development with shorter inter-moult periods giving an overall 11% reduction in time to Stage VI and with improved survival compared to the earlier studies of Kittaka et al. (2002). On behalf of its sister company, Seiont Research Ltd, RASAR secured funding in 2013 from the European Fisheries Fund and Welsh Assembly Government to develop a purpose built laboratory for *P. elephas* research. The ultimate objective is to develop hatchery culture of this species to evaluate the long term potential for initiating restocking programmes or on-growing *P. elephas* to market size using water treatment technologies developed during the last 12 years for land based finfish production. A parallel programme has been initiated to develop improved feeds for *P. elephas* phyllosoma based on feeding behaviour observations during pilot trials.

Improving feed reception and larval survival through use of scyphozoan medusae as feed in scyllarid larviculture [O72]

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The sand lobster *Thenus unimaculatus* is caught predominantly by trawl nets operated in the coastal waters along the Indian coast. The species which inhabits soft sediments and flat sea beds, has become easy prey to over exploitation by trawlers. Aquaculture prospects for this species are good, since larval development in captivity has been achieved and fattening trials in indoor rearing systems have shown good growth rates. However, feed and disease, particularly during the larval phase remain major bottlenecks in establishing a viable hatchery technology for lucrative mass production. The primary requisite for improving larval survival particularly in the late phyllosomal stages is to identify or develop balanced diet and feeding strategies. The use of the estuarine jellyfishes, *Acromitus flagellatus* and *Crambionella stuhlmanni* as feed to the phyllosomal stages, feed reception and larval conversion rates at different stages were assessed. The texture of these jellyfish is gelatinous, comprised of 94-95% (w/v) water and suited to the feeding behaviour of the larvae. The newly hatched phyllosomal stages showed instant reception and continuous feeding for more than six hours. Faecal strand width at the exit point and the ratio of gut width to abdomen width were higher than observed in phyllosomas fed with clam meat. The reception shown by stage two phyllosomas was comparatively lower initially. These jellyfishes are persistent invaders of the saline creeks and barmouths of estuarine systems along north Tamil Nadu coast in India, and the current investigation could possibly highlight a utility purpose for these species.

Can larval culture vessel surfaces influence the diversity of bacterial biofilms in spiny lobster culture? [O73]

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Research into closed life cycle spiny lobster aquaculture has been consistently impeded by disease during the larval phase. The scope of these diseases extends from the proliferation of external bacterial fouling organisms that compromise phyllosoma feeding capacity and health to the degradation of the internal organs by specific bacterial species. Much of the seminal larval research conducted on spiny lobster species has been in the presence of antibiotics allowing the influence of bacterial pathogens to be suppressed while important data is collected; this will not be commercially sustainable. One of the repositories of bacterial pathogens is the biofilm that quickly establishes on tank surfaces, it is typically comprised of numerous bacteria genera fixed to surfaces by a polysaccharide matrix that continuously seeds pathogens into the water column. We conducted a study where temperate spiny lobster phyllosoma were cultured in vessels with a range of trial biofilm inhibition surfaces (cold sprayed Cu and Zn, and TiO₂ UV irradiated surfaces and associated blanks). Phyllosoma survival and growth were negatively affected by the cold spray surfaces, there were no detrimental effects of the TiO₂ UV irradiated or blank surfaces. During the four week study detectable heterotrophic bacterial growth on the surfaces was in the range of 1 x 10²-10⁴ CFU's per cm². Bacterial proliferation was highest on some of the biofilm inhibition surfaces, particularly the Zn surface. All surfaces developed biofilm communities distinctly different both among and within surface comparisons; surface roughness did not appear to have a large impact on the communities developed.

Impact of technology transfer on development of lobster farming in Indonesia using Vietnamese practices [O74]

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Lobster farming is a successful and sustainable aquaculture industry in Vietnam, which primarily benefits impoverished coastal communities. The industry is reliant on naturally settling pueruli which are seasonally abundant along the coast of Vietnam, and which are caught by fishers using specific techniques. Since 2004, lobster farming has established in Lombok, Indonesia, where a resource of naturally settling seed is likewise available, but farming practices are sub-optimal. For every puerulus captured in Vietnam, \$65 is returned, while in Indonesia it is \$3. There is scope for the Indonesian return to be increased, with improved farming methods. A study tour of Indonesian lobster farmers was conducted to assist in the transfer of best practice technologies. In the 12 months since the tour, it is evident that practices have improved and particularly the seed catch rate. The application of lights to attract pueruli to catching devices appears to have quadrupled the catch rate. Total catch for the past 12 months in Lombok is estimated to be more than 2.5 million pieces, up from approximately 600,000 pieces caught per year for the preceding 5 years. This increased catch has not yet translated to increased farm production, as demand for the seed from neighbouring countries is strong and prices are increasing. Consequently, the return per seed caught has dropped, and the challenge now is to improve puerulus survival and growout production to stimulate more farmers to enter the industry and expand, to ensure the benefits are maximised and seed resources are retained in Indonesia.

The effect of trap type and depth on catch rate of puerulus collectors in the spiny lobster aquaculture industry of Indonesia [O75]

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Commercial fishery production of spiny lobsters throughout the world is stable or in decline. Aquaculture is one of the viable strategies to supply the increasing demand for this valued seafood. However, the availability of the lobster seed is limited by farmers' lack of skill in catching and handling pueruli, and suitable grow-out technology. In Lombok, a viable puerulus fishery has been established supporting a local lobster grow-out industry. By understanding the habitat and environmental conditions conducive to puerulus settlement, other locations in Indonesia may be identified where puerulus fishing and lobster aquaculture could be established, and catch rates will be maximised. Anecdotal evidence suggests depth may be an important factor in maximising catch of the collecting equipment used. This paper reports on an experiment which examined the effect of depth and trap type on the effectiveness of puerulus collectors in the wet season, when the pueruli abundance is greatest. Four trap types were deployed at 5 depths, with 5 replicates of each. The depths at which these were deployed comprised; i) at surface, ii) 1m below surface, iii) 2m below surface, iv) 1m above sea floor and v) touching the sea floor. The puerulus collectors were positioned at a location in southeast Lombok known to support good puerulus catch. A two-way ANOVA analysis was used to analyse the effect of depth and trap type. The results will be used to define best management practise in the catching and handling of puerulus to enhance the productivity of lobster farming in Indonesia.

Potential environmental impacts from sea-cage aquaculture of tropical spiny lobster (*Panulirus ornatus*) [O76]

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The tropical spiny lobster, *Panulirus ornatus*, is a commercially important and highly-priced aquaculture species in the Asia-Pacific region. They are usually farmed in floating sea-cages situated in shallow coastal waters. This aquaculture activity is rapidly expanding, yet very little is known about the potential environmental impacts on the seabed as well as surrounding water quality. This study uses both laboratory measurements and computer modelling in an attempt to begin to understand the patterns of faecal deposition and dissolved inorganic nitrogen (DIN) dispersal from hypothetical sea-cage aquaculture of spiny lobsters being fed two different diets (natural and artificial diet). Modelling scenarios were set up with two different stocking densities (3 and 5 kg m⁻³) and feed conversion ratios (FCR = 3 and 5). Computer modelling results showed that faecal deposition varied between 0.1 and 0.8 kg C m⁻² yr⁻¹, while elevated DIN ranged from 5 to 9 µg L⁻¹ depending on the combination of stocking density, FCR values, and the type of diet. The effects from spiny lobster aquaculture were spatially localised with highest concentration of faecal deposition and elevated DIN directly beneath the sea-cages. Based on the hypothetical scenarios, it seems spiny lobster aquaculture in sea-cages is not likely to cause detrimental effects on the environment unless spiny lobsters are stocked at high densities and are feed with diets with poor FCR.

Rearing, ongrowing and harvesting of Caribbean spiny lobster (*Panulirus argus*) in a marine farm in Cuba [O77]

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An experimental marine farm for rearing and ongrowing of Caribbean spiny lobsters (*Panulirus argus*) was installed in Carahatas Bay, Villa Clara, Cuba, through a cooperation agreement between Vietnam and Cuba. The first operation of the farm began in April 2012, when about 30 kg of juvenile lobsters were introduced into three ongrowing cages. Thirteen months later (June 2013), 289 kg of commercial-size lobsters were harvested, with an average individual weight between 400 and 525 g. An initial mortality of 10% occurred due to capture and handling stress, but survival rate throughout the ongrowing period was 80%. The value of the food conversion factor (CF), based on wet weight, was 15. Growth rate (von Bertalanffy's k) was higher ($k = 0.34$) than previously reported for commercial-size lobsters ($k = 0.24$ on average). Upon harvesting, over 82% of all lobsters had reached commercial sizes and several females exhibited spermatophores and egg masses, indicating that the quality of life for lobsters in the ongrowing cages was adequate. These results show the feasibility of the Vietnamese experience on spiny lobster ongrowing as applied to *P. argus* in Cuba.

The New Zealand Scampi (*Metanephrops challengeri*): A new aquaculture challenge [O78]

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A new aquaculture program investigating the potential of the New Zealand Scampi (*Metanephrops challengeri*) was initiated in early 2014. This species has never been the subject of aquaculture research, so there is limited understanding of the husbandry and behavioural requirements of the species in captivity. In this six-year research program, wild-caught scampi, 85% of which are females carrying fertilised eggs, will be harvested as brood-stock for the research in a purpose-built land-based scampi system. We have drawn on research carried out on similar species to design our systems and procedures. A recirculating aquaculture system was completed at the end of March 2014 and is currently housing 50 wild-caught females in individual chambers. Each female is holding fertilised eggs at varying stages of development. Two methods have been used to obtain larvae. Firstly, leaving the females to tend to the eggs until they hatch, and secondly physically removing the eggs and rearing them in upweller systems. The eggs have hatched using both methods, with the first larvae produced in April 2014. We will present early husbandry and behavioural information generated to date. [This aquaculture research program is part of a larger program on the scampi fishery in New Zealand (see Ogilvie, S. this conference)].

Fisheries and Fisheries Technology

New approaches to fishing for Scampi (*Metanephrops challenger*) in New Zealand [O79]

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Maori, the indigenous people of New Zealand, have always fished, and fishing traditions have been passed down through generations. Such traditions are part of a wider body of indigenous knowledge, known in New Zealand as mātāuranga Māori. The Maori-owned Waikawa Fishing Company Ltd are concerned that existing scampi (*Metanephrops challenger*) fishing methods may not be sustainable. They see a timely need for innovative ways of managing the fishery, and one approach is to solidify the links between what are often considered two distinct bodies of knowledge: mātāuranga Māori and applied fisheries ecology. In a newly-launched research programme, we are investigating two new fishery approaches. Firstly, we will investigate innovative potting technologies, with origins in mātāuranga Māori, as a potential alternative to conventional trawling methods. Secondly, wild-caught female scampi carrying fertilised eggs will be harvested as broodstock for a new land-based scampi aquaculture industry. In this presentation we will explore the cultural background that led to this new research project, the planned research approach (with a particular focus on fishing technologies), and the contribution that such an approach could make to future scampi management. [The aquaculture part of this research programme will be presented by Heasman, K., this Conference.]

The development and deployment of GIS based, Electronic Logbook (eLog) in the South African south coast rock lobster fishery (*Palinurus gilchristi*) [O80]

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Olrac-SPS, a South African company, has developed a GIS based electronic logbook, named Olrac, specifically designed for the commercial fishing industry. Over the last five years, despite many technical and logistical hurdles, Olrac-SPS managed to implement and deploy its Olrac eLog technology on board hundreds of vessels around the world. During this period many lessons were learnt which need to be considered, before Electronic Logbook Reporting in commercial fishing can become a global reality. In this paper the authors describe some of challenges and lessons learnt during the deployment of the Olrac eLog technology, onboard longline trap lobster fishing vessels off the South African south coast. The Olrac Lobster eLog technology was first installed in 2009 by Ruwekus Fishing (Pty) LTD, onboard the South Coast Rock Lobster fishing vessel the 'MFV Rigel 4'. Following the successful implementation of the software onboard the 'MFV Rigel 4', all the other operators in the fishery (10 vessels) adopted the Electronic Logbook. The deployment of the Olrac Lobster eLog provided many challenges and continues to be a work in progress. With vessels completing 30–45 day voyages, software problems had to be slowly worked through in between trips. This required patience and a working relationship between the vessel officers, shore management and Olrac SPS. Vessels officers proved hesitant to adopt the new technology, but by educating the officers on the need for such a system, the barriers of perception were broken down. The system is now viewed as a tool rather than a burden.

Long term spatial and temporal variability in catches of common spiny lobster *Palinurus elephas* (Fabricius, 1787) in Corsica (NW Mediterranean): fisheries trends, biological trends or both? [O81]

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The small-scale fishing fleet of Corsica (France, NW Mediterranean) is mostly composed of small artisanal boats. The common spiny lobster, *Palinurus elephas*, is the most valuable of all caught species. As a result, it is the main target of most fishermen during the 7-months fishing season. Populations of this species seem to decrease since the 1950's. The aim of this study was to understand if this decline could be linked with overfishing, or if other biological, ecological or climatic factors could explain this population drop. To achieve this goal, we combined 1) a meta-analysis of all data concerning fishing effort and captures in published and grey literature and 2) an on-board monitoring program that started in 2004. Using obtained data, we followed fleet structure, fishing effort and captures evolution from 1950 to 2011. Our results point out an important capture decrease during the 20th century. This trend started during the 1950's and 1960's, when trammel nets replaced traditional wood traps. A micro-regional analysis revealed that exploitation intensity widely varied among different areas around the island. Moreover, landings and catch rates showed important spatial and temporal variations. This could be caused by changes in recruitment rates. However, recruitment processes of this species are still poorly understood. Improving our knowledge of common spiny lobster life cycle will likely lead to a more comprehensive and efficient assessment of Corsican stocks of this species

Health risk associated to the lobster fishery in coastal communities of Yucatan, Mexico [O82]

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Hookah diving fishing method employed in the lobster fishery of Yucatan allowed fishermen to spend indefinite time underwater compared to other methods, leading to injuries, decompression sickness (DCS) and pollutant poisoning. Several DCS cases are treated at medical facilities every year; nonetheless, the risk problem has not been addressed. Diving behavior of lobster fishermen was evaluated in two communities to learn about conditions that favor health risk. Six fishermen were randomly selected according to their fishing skills to be followed during their fishing journeys. Diving data was recorded using Sensus Ultra dive computers and to analyze air quality in the hookah systems, carbon monoxide (CO) Dräger tubes. A total of 120 dives were recorded and 10 hookah systems sampled. The average of dives per day was 2.5, average depth of 47.2 FSW \pm 2.21, and average total bottom time of 95.12 minutes \pm 10.81. The no-decompression limit was exceeded in 24% of the dives. The average ascent rate was 20.28 FSW/min and recommended speed was exceeded in 5%. The CO exceeded the limits on 90% of the systems sampled, despite some fishermen use active carbon as filter for better air quality. Probability to DCS calculated for dives was between 4.7 and 11.7%. The fishing method used is an important factor for fishermen health status leading to diving accidents and pollute breathing air, hence recommended diving norms were exceeded. The factors that contribute the observed diving behavior are discussed, it is contended that market demand, scarcity of lobster, and financial stress are relevant.

Redesigning the lobster trap for efficiency: Development of a better escape vent for lobster, *Homarus americanus* [O83]

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This project is investigating the use of a shorter escape vent to use when fishing for American lobster, *Homarus americanus* and Rock/Jonah crabs, *Cancer* spp. These three species are caught in the same gear but the length requirement of the lobster escape vent allows for escapement of *Cancer* crabs. Two standard lobster traps were placed in a temperature controlled tank (16° C). One contained the standard vent (2 x 5 ¾ inches) and the other, a shorter vent (2 x 3.5 inches). For each trial, 6 sublegal and 2 legal lobsters were placed into the parlor section of the traps. The vent size was reduced using a white piece of Plexiglas screwed in place. The tank was covered with black plastic and a 16L:8D light cycle was used. Bait (herring) was placed next to water flow. Five trials of 5 soak days each have been conducted to date (total of 74 lobsters). Mean proportion of sub-legal lobster escaping from the modified trap was 0.886 (SE +/- 0.097) and 0.20 for legal sized animals (SE +/- 0.2). Mean proportion escaping from the regular vent (control) was 0.633 (+/- 0.87) for sublegal and 0.5 (+/- 0.158) for legal lobsters. There was a statistical difference (Chi square test for independence, $p = 0.0465$) in escapement of sublegals (higher in experimental trap) but not of legal sized animals ($p=0.4024$). This result is being tested further to determine the role of the vent color.

Ghost fishing lobster traps in the Florida Keys [O84]

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Ghost fishing by derelict lobster traps is common in the Florida Keys. Three types of traps (wire, wood-wire hybrid, and wood slat traps) were each deployed without buoys to simulate ghost fishing at three locations. We measured the time unattended traps continued to fish, identified the species in each trap, and estimated lobster and fish mortality. Divers recorded the contents of each trap (N=120 traps) biweekly for three years. Wood slat and hybrid traps fished on average 509 and 480 days respectively, wire traps fished significantly longer (637d, $P<0.001$), and several wire traps fished until the end of the experiment (1071d). Traps in Florida Bay fished for longer (711.5d) than traps inshore (509d) and offshore (381d) ($P<0.001$) in the Atlantic. More lobsters were observed in hybrid traps ($2.24\pm 1.5sd$) than wood slat ($2.09\pm 1.45sd$) and wire traps ($2.04\pm 1.39sd$) ($F=40.15$, $df=2$, $P<0.001$). Wire traps accounted for 83% of fish observed in traps and 74 of the 100 dead fish. We estimate that 8 lobsters/trap/year die in wood slat ghost fishing traps. Previous studies indicate that approximately 100,000 traps are lost annually, of which 85,000 are ghost fishing traps, potentially resulting in hundreds of thousands of dead lobsters. The number of lost traps and the prolonged duration lost traps continue to fish are major contributors to ghost fishing mortality. The most effective means to reduce ghost fishing will be to: 1) reduce traps to the lowest number which will maintain catch levels, thereby reducing those that could be lost, and 2) use biodegradable materials that more effectively render lost traps non-fishing.

Catch me if you can: Factors influencing the catch of American lobsters in ventless traps [O85]

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Ventless trap surveys are an increasingly common tool for obtaining data that are useful for making well-informed management decisions. The primary goal of this study was to conduct ventless and standard trap surveys, in parallel with a series of SCUBA surveys, to determine how lobster catch in both types of traps relates to the size structure and abundance of the lobster population on the bottom. Because trap saturation may impact catch values, we also quantified how catch changed over time by pulling traps after 10 distinct soak times, ranging from 2-96 hours. Ventless traps collectively captured ~ ten times as many lobsters as did standard traps, however the mean size of the lobsters captured did not differ between the trap types ($CL_{\text{ventless}} = 62.38 \pm 0.12$ mm; $CL_{\text{standard}} = 61.98 \pm 0.61$ mm). Importantly, ventless trap catch was a much better indicator of actual lobster abundance on the bottom, as determined with SCUBA surveys. Furthermore, while catch in standard traps changed little over time, ventless traps captured approximately one lobster/hr and then gradually saturated between 16-24 hours. In a subsequent study, we investigated two possible causes of ventless trap saturation: 1) retention of all the lobsters in the vicinity of the trap and; 2) loss of bait attractiveness. Our data suggest that loss of bait attractiveness could be the dominant cause of trap saturation. These data indicate that ventless traps are useful for estimating the abundance of natural lobster populations, especially if steps are taken to adjust for trap saturation.

Scottish lobster fisheries and environmental variability [O86]

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Variability in the fluctuations of two Scottish lobster populations, the Hebrides and Southeast, was investigated from available long data series of fishery and environmental variables. In a multivariate context, relationships between selected environmental variables and the fishery data were studied at different spatial and temporal (annual, spring and autumn) scales and from individual and overall sampled fleet. Multivariate techniques such as cross correlation function (CCF), principal components analysis (PCA) and redundancy analysis (RDA) confirmed that the capture of lobsters was strongly influenced by sea surface temperature (SST), wind speed (WS), and sea level pressure (SLP) throughout the year, and this dependence affected the duration of the fishery. In the Hebrides, the total variation (42%) of the interaction fishery-environmental variables for the spring and autumn fisheries could be attributed to the environmental variables in an 89%. For the Southeast, the spring fishery was more affected by changes in the environment, with a total variation of 34%, from which 85% could be explained by the environmental variables tested, than the autumn fishery where density-dependent processes were more important. From the analyses, it is deduced that the Hebrides lobster population is strongly influenced by density-independence processes at large and small spatial scales. Density-dependent processes at all spatial scales mainly drive the Southeast lobster population and environmental variables are important in spring.

Cost-effective puerulus settlement monitoring in deep, remote, and exposed waters utilizing the commercial lobster fleet [O87]

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Trends in puerulus settlement are used to predict future recruitment to commercial fisheries. Current puerulus settlement monitoring strategies conducted by the research community are costly and are limited to shallow accessible sites, despite the importance of remote deep water for lobster catches. In consultation with industry, a crevice-type puerulus collector was designed and constructed to cost-effectively monitor puerulus settlement in the deep, remote, and highly exposed waters of the Tasmanian south coast. This area yields significant landings in the Tasmanian lobster trap fishery; however, previous attempts to monitor puerulus in these waters were both very costly and unsuccessful due to remoteness and exposure. The novel puerulus collectors developed by this project were small enough to be deployed and serviced bimonthly by lobster fishers from their vessels during normal fishing operations, and successfully endured the highly adverse conditions typical of the Tasmanian south coast (swell exceeding 8m and winds exceeding 100km/hr). Collectors were deployed into two regions and across depth ranges and *Jasus edwardsii* pueruli settled across all conditions, including in depths exceeding 100m. The use of this collector design has the potential to reduce the cost, and increase the range of puerulus settlement monitoring; and also promotes industry participation in resource management. Further, monitoring of temporal trends in the faunal assemblages attracted by the collectors has potential for tracking the impacts of climate change on deep water benthic ecosystems.

Marine Protected Areas

Performance evaluation of No Take Marine Reserves in the Florida Keys National Marine Sanctuary for spiny lobsters, *Panulirus argus* [O88]

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The Florida Keys National Marine Sanctuary established 23 no-take marine reserves (NTMRs) of various sizes throughout the Florida Keys in 1997. The Florida Fish and Wildlife Conservation Commission (FWC) evaluated the performance of these NTMRs for the Caribbean spiny lobster, *Panulirus argus*, from 1997 to 2006 using timed surveys. We found no change in lobster abundance in small NTMRs compared to fished sites, but did observe an increase in abundance in the larger 30.8-km² (3080 ha) NTMR, Western Sambo Ecological Reserve (WSER). Hence, our surveys from 2006 to 2012 focused on WSER and methodology changed from timed to fixed area surveys to provide better density estimates. Analyses of transect data show that WSER is functioning to protect lobster, evidenced, in part, by a persistent population of lobsters with carapace lengths larger than 100 mm. However, data suggest that WSER region has reached a dynamic equilibrium whereby lobster populations inside WSER vary annually but are no longer changing relative to the fished population. WSER was designed to encompass habitat used by all life stages of marine life including spiny lobster. Not included in WSER is the outlier reef, where female lobsters go to spawn. Including the outlier reef as an integral part of WSER would improve on the original design goals and would protect female lobsters during their reproductive migration.

Population recovery in a newly protected area adjacent to a well-established marine reserve [O89]

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The Columbretes Islands marine reserve (CIMR) has been closed to *Palinurus elephas* since 1990. Based on a long term study started in 1997 we documented the recovery of biomass and demography, as well as adult emigration producing net benefits to the adjacent artisanal fishery. In 2009 the CIMR (oldMPA) was expanded to encompass vulnerable benthic communities subject to intense fishing in what until then were the grounds adjacent to the boundary (newMPA). The creation of the newMPA was a unique man-made experiment, where a newly created MPA is sandwiched between a 19-year old MPA and a fully exploited area. This particular circumstance offers an exceptional opportunity to shed light on spillover and biomass recovery processes in MPAs. Our initial hypothesis is that, in addition to density independent movements, density-dependence plays a role in spillover from high-biomass MPAs to nearby fished areas and that, because of its location between the oldMPA and the fished area, this will be a dominant process in the recovery of biomass in the newMPA. Data collected in years -1 to +4 of the newMPA indicate a swift recovery from 15% to 35% of the density in the oldMPA with a declining trend away from the new to old MPA boundary and a predominance of males (70%) in the newMPA compared to the oldMPA (50%). This study intends to contribute to the science of MPAs by improving our understanding of processes involved in biomass rebuilding, ensuing density-dependent movements and replenishment of fished areas.

Evaluating the use of an MPA as a management tool for the Juan Fernández rock lobster fishery [O90]

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The Juan Fernández lobster fishery is one of the oldest crustacean fisheries of Chile and the main economic resource for the Juan Fernández Archipelago. This fishery operates under a dual management system, with formal and traditional components. From the mid 1960's to 2000, landings showed a negative trend, which has been attributed to overfishing. Several management strategies have been proposed, including the establishment of a marine protected area (MPA) in the north side of Robinson Crusoe Island (RC). Given the major social and economic implications of this management strategy and the uncertainty about the potential benefits of this initiative, we developed a modeling framework to assess the effectiveness of a MPA using models that simulate the entire life cycle of *Jasus frontalis* and its fishery. A biophysical model for the pelagic life cycle (early life stages), together with a spatially explicit size-structured model for benthic component was used to assess the performance of a MPA. Model conditioning was obtained by fitting a statistical dynamic size-structured model to historical data using standard maximum likelihood methods. In addition a pelagic component based on IBM results were used to assess impact of pelagic larval connectivity between subareas on performance of modeled variables linked to MPA. A simulation study was put in place to assess the effect of the implementation of a marine protected area in different areas around RC subsystem using several performance statistics (e.g. catch, average size and spawning stock). A sensitivity analysis was implemented to evaluate results on structural model uncertainty.

Fisheries effect on mating behavior and mate choice in wild European lobster (*Homarus gammarus*) [O91]

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Understanding the mechanisms driving mating systems is difficult for wild populations where behavioral observations are difficult, but nevertheless imperative for harvested species. In European lobster (*Homarus gammarus*), as for many marine species, the level of recruitment is size-dependent as large and old females are typically more fecund compared to smaller females. Generally, large size has often been shown to be favored by sexual selection. However, when large size is also economically valuable, fishermen might disrupt mating behavior and reduce effects of sexual selection by removing those individuals from the population. Here we investigate how the fishery may affect mate choice by studying the occurrence and frequency of multiple paternity (n = 100 females) for the European lobster, contrasting a marine reserve (MPA) with a heavily exploited control area, on the Norwegian Skagerrak coast. Also, this study is the first to conduct a quantitative (n= 550 males) parental assignment in a wild lobster population.

Habitat and Ecosystem Issues for Fisheries Management

Addressing habitat and ecosystem issues in fisheries management: a case study with western rock lobster (*Panulirus cygnus*) [O92]

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In recent years there has been concern over the sustainability of global fish stocks and the impact of fishing on the marine environment. While many fisheries around the world are being fished and managed sustainably the increased profile of stock sustainability and the potential impacts of fishing practices on the environment has led to an increased awareness of environmental issues by the general public and conservation groups. This increased demand has led to the prevalence of third party certification programs worldwide, coupled with the rise in public awareness is the progression towards a more holistic approach to fisheries management in the form of Ecosystem Based Fisheries Management (EBFM). EBFM considers the cumulative impacts on the environment of all fisheries-related activities operating in an area while also taking into account social, economic and external factors (i.e. climate change and other non-fishing related activities). These areas have not, in many cases, been the traditional focus of management agencies and have required considerable research and management input for a number of fisheries. Western rock lobster, *Panulirus cygnus*, is distributed along the west coast of Australia from North West Cape to Cape Leeuwin. The West Coast Rock Lobster Fishery is Australia's most valuable single-species fishery and was the first fishery to obtain Marine Stewardship Council (MSC) certification in 2000. Here we discuss the research and management initiatives that have been implemented in the fishery to address habitat and ecosystem issues and how these processes have assisted with fisheries management, including third party certification.

Socio-economic evaluation of a California lobster fishery in the context of ecosystem [O93]

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In the western coast of the Baja California peninsula, the red spiny lobster (*Panulirus interruptus*) co-exists with abalone, another valuable benthic species. Both exploited stocks inhabit rocky reefs characterized by high diversity of seaweeds. In these fishing grounds there is an intense fishing activity, inducing changes in the structure of benthic community, such as critical reduction of biomass of other species with high commercial value and habitat deterioration. The lobster fishery together with the abalone fishery, exist for decades and sustain local fishing communities. The lobster fishery contributes with 85% - 92% of the total catch of the Pacific coast of the peninsula and locally, between Punta Eugenia and Punta Abreojos, represents 95% to 97%, with Bahía Tortugas being the main fishing village. In this paper, the level of habitat complexity is analyzed and its possible relationship to the abundance of spiny lobster is examined. Socio-economic optimum fishing strategies are also explored using a simulation model under three possible scenarios as management targets. It is expected that these results will emerge in proposals for the management strategies of the spiny lobster fishery in the context of ecosystem.

Spiny lobster fishing and maërl conservation: short term losses and long-term benefits of modifying *Palinurus elephas* trammel net material [O94]

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Quantitatively assessing the ecosystem effects of artisanal gears is important because the long-term survival of nearshore fisheries relies on healthy fishing grounds. Hence, improving gear technology is needed to minimize the impacts of fishing activities on target and non-target organisms as well. However, information about the ecosystem impacts of artisanal gears to elaborate mitigation plans is generally lacking. In western Mediterranean, *Palinurus elephas* trammel net fishery is conducted over coralligenous and maërl habitats and constitutes the largest annual income of artisanal fishermen, especially in the Balearic Islands. Therefore, management plans that balance the profitable exploitation of the lobster resource and the health of their ecosystem is vital. Additionally, structural species, such as those in the maërl are protected by national and European environmental laws because of their fragility. In this study we compare the performance of traditional trammel nets made of polyamide multifilament (PMF) with an experimental trammel net built with polyethylene multi-monofilament (MMF) in terms of the catch of: 1) immature, undersized and legal lobster; 2) associated commercial fish bycatch; and 3) structural species (maërl). We conducted experimental fishing surveys from September 2011 to August 2012 at depths of 40 to 160 metres. Fishing sets were constructed of alternating PMF and MMF net panels and catch composition and catch rates were determined for the two net types. Results indicate a significant reduction of the catch rates of structural species and of undersized lobsters at the cost of a 40% drop of commercial lobster catch rates with the experimental trammel net.

Complex effects of casitas on spiny lobsters in the Florida Keys, FL (USA) [O95]

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Casitas are artificial shelters used by fishermen to aggregate Caribbean spiny lobsters (*Panulirus argus*) for capture, and have also been touted as a means of population enhancement that allow lobsters to exploit shelter-deficient habitats. Conversely, lobsters may simply be attracted to casitas without a concomitant increase in growth or reduction in mortality. It is also possible that lobster growth or mortality may suffer when they are over-aggregated in casitas. Juvenile lobsters may be at particular risk if attracted to casitas, because they may be less able to forage effectively or defend themselves than larger individuals. If so, then casitas may function as an ecological trap for juvenile lobsters, whose normally beneficial sociality may lead to maladaptive shelter choice. We compared the nutritional condition, relative mortality, and activity of lobsters of various sizes in casitas and natural shelters in adult and juvenile lobster dominated habitats in the Florida Keys (USA). We found that the ecological effects of casitas are complex and location-dependent. Juvenile lobsters in casitas experienced higher rates of mortality than did individuals in natural shelters; however, animals in casitas were in better condition. Thus, casitas in nursery habitats may function as ecological traps where juvenile lobsters are lured by conspecifics to shelters where their risk of predation is higher. Outside of nursery areas, casitas can potentially enhance lobster productivity by increasing lobster growth. These results highlight the importance of accounting for animal size and location-specific effects when attempting to predict the consequences of habitat modification for fisheries enhancement.

Does large scale harvesting of the spiny lobster, *Jasus edwardsii*, affect their subsequent recruitment into reefs? [O96]

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The most valuable spiny lobster fishery in New Zealand is for *Jasus edwardsii*, which inhabits the temperate rocky reefs around the entire country. There is strong evidence that the removal of these important predators by fishing plays a role in altering the habitat structure of reefs, especially in north-eastern New Zealand. Reduction of adult lobster abundance on reefs is thought to trigger a trophic cascade by reducing predation on the common sea urchin, *Evechinus chloroticus*, which in turn increase in number and graze down kelp forest habitats to form barren reef habitats. Possible habitat settlement preferences of *J. edwardsii* pueruli were investigated using experimental settlement collectors that simulated artificial kelp forest, natural kelp forest and barren reef. Overall, the pueruli showed no discrimination among the three treatments ($p=0.955$, $df=20$), however, later stage pueruli showed trends towards barren and kelp collector treatments (stage II, $p=0.39$ $df=413$). Baited underwater video surveys of potential predators of early juvenile lobsters showed significant differences in species diversity and abundance among kelp and barren reef habitats which may indicate differences in predatory pressures. A novel method for 24 hour uninterrupted predation observation has been developed to estimate potential predatory pressure on juvenile lobsters in barren and kelp forest habitats. Results indicated a significantly higher relative predation pressure on barren habitats ($p=0.01$, $df=23$). Overall, this study suggests that the settlement and subsequent survival of early juvenile *J. edwardsii* may be influenced by changes in reef habitats which appear to be associated with lobster fishing.

Upscaling habitat data to understand the spatial arrangement of lobster habitat across its geographic range: the effect of spatial scale on the predictability of lobster habitat [O97]

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One of the core concepts of ecosystem-based management relates to understanding the spatial relationships between target species and key habitats. However, the choice of scale of analysis (i.e. resolution or grain size) directly influences these spatial relationships, and thus our visual perception of spatial patterns. Often the limiting factor is the resolution of the available data, which generally decreases as you move over a broad spatial extent like a species range. This becomes problematic when trying to upscale habitat data to understand the spatial arrangement of habitats across a target species geographic range. This study investigated the effects of scale on the predictability and visual perception of patterns in the distribution of *P. cygnus* and associated habitats; in an effort to produce habitat distribution maps across 1000 km of coastline, based on the Australian national bathymetry dataset (resolution: 9 arc seconds or 250 m grid). Firstly, we collected high resolution bathymetry (3 x 3 m grid), habitat and lobster data within a 40 km² area, then developed models to predict and then map habitat and lobster distributions within this area. This bathymetry dataset was then resampled at various scales, up to 1km grids, and new models developed. The outputs of the models revealed that a strong relationship between terrain variables and lobster habitat was retained up to 50 m resolution, with reasonable predictive performance being retained at 250 m resolution, before breaking down completely at 1km resolution. Models were then developed over *P. cygnus* geographic range using the national bathymetry grid and additional habitat data. Interestingly, the performance of the extended 250 m model was significantly greater than the resampled 250 m model, suggesting that spatial extent (area) can potentially buffer spurious extrapolation of species distribution with decreasing resolution. Most importantly, we now have spatially explicit, detailed habitat maps across the range of this commercially important lobster species which will be a key tool in future spatial management.

An unfished area enhances a *Panulirus argus* fishery: Implications for management and conservation within a Biosphere Reserve in Mexico [O98]

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The Caribbean spiny lobster (*Panulirus argus*) is the main economic source for the communities in the Sian Ka'an Biosphere Reserve, Mexico (SKBR). Within the SKBR, the main lobster fishing grounds are located in two large, shallow bays (≤ 20 m in depth) where around 20,000 casitas (large artificial shelters) are used as fishing gear. As they grow, and especially during the 4-month closed season, many lobsters move from the bays to offshore, deeper (≥ 20 m) areas not subject to fishing, which essentially act as spatial refugia. In 2012, the SKBR lobster fishery was certified as "sustainable" by the Marine Stewardship Council but with some conditions that include the development of further stock assessments. To assess whether lobsters dwelling in the deeper areas remain in these spatial refugia and are thus fully protected, 379 large lobsters were captured, tagged and released in the deep unfished area off SKBR's southernmost bay (Bahía del Espíritu Santo). The lobsters recaptured in the shallow fished area (5.3%) were sufficient to develop a multi-state mark recapture model, which takes into account fishing and natural mortality, tag reporting rate and tag loss. Results of the model showed that between 15% and 20% of the adult lobsters dwelling in the deeper unfished area move into the shallow fishing grounds and are subject to exploitation. These results suggest that the unfished lobsters in the offshore area, while being mostly protected from exploitation, also enhance fishing yields within the inshore commercial fishery.

Delousing chemicals containing teflubenzuron will affect European lobster (*Homarus gammarus*) juveniles [O99]

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Experiments were carried out to examine effects of the antiparasitic drug teflubenzuron used in delousing farmed salmon on a non-target species, the European lobster (*Homarus gammarus*). Juvenile lobsters were fed either of two doses of teflubenzuron for seven days. One dose corresponded to standard medication of salmon (10 mg/kg day) and the other dose corresponded to the concentration found in faecal particles from treated salmon (20 mg/kg day). Monitoring lasted three months to include at least one moulting period for all individuals. Cumulative mortality was higher in all replicates given medicated feed compared with the control group. After 20 days, mortality was about 30% among juveniles given teflubenzuron, and 40% after 70 days. Drug residue was analysed in all juveniles that died as well as 12 individuals at day 8 and the first 12 individuals surviving moulting. The concentration declined from over 8000 ng/g at day 5 to 14.3 ng/g at day 70 in juveniles that died during the experiment. Twelve juveniles contained 82 ng/g or less whereas the mean concentration in the first 12 lobsters that survived moulting was 152 ng/g. We could not determine a break point where higher concentrations induced mortality and lower concentrations ensured survival. In surviving juveniles deformities were found in carapace, pereopods, cheliped, tail fan, abdomen and antenna. Deformities may affect respiration, the ability to locate and consume food and to escape predators. In total, the mortality and senescent damages were close to 50%. This may potentially affect recruitment in a local area.

Effects of pesticide-spiked sediment exposure on stage V juvenile lobster *Homarus americanus* [O100]

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Toxicity to non-target aquatic species by pesticides used in human industrial and agricultural activities is yet to be unambiguously proven. Chemicals in the environment during critical periods could affect the physiology of American lobster (*Homarus americanus*), an economically valuable species. The fishing industry is keen to gather information on the factors that may have constrained lobster population recruitment in some lobster fishing areas of Eastern Canada and limited the success of management measures aimed at a sustainable fishery. In this laboratory study, stage V lobsters were exposed for 14 days to sediment spiked with either Deltamethrin or Permethrin. These pyrethroids are highly toxic, hydrophobic, and found in Canadian soils. We employed an integrative approach using bioenergetic endpoints at the level of the individual (survival, metabolic rates, behaviour) and at the molecular and cellular levels (genomic, biochemistry, histology) to elucidate the effect these pyrethroid may have on lobster. All concentrations used were sublethal except for the Deltamethrin-5 µg/kg of sediment group. No standard concentrations were known for the sediment-bound contaminants; the levels that were tried for Permethrin ended up below the toxic LC₅₀ for this contaminant, and the toxic LC₅₀ for Deltamethrin ended up between 0.5 and 5 µg/kg of sediment. The highest sublethal concentrations had obvious negative effects on growth and development of the juvenile lobsters. Physiological, behavioral, histological and biochemical observations will be presented.

Settlement delay and growth of postlarval American lobsters on different seafloor substrates, and juvenile use of mud seafloor [O101]

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Postlarval American lobsters, *Homarus americanus*, prefer settling onto a cobble substrate and delay settling (prolong swimming) over mud or sand. Whether prolonged swimming consumes energy at the expense of development and growth is unknown but important given the sparse distribution of cobble seabed across the American lobster's range. Using tanks lined with cobble, mud, or sand, we measured postlarval settlement time onto each substrate and examined whether prolonged swimming over mud or sand affected development by delaying moult, or affected growth by reducing post-moult size. Postlarvae settled first onto cobble, second onto mud, and last onto sand. Postlarvae also moulted first on cobble, second on mud, and last on sand. The longest delay of settlement, over sand-lined tanks, resulted in reduced carapace length and mass at the next moult in comparison to postlarvae which settled earlier onto mud or cobble. Given that only over sand did lobsters delay settlement to the point of impairing growth, and given the prevalence of mud bottom across the lobster's range, postlarvae may settle upon and exploit mud seafloor as habitat when cobble is unavailable. We therefore deployed cobble-filled collectors onto mud seafloor in Maces Bay (Bay of Fundy, Canada). The collectors represent preferred cobble habitat and attract juvenile lobsters from the immediately surrounding area for enumeration. Juvenile lobsters, ranging in size from young of the year up to adolescents, colonized the collectors on mud. Consequently, we identify mud habitat as an overlooked nursery habitat for American lobster settlement and early life history.

Does fishing for Western rock lobster impact benthic ecosystems? [O102]

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Fishing of target species, including lobsters, can alter food webs and impact benthic ecosystem function. The western rock lobster fishery has historically been characterized by high exploitation rates and ecological risk assessments have identified a potential for biomass removal to impact deep water ecosystems. Considerable research effort has targeted this question including dietary studies, trophic modelling and high resolution habitat mapping. Here we outline the role of a deep water closed area specifically negotiated to quantify any ecosystem impacts of fishing for lobster. The spatially explicit sampling regime implemented to monitor lobsters has provided a refined understanding of lobster/habitat relationships at different levels of exploitation. Lobster populations have demonstrated a rapid and marked response to protection from fishing. For example, after only 3 years of protection the biomass of large males in the closed area is *ca* 30 times that observed in fished controls. Qualitative modelling was used to identify ecosystem indicators to monitor and benthic habitats have been monitored remotely using an autonomous underwater vehicle (AUV). The AUV allows benthic assemblages to be re-sampled with a high degree of spatial precision and statistical power. However, it will presumably take considerably longer for any indirect changes to propagate through the ecosystem.

Habitat characterization of juvenile lobsters *Panulirus argus* in central coast of Yucatán, México [O103]

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In this work benthic habitat preferred by lobster *Panulirus argus* in their late juvenile stage is characterized. Observation campaigns were conducted by SCUBA and hookah diving during the closed season (March-June) of 2010, 2011 and 2013 in the coast of Dzilam de Bravo. Sampling stations were located in areas identified by fishermen and data were obtained of video transects of places in where lobsters were observed. Bottom types were defined, lobster densities were estimated and interpolations were made to the study area. Species of algae, seagrasses, and fishes associated with lobster habitat were identified. The bottom coverage and fish diversity indices were calculated. Some fishery indicators were reviewed: catch, catch per unit effort, and size composition. The average densities estimated were: 133 lobsters/ha in 2010 and 167 lobsters/ha in both 2011 y 2013. The number of fish species observed during the three campaigns was similar (33, 34 and 37, respectively). Diversity indices in the area were statistically different between two sites in the area: 0.801 (east) and 0.621 (west). The study area has a bottom type gradient of physical and biotic structures to the east, where diversity index and lobster densities were higher.

Habitat complexity: A key factor in spatiotemporal fluctuation of abundance of spiny lobster *Panulirus gracilis* in Manabí, Ecuador [O104]

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Green spiny lobster *Panulirus gracilis* inhabits rocky reefs and coral patches. Its reproductive success and survival are linked to the availability of areas with a high density of shelters. The influence of habitat complexity on recruitment processes and abundance fluctuation of this species has not previously been investigated in Ecuador and could be a key factor in future conservation and management initiatives. From April 2012 to July 2013, we analyzed ecological descriptors related to habitat complexity (substratum cover, rugosity, size and height of shelters and depth) and monthly lobster abundance fluctuations at 9 study sites: 4 no-fishing (NF) and 5 fishing (F) sites of Jaramijó and Manta, coast of Manabi. All sites showed predominance of hard substrate. 77% of sites showed high habitat complexity and abundance of lobsters ($r^2=0.93$; $F=82.68$, $p>0.05$). Principal Component Analysis showed that in NF sites, abundance was tightly correlated with rugosity index and depth (78.7%) while in F sites, abundance was a function of depth (60%). 655 lobsters were observed in 100 hours of diving. 152 lobsters (28 males and 124 females) were caught by hand, sex ratio of 1:4. Sites with high habitat complexity showed recruitment pulses between May and July 2013. Our results suggest that spatiotemporal fluctuation of abundance in *P. gracilis* was highly correlated with habitat complexity of those sites supporting pronounced annual pulses of population recruitment. This condition appears to be favorable for maintaining population stability of the species, therefore measures to protect these sites from fishing activities should be seriously considered.

Stock Assessment

Growth of juvenile lobster, *Homarus americanus*, in a changing environment [O105]

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The American lobster (*Homarus americanus*) is one of the most economically important species in the USA, with most landings from coastal Maine. In recent years, lobster stock abundance has exponentially increased in coastal Maine, which is likely due to increased recruitment, enhanced growth rates, and predator release. We analyzed the effects of lobster size class (12-19.9, 20-29.9, and 30-39.9 mm CL) and time period (1993-1999 and 2001-2010) on their growth rates using an 18-year lobster mark-recapture study in coastal Maine. Analysis of all size classes over both time periods showed that the minimum amount of percent growth significantly increased over time ($P < 0.05$). In addition, molt probability parameters ($t50$) were significantly greater for the 2001-2010 time period when water temperatures were warmer. Overall, smaller juvenile American lobsters (12-19.9 mm CL) exhibit growth patterns that are significantly different from larger juveniles (20-39.9 mm CL), and an increase in water temperature over the past 18 years likely has increased percent growth and molt probability while also reducing intermolt interval. These results are of great value for use in future lobster stock assessment and resource management.

A new forecasting model for the American lobster fishery using the American Lobster Settlement Index [O106]

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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. Settler-recruit relationships that track cohorts after larvae have settled to the sea bed have proven more productive, however. Here we describe a fishery recruitment forecasting model that we are developing based on the American Lobster Settlement Index (ALSI), a comprehensive annual diver-based survey that quantifies the abundance of young-of-year lobsters as they populate coastal nurseries. Encouraged by our initial success in forecasting fishery recruitment trends in southern New England, USA, we are now developing projection models for other parts of the species range for which settlement time series exist. The model starts with the settlement index to set initial year-class strength and subjects cohorts to variable growth as determined by temperature regime, as well as proxies for natural mortality, including predator abundance and shell disease prevalence. Projections are validated against independent indicators of recruitment to the fishery. This talk will describe our model development to date. We anticipate the projection models such as this will contribute to the stock assessment process and allow stakeholders to make informed decisions relating to the management of this fishery.

Has exploitation caused a downward shift in size-at-maturity of female American lobster *Homarus americanus* in Atlantic Canada? [O107]

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Exploitation has been shown to have substantial effects on life-history characteristics on a number of finfish and invertebrate fisheries, particularly in terms of altering the size or age of maturation. The American lobster, *Homarus americanus*, is Canada's most valuable fishery and exploitation rates are substantial (generally exceeding 75%), yet no efforts have been made to date to determine whether the fishery is causing changes to life-history characteristics. Female size-at-maturity (SOM) is an important parameter in fisheries management as it is critical for the efficacy of minimum legal size (MLS) regulations. In this study we therefore assess available historic and recent data on SOM of female lobsters to determine whether there is evidence that SOM has changed over the past century. The magnitudes of changes in SOM were then compared spatially to the magnitudes of fishery-induced size-based selection, measured as the discrepancies between MLS regulations and SOM. Our results clearly show that SOM of female lobsters has declined across Atlantic Canada, in some areas by as much as 30% since the 1930s. The temporal patterns of these declines are inconsistent with patterns of rising ocean temperature and stock size, making these unlikely drivers of declining SOM. There is, however, a strong correlation between the strength of size-based fishery selection and the magnitude of SOM declines, suggesting an evolutionary response to intense exploitation over the past century has likely been the cause of declines.

Scampi (*Metanephrops challengerii*) emergence patterns and catchability [O108]

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Scampi (*Metanephrops challengerii*) are widely distributed around New Zealand, with the main fisheries occurring from 250–550 m deep. As with *Nephrops*, they occupy burrows, and are only available to trawl fisheries when emerged on the seabed. Uncertainty over trawl catchability associated with emergence patterns has led to the development of photographic survey approaches based on counts of scampi burrows, although burrow occupancy and emergence rates remain key uncertainties, and a greater understanding of these aspects is likely to be central to quantifying catchability for both trawl and photographic survey approaches. We used acoustic tagging approaches to examine levels of, and patterns in emergence of *Metanephrops*, using hydrophone receivers moored close to the seabed. This is the deepest acoustic tagging of a lobster that we are aware of. New Zealand *Metanephrops* stocks are currently assessed using a Bayesian length based assessment model, and the emergence data are used in conjunction with burrow and animal counts from photographic surveys to provide informed priors for trawl survey catchability and burrow occupancy.

Assessment of maximum economic yield of the western rock lobster fishery of Western Australia under quota control [O109]

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The western rock lobster (*Panulirus cygnus*) fishery is Australia's largest single-species fishery, worth AUD\$200–\$400 million annually. The fishery stock assessment utilises puerulus settlement levels to predict recruitment to the fishery 3–4 years later. This predictive ability has been particularly useful recently due to a period of unusual puerulus settlement decline over seven years (2006/07 to 2012/13) including the two lowest settlements in 40 years. In 2008/09, pre-emptive management action was taken to provide greater protection to the stock, resulting in effort reductions commensurate to the maximum economic yield (MEY) level of effort. In 2010/11, the fishery moved from an effort-controlled fishery to a quota-controlled fishery, which has resulted in changes in fishing practices, a move to a 12-month season and changes in costs and lobster prices. This study examined the MEY under catch quota controls over a five-year period which showed that an annual harvest rate of 37–47% of legal biomass provides a socio-economic target reference range based on MEY and GVP. This target complements the existing threshold and limit reference points based on egg production that are associated with sustainability. This level of fishing also predicts relatively stable catches, catch rates and egg production over the five years. The movement to catch quota under MEY has resulted in egg production levels well above threshold levels and has resulted in consideration of relaxing some biological controls on female maximum size, setose (mature) females and lobsters 76–77 mm carapace length. The relaxation of these controls is estimated to increase profits by about AUD\$15 million annually due to the higher resultant catch rates.

Depletion Analysis of spiny lobster (*Panulirus argus*) at Glover's Reef Marine Reserve, Belize, incorporating estimates of in-season recruitment [O110]

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Beginning in 2011, fishermen catching Caribbean spiny lobster (*Panulirus argus*) at Glover's Reef Marine Reserve (GRMR), Belize, have been required to keep logbooks. The catch per unit effort (CPUE) calculated from the logbooks varies both with lobster abundance and between fishing boats; a generalized linear mixed model was used to remove the effect of boat and extract an unbiased CPUE index of abundance. Depletion models including in-season recruitment were fitted to the CPUE data to estimate the abundance and fishing mortality of lobsters in the fished zone at GRMR during the 2011–2012 and 2012–2013 seasons. A typical model estimated that abundance was around 74.7 (61.1–145.1) thousand lobsters in 2011, and 67.7 (59.2–113.9) thousand lobsters in 2012. Of these, about 77–86% were present at the beginning of the season and the rest recruited during the season. Alternative models of the timing of in-season recruitment gave similar results, but models without in-season recruitment were not supported by the data in either season. Because the fishery takes place in the General Use Zone (GUZ) of a marine protected area that also has a no-take zone (Conservation Zone: CZ), only part of the population is vulnerable to the fishery. If the depletion model estimates of abundance are adjusted to include the lobsters in the unfished zone, the current abundance is 31–41% higher, and the current catch appears to be sustainable. In-season recruitment is an important part of the dynamics of spiny lobsters at GRMR and perhaps at other locations in the Caribbean.

On the recruitment dynamics of *Panulirus argus* [O111]

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Despite management practices to achieve sustainability, commercial landings for Caribbean spiny lobster, *Panulirus argus*, have experienced significant steady declines in several countries since 2000. This is cause for concern not only for economic reasons, but for issues of sustainability. Several hypothesis have been mentioned about the most likely cause and effect of such declines. These cover from virus infections over extended areas to climate change, excessive exploitation of juveniles, to uncontrolled fishing effort. Despite the fact that some research results support the contention that local spawning populations are a significant contributing factor of local post-larval recruitment, prevalence of the Pan-Caribbean recruitment paradigm has prevailed. Consequently, most of Caribbean spiny lobster fisheries are exploited with no fishing mortality controls due to the regional larval recruitment concept adopted. In this work analysis of the recruitment dynamics of *P. argus* in Brazil, Honduras-Nicaragua, and Florida are assessed and compared relative to environmental variability. Several common signals supported by regional atmospheric-oceanographic indices are providing regional patterns that are reflected in the fisheries.

Numerical age-length key algorithm applicable to species when direct aging is not possible: The case of the Caribbean spiny lobster, *Panulirus argus* [O112]

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Age-length keys (ALKs) are distributions of age at length used to estimate catch-at-age from length-frequencies in total landings. This information is paramount to stock assessments and the estimation of status of exploitation of stocks. ALKs are specific to recruitment and exploitation patterns; therefore, construction of ALKs must be estimated within specific time frames and gear types for species that can be aged. This is not possible for most crustaceans that require complex ageing methodologies; therefore, determination of catch at age is usually obtained from length-frequency data “sliced” into ages by a growth function (e.g von Bertalanffy) not taking full consideration of the variability of size-at-age. Spiny lobster, *Panulirus argus*, throughout their habitat range are heavily exploited by trap, gillnet, and diving fisheries. Size frequencies collected in those fisheries may be subjected to stochastic age-slicing, which utilizes variance of size-at-age, but does not consider linkages in the growth trajectories that depend on intrinsic (heritable or predetermined) biological composition. This paper presents a numerical algorithm that follows groups of lobsters throughout time within segmented size increments between molting periods that typically characterizes crustacean grow. By implementing knowledge on the standard errors of segmented growth at molting times and standard errors of pre- and post-molting sizes under given exploitation patterns, distribution of age frequencies within length bins are generated through a numerical solution for an ALK. This method significantly contributes to better estimates of fishing mortality and abundance in data-complex fisheries such as the Caribbean spiny lobster.

Environmental effects associated with cold fronts increase catch rates of *Panulirus argus* in a Mexican Caribbean Biosphere Reserve [O113]

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Bahía de la Ascensión (Sian Ka'an Biosphere Reserve, Mexico) is a large, shallow bay located on the eastern margin of the Yucatan peninsula that sustains a productive fishery for *Panulirus argus*. Fishers extract legal-sized lobsters by hand from casitas distributed in fishing areas within the bay and from shallow coral reef habitats (≤ 15 m in depth) along the mouth of the bay. Although catch rates tend to decline from high values at the beginning of the fishing season (July) to low values at the end of the season (February), catch rates usually exhibit a secondary peak within the autumn. We analysed environmental and catch data sets from 1985 to 2012 to test whether this secondary autumnal peak was linked to the passage of northerly cold fronts ("Nortes"). Results showed that catch rates tend to increase 5 to 15 days after the passage of a Norte, but only when the strength of northerly winds reaches or surpasses a threshold value of $\sim 2.0 \text{ m s}^{-1}$. The autumnal peak in catch rates reflects an increased abundance of legal-sized lobsters over the outermost bay fishing areas adjacent to the coral reef. These lobsters include subadults moving out from shallow, inner bay areas and large adults moving in from deeper (> 20 m) areas off the bay where lobsters are not subject to fishing. Our results suggest that local production of *P. argus* may be significantly influenced by biological and behavioural responses of lobsters to environmental effects associated with strong Nortes.

Local dynamics of spiny lobster *Panulirus argus* resource under contrasting exploitation patterns in two fishing banks of the Mexican Caribbean [O114]

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Resource modeling of spiny lobster *Panulirus argus* was conducted in two major fishing banks of the Mexican Caribbean: Bahía de la Ascension and Banco Chinchorro, pertaining to Sian Ka'an Biosphere Reserve and Banco Chinchorro Biosphere Reserve, respectively. The analytical framework consisted of: i) depletion models for multiple-seasons fit to available information on catch-effort, and ii) simple indicators for sparse data on size structure of the catch. Each bank exhibits contrasting exploitation patterns and environmental settings. In Bahía de la Ascension, free-diving fishers target young and pre-adult lobsters occupying artificial shelters ("casitas"). In contrast, free-diving fishers at Banco Chinchorro target older, larger lobsters found in natural reef habitats. Although these banks have similar areal extent, the cover of mangrove and seagrass habitats are greater in Bahía de la Ascension. Our results indicate a higher fishing mortality rate on lobsters in Bahía de la Ascension than in Banco Chinchorro. Simple indicators of fishing pressure based on lobster size, show the same pattern. Differences in annual recruitment were also observed, with larger recruitment in Bahía de la Ascension. Local fishers follow distinct co-management strategies reflected on the adoption of cooperative and organizational practices in each fishing community. Both fisheries obtained the Marine Stewardship Council (MSC) certification in July 2012, an achievement viewed as a success in the development of sustainable fishing practices at local level. Finally, challenges that could affect both fishery systems in the near future are discussed.

Estimating survival from long-term tagging data sets – how does time and duration of study influence survival estimates? [O115]

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Capture-mark-recapture (CMR) modelling is one of the methods used for estimating demographic parameters including survival rate and population size, although they can be expensive, as there is a trade-off between sampling design, data collection methods and the costs of surveys. A long-term mark recapture data set based on the southern rock lobster *Jasus edwardsii* provided an opportunity to determine how the number of surveys and different survey intervals affected the accuracy and precision of estimated survival probability for male and female lobsters. Tagging surveys were undertaken using a uniquely coded T-bar tag, twice a year from 2000 to 2003 with unequal time intervals between surveys and once per year from 2004 to 2012 during the January/February period (i.e., equal intervals). The results showed that the most parsimonious Cormack-Jolly-Seber (CJS) model for estimating survival of lobsters was dependent on the timing of the tagging and recapture surveys, the time between consecutive recapture surveys and gender. The number of surveys required to provide a precise and accurate survival probability was dependent on gender and time between recapture surveys. In general, females required more surveys than males to obtain similar precision in survival estimates. For surveys where there was unequal time between recapture surveys 7 and 5 surveys were required for female and male lobsters, respectively, whereas only 5 and 4 surveys were required when annual surveys were undertaken. Thus, for an annual model, the length of a tagging project is beyond the standard three year project duration common in science.

Handle with care: an analysis of the effects of appendage damage on the growth and productivity of the southern rock lobster (*Jasus edwardsii*) [O116]

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The capture, handling and release of lobsters during commercial fishing operations can damage appendages and reduce the exploitable biomass available to fishers as moulting lobsters expend energy resources regrowing limbs at the expense of increasing in size. To assess the effect of different types of injuries on the growth of juvenile male and female lobsters, a Bayesian hierarchical approach was taken to fit the parameters of the von Bertalanffy growth equation to mark-recapture observer data from southern areas of the Tasmanian southern rock lobster (TSRL) fishery in Australia. While the effect of handling damage on the growth of females could not be distinguished from zero, the impact on males was marked, with damage to an antennae or legs estimated to have a similar proportional impact on growth of 7% (0-16%, 95% CI) and 7% (0-14%, 95% CI) respectively. Damage to both antennae and legs had a greater proportional impact on growth of 40% (24-57%, 95% CI). Despite handling damage causing reductions in predicted growth, less than 6% of undersize male lobsters displayed these types of injuries. With an estimated 4.51 ± 0.08 million lobsters discarded annually between 2001 and 2010 from southern areas of the TSRL fishery, this led to a predicted annual lost productivity and profitability of 1.6 tonnes and \$72,905 respectively. This was less than 1% of the total allowable catch and revenue of the fishery in 2010. This result highlights the effectiveness of management measures and biology of the species in reducing excessive amounts of handling damage.

Population dynamics of the Baja California spiny lobster (*Panulirus interruptus*): biological reference points of a sustainable fishery [O117]

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The spiny lobster is a high value resource that sustains a community-based fishery along west Baja California peninsula (Mexico). Time series of total landings show interannual fluctuations within a long-term increasing trend. During the last 5 years average total catch was 2200 t with the maximum historical level (2750 t) in the 2011/2012 fishing season. This paper describes an assessment of the main *P. interruptus* stock in central Baja California, which on average accounts for 77% of total landings during the last 15 years. Since 2004 this fishery is certified as ecologically and well managed under the MSC standards. The stock status is periodically examined by some biological reference points (BRP) estimated from alternative quantitative models. The dynamic biomass model estimates the most probable MSY in ~2130 t. As current average catch from the central stock between 2008/09 and 2012/13 (1578 t) is under the predicted MSY level and average biomass during the same period exceeds the optimal level ($B_0/2$) to obtain the MSY, it is quite evident that this fishery is healthy and has a slight development potential. BRP estimated from size-structured models indicate that current average harvesting biomass and average yield have increased. BRP from both models are consistent with the upward tendency of catches at historical levels in the series during the highest abundance period. Our analysis demonstrates that this fishery remains sustainable and well-managed, based upon systematic research and co-management strategies. Consequently, this fishery was awarded with the MSC recertification in 2011.

Management

Comparing MSC certification process and obtained benefits for lobster fisheries [O118]

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Marine Stewardship Council (MSC) certification is a market-based incentive program recognizing well-managed fisheries. MSC standards evaluate: (1) target species, (2) fishery impact on the ecosystem, and (3) management system. Worldwide eight lobster fisheries are MSC-certified. This study addresses their management systems regarding to standard 3 and their market features testing the hypothesis that different fisheries have different objectives to seek MSC certification. We based on bibliographic review, a case study (Baja California red rock lobster), and electronic surveys with industry managers. MSC-certification is positively perceived. For European lobster fisheries the main motivation to seek certification is to maintain market local share. Most respondents consider that the certification process identify pitfalls in the fishery, which should be handled by implementing the action plan (set of management operations to meet the MSC standards). For example, in the Western Australia rock lobster fishery, emerging research developed in habitat and ecosystem issues after certification. Certification experiences highlighted the importance of comprehensive documentation of current and historical information; monitoring and research. On the other hand, certification may confer non-economic benefits, such as international recognition and improved fishery's image. The case study reveals that MSC certification provides the fishing industry a stronger negotiating position with stakeholders. We conclude that market/political/social realities will prove a more intense participation of lobster fisheries in the certification initiative.

Microsatellite DNA profiling: a viable tool for the conservation and long-term sustainability of European lobsters (*Homarus gammarus*) stocks [O119]

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V-notching is a common management strategy used for the conservation and long-term sustainability of lobster stocks. It involves marking berried females with a small triangular 'V'-notch, and subsequently returning them to sea. This increases the potential number of surviving offspring with the associated benefits to stock recruitment. The main difficulty with V-notching schemes is the need to implement appropriate monitoring mechanisms. Invariably, this means fishermen bringing berried lobsters ashore and keeping them in cages while waiting for V-notching by fisheries officers. In addition to the complex/expensive logistics, this approach can cause substantial egg loss, undue stress, and high mortality. Microsatellite DNA profiling allows for the unambiguous identification of individual and families and hence provides an ideal tool for both monitoring and measuring the impact(s) of V-notching on local stocks. Thus, the comparison of the maternal genetic profile (DNA extracted from V-notches) with that of the offspring (DNA extracted from eggs) enables the confirmation that the V-notch is indeed from a berried lobster. Furthermore, the identification of the paternal contribution to the eggs can be acquired by subtracting the genetic input from the mother. The resulting family information can be used to assign an individual lobster caught in the fishery back to an individual that was released some years previously. Over time, it is possible to assess the contribution of the released V-notched individuals to the population and ultimately to the commercial fisheries. In here, we describe the initial results of a novel ongoing project/monitoring V-notching scheme using DNA profiling involving a partnership between the North-East Lobster Fishermen's Co-operative Ltd, in Northern Ireland, and Queen's University Belfast. A total of 26,000 lobsters have been genetically tagged over a ten years period.

Fishing for revenue: how leasing quota can be hazardous to your health [O120]

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Fisheries management decisions have the potential to influence the safety of fishers by affecting how and when they fish. This implies a responsibility of government agencies to consider how fishers may behave under different policies and regulations in order to reduce the incidence of undesirable operational health and safety outcomes. In the Tasmanian southern rock lobster fishery, Australia, the expansion of the quota lease market under individual transferable quota (ITQ) management coincided with a rise in the number of commercial fishing fatalities, with five between 2008 and 2012. A discrete choice model of daily participation was fitted to compare whether physical risk tolerance varied between fishers who owned the majority of their quota units (quota owners) and those who mainly leased (lease quota fishers). In general, fishers were averse to physical risk (wave height), however this was offset by increases in expected revenue. Lease quota fishers were more responsive to changes in expected revenue than quota owners, which contributed to risk tolerance levels that were significantly higher than quota owners in some areas. This pattern in behaviour appeared to be related to the cost of leasing quota. Although ITQs have often been considered to reduce the incentive for fishers to operate in hazardous weather conditions, this assumes fishing by quota owners. This analysis indicated that this doesn't hold true for lease quota fishers in an ITQ system, where in some instances there remains an economic incentive to fish in conditions with high levels of physical risk.

The use of management procedures in New Zealand rock lobster fisheries [O121]

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Management procedures (MPs) have been implemented in five rock lobster (*Jasus edwardsii*) fisheries in New Zealand and are currently being considered for 2 more stocks. The initial MP was implemented in 1997 to ensure the rebuild of stocks from a depleted state, while current MPs ensure that stock status is maintained above target levels. All current MPs use catch-per-unit-effort indices from the commercial fishery in the most recent year as an indicator of population abundance to determine the catch limits in the fisheries. Each management procedure has been simulation tested for robustness to uncertainty in the assessment model and assumptions on future recruitment and catch. A significant benefit observed from the implementation of MPs in the rock lobster fisheries has been that the fisheries are now managed more conservatively than required by New Zealand legislation. The MPs provide more certainty in setting catch limits and have resulted in healthy stock abundance, improved catch rates and better economic returns.

The pathway from research on lobster translocation into an industry-funded commercial enterprise [O122]

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Translocation of Southern Rock Lobster (*Jasus edwardsii*) involves capturing and moving lobsters between areas and has been explored in the Tasmanian fishery for decades. Lobsters in some areas are slow growing and can be captured in large numbers. These are then moved to areas with faster growth and released, achieving gains in production of around eight-fold. There were numerous concerns around this exercise which have been explored in a range of research projects including possible risk of disease transfer, economic feasibility, effects on egg production, ecological changes in source and release areas, and change to market traits of translocated lobsters. Operations have gradually transited from small research scale operations to commercial scale operations that now increase production in the fishery by around 5%. These are fully funded by the commercial sector and provide a return on investment of around 700% each year. Although the case for investment in this exercise seems clear, the pathway to adoption of this novel approach has not been smooth with much debate amongst industry. As a result the current operations have been kept well below the full potential. The project provides insight into successfully managing change by co-management with a large group of commercial fishers.

Spatial management of a rock lobster resource under a quota system: biological, fishery and economic considerations [O123]

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The Northern Zone rock lobster fishery of South Australia is extensive, covering approximately 207,000 km². The fishery is managed under transferable quotas, with a current total allowable commercial catch of 345 tonnes. The majority of catch is taken in eastern inshore grounds (<60 m), with low levels of exploitation in western and offshore (>60 m) sites. A number of spatial management options are currently being considered that broadly aim to encourage higher levels of exploitation in outlying fishing areas. As a basis for informing these options, this study examined biological, fishery and economic components of the fishery. Biological characteristics of maturity and size, including recruits as a proportion of catch, all varied spatially. Specifically, size of maturity and mean size were higher in western regions while recruitment indices were considerably lower. Spatial analysis of catch and effort from 1970 to 2012 quantified the gradual contraction eastwards within the fishing fleet, particularly after the introduction of quota. This occurred despite western region catch rates being the highest in the fishery. This is likely to reflect a change in fishing behavior after quota implementation, where fishers maximized economic return by targeting grounds where recruitment is most consistent. The economics of fishing western and offshore grounds was investigated during two experimental fishing trips that detailed price, cost, fishery catch and biological information. Overall, the work acts as a case study for lobster fisheries working over broad geographical regions and highlights specific requirements if management options are to be considered at finer spatial scales.

Pressure for co-management and certification of Brazil lobster (*Panulirus argus*) fishery – Fisheries Improvement Program FIP [O124]

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US importers are collaborating with Brazil to control the illegal fishing and exportation of the spiny lobster. Negotiations with Brazilian exporters are helping to control the supply-chain and providing financial support for a Fisheries Improvement Program (FIP) <http://www.sustainablefish.org/fisheries-improvement/shrimp/brazilian-lobster> launched by UNEP. Lobster exports from Brazil since 1950s have been mostly from the artisanal fishery. Later, driven by government subsidies the fleet expanded with over 250 steel vessels, catches reached 3.660 t lobster tails in 1979 quickly declining to 1.500 t in 1985. With the expansion of the fishing area, catches reached 3.500 t in 1993, and under pressure from artisanal fishers, the government entered into a co-management agreement. Lack of support from fishing industry and intergovernmental power struggles led to a stalemate and only a few management measures were implemented. Meanwhile, fishing effort increased with illegal fishing gear (gillnets and compressor diving), with a majority of exports to US from illegal origin. In 2012 exports crashed to 1.474 t, the lowest figure since 1985. In 2009 NGOs and artisanal fisher representatives convinced UNEP that it is possible to maintain a lobster fishery with a supply chain project, using control of origin and legal gear certification. But now they are concerned that the government is not investing in developing science and enforcement of the fishery recommended by the FIP. In 2012 fishers took to the streets and demanded to close the fishery for 2 years to give time for changes in deficient fisheries management and research in hopes for a chance at sustainability.

The Caribbean spiny lobster (*Panulirus argus*) fishery management system in Cuba [O125]

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The lack of an effective system of governance that contains the necessary elements to provide for Ecosystem Based Fishery Management, and the lack of compliance with regulations are probably the major threats to the sustainability of any commercial lobster fishery. The Caribbean spiny lobster *Panulirus argus*, the most valuable Cuban fishery resource, is managed with input, output and biological controls, which include: a state property limited entry regime, territorial rights to fishing enterprises, restrictions in the numbers of gear and boats, a 145-days closed season from February to June, permanently closed areas to protect juveniles and spawners, a legal minimum size of 76 mm carapace length (CL), a maximum legal size of 140 mm CL for females, a prohibition on taking berried females and females with spermatophores and a Total Allowable Catch (TAC) which is set annually depending on the previous stock assessment taking into account the environmental conditions. The Fisheries Research Centre (Centro de Investigaciones Pesqueras (CIP)) is the scientific branch of the Ministry of Food (MINAL) that coordinates groups of specialists that collect the biological information from the provincial fishing enterprises. Based on their studies, the CIP proposes the fisheries regulations to the Division of Fishing Regulations. Once the Advisory Commission on Fishing has analyzed and approved these regulations, it submits them to the Minister of the MINAL. Finally, the approved regulations are published by law decree. The control and enforcement is then carried out by the Fishing Inspection Office (ONIP).

Effects of changing the commercial strategy of lobster capture and sales at Banco Chinchorro, Mexico [O126]

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The reef community of the southern lagoon in Banco Chinchorro is rich and diverse, in contrast with the extensive sandy northern lagoon, almost lacking of visible life. Traditional spiny lobster fishery occurs in the southern lagoon and the reef slope. The ecosystem is assessed and the bio-economic status of this fishery is described. As from 2011, lobsters have been caught live with snares instead of with hooks, allowing for a change in the marketing strategy which shifted from lobster tails to whole/live lobsters. This change had a significant economic impact on the fishery as profits have increased up to 30% and landings up to three times in weight. Current profits should allow fishermen to contend with adverse climatic effects, to defray the costs of implementing new and more sustainable fishing gears such as artificial shelters (casitas) and practices in accordance to Principle 2 of the Marine Stewardship Council, as well as reducing fishing pressure on the southern reef lagoon. Recent adverse climate impacts like hurricanes, have contributed to reef deterioration in general; thus, a reduction in human activity in the southern area would be advisable to phase out the use of this portion of the reef and promote fishing only in the northern lagoon, where casitas are being installed as an alternative mean of recruitment and fishing technique. A reef ecosystem recovery of the southern portion of the lagoon would be best achieved by reducing human activities in the south, and favoring recruits in the north.

The Bahamian spiny lobster fishery: Current status and the ongoing journey [O127]

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During the most recent (2006) Western Central Atlantic Fishery Commission lobster management meeting, the status of the Caribbean spiny lobster (*Panulirus argus*) fishery in The Bahamas was classified as “unknown”. Indeed, a lack of region-specific information upon which informed management decisions could be made typified the fishery. However, The Bahamas recently embarked on a multiyear fisheries improvement project made possible by unprecedented cooperation among the government, private sector, local and international NGOs, and fisher organizations with further motivation for change driven by an interest in Marine Stewardship Council (MSC) certification of the fishery. As a result, management effort has grown by leaps and bounds. There is now a peer reviewed stock assessment of the fishery, an attempt to quantify illegal unreported and unregulated fishing, a study on the prevalence of the PaV1 viral disease, better stakeholder involvement through a formally established national spiny lobster working group, and studies aimed at unraveling some of the unknowns surrounding the effect of casitas on lobster fisheries. However, the journey is not complete, as The Bahamas aims to soon enter an MSC full assessment with the larger goal of ensuring sustainability.

Solving the lobster diving paradox: Closing the Honduran dive fishery without collapsing the rural economy [O128]

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For four decades the Miskito people who populate the remote region of eastern Honduras have worked in the scuba diving fishery to harvest spiny lobster from offshore banks. With basic and often poorly maintained SCUBA equipment these divers will complete up to 12 dives a day for 12 consecutive days during a typical fishing trip. The work is dangerous, with an average of 120 dive accidents each season requiring treatment in a decompression chamber. Around 20 of these accidents are fatal. In 2012 a census of communities in the Honduran Moskitia found 1,180 paralyzed men. This is 18% of the male, working age population in the region. There is general consensus that this damaging fishery needs to end, but the challenge is that closing the dive fishery would remove an estimated \$7.2 million from the rural economy, in an area where dive fishing is the main source of employment. Local groups in the Moskitia have been developing a viable solution: to replace the dive fishery with a skin diving fishery using lobster shades positioned around a string of 49 offshore cays, in a 14,500 km² area that the Miskito groups are asking to be designated for the exclusive use of artisanal fishers. Ongoing research to support the Miskito plans have integrated remote sensing, in-water surveys, genetic studies and market chain analysis to help underpin the development of this new lobster fishery. The aim is to convert a socially and ecologically damaging fishery into one that's locally managed and sustainable.

Poster Presentations

Abstracts

Climate Change

Interactive effects of ocean warming and acidification on aspects of the developmental eco-physiology of the European lobster, *Homarus gammarus* (L.) [P1]

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When investigating the potential effects of ocean warming and acidification on marine organisms with complex life cycles, understanding how physiological responses change during larval development is critical as physiological processes link life history traits to the environment. Consequently we investigated the physiological responses of the European lobster, *Homarus gammarus* (L.) to elevated temperature and $p\text{CO}_2$ at each stage of larval development. Larvae were reared under current and predicted future ocean warming and acidification scenarios and oxygen consumption, mineralization, organic content, survival and growth were measured throughout development. Larvae exhibited stage-specific changes in temperature sensitivity of their oxygen consumption, $p\text{CO}_2$ -related increases in C:N ratios and $p\text{CO}_2$ -related decreases in carapace mineralization. While no interaction between temperature and $p\text{CO}_2$ was found, the effects of $p\text{CO}_2$ were only present in stages experiencing decreased oxygen consumption due to elevated temperature. These physiological responses can be strongly linked to concomitant changes in survivorship and growth, presenting bottlenecks during *H. gammarus* larval development at Stages I and IV. Natural changes in optimum temperature during ontogeny is key to larvae survival in a future warmer ocean and when coupled with elevated temperature and $p\text{CO}_2$ result in significantly altered physiological condition and body size of the final larval stage which encompasses the shift from a planktonic to benthic life style (Stage IV). Thus larval lobster function is compromised by living and growing in warm, hypercapnic water with potentially knock-on negative consequences for later life history stages such as juveniles and adults through stage specific physiological bottlenecks during larval development.

Behavioral Ecology

Into a rhythm: Diel activity patterns and behavior in Mediterranean slipper lobsters, *Scyllarides latus* [P2]

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Although the natural history for Mediterranean slipper lobsters (*Scyllarides latus*) is well established, there exists a disproportionate lack of important biological and physiological data that verify many key traits, including to what extent endogenous rhythms modulate aspects of their behavior. Although Scyllarids, by and large, appear to be nocturnally active, few studies exist that directly examine these kinds of activity. Our overall objective was to determine and describe the patterns of activity expressed by adult slipper lobsters associated with light-dark (L:D) and constant (D:D) conditions. In the laboratory we exposed a total of 12 animals ($CL_{avg} = 92.6 \text{ mm} \pm 6.6$) to 12:12 L:D conditions for 7-10 days followed by D:D for 15-20 days. Activity was assessed using a combination of time-lapse video and accelerometers. Preliminary data suggests that most lobsters exhibit a preference for nocturnal activity although we did observe small bouts of activity during the day. These lobsters synchronize to a L:D cycle, expressing a daily activity pattern ($24.04 \pm 0.13 \text{ hr.}$). Over D:D periods, lobsters appear to maintain a circadian rhythm for at least several days (active 47% of nighttime vs. 14% of daytime). Actogram and periodogram analysis suggest *S. latus* activity is driven by an endogenous clock, as all individuals maintained a ~24 hr. pattern of activity ($23.87 \pm 0.07 \text{ hr.}$). These findings are important descriptors of behavior in this species and may be useful in interpreting subsequent locomotion, seasonal migration, and the ability to anticipate and respond to unfavorable environmental conditions.

Does aggression influence denning behavior of gregarious spiny lobsters in shelter limited habitats? [P3]

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Panulirus argus are highly gregarious and exhibit ontogenetic shifts in habitat use. Juveniles are often seen sharing natural shelters with conspecifics, and although *P. argus* is considered to be highly social, variation in aggressive and gregarious behavior is exhibited with high levels of aggression often resulting in individuals being excluded from dens. Natural shelters in Florida Bay, which provide *P. argus* with protection from predation, have recently decreased due to sponge loss events. Even after shelter loss, den use, den sharing, and lobster abundance have remained relatively constant suggesting that den competition may increase. To examine the influence of habitat loss on denning behavior, twenty individuals were collected from shelter high ($n = 8$) and low ($n = 8$) sites located within the National Marine Sanctuary of Florida Bay (USA). We measured individual characteristics (such as size, sex, health, etc.), and determined the frequency of den use, den sharing, and den fidelity of each individual in a mesocosm containing ten crevice shelters. To simulate a sudden shelter loss, five crevice shelters were removed and denning behaviors were remeasured. Surprisingly, the reduction of crevice shelters resulted in similar levels of den sharing, but reduced den use and den fidelity for large, aggressive lobsters. In addition, the frequency of solitary lobsters within a shelter was higher than expectations by random choice. This study suggests that vulnerability rather than aggression predicts which individuals remain within a shelter after habitat loss and that behavioral changes associated with ontogenetic habitat shifts have the potential to influence den competition.

Diseases and Parasites

Shell disease in American lobster: Identification of infection-promoting agents and projections for an expanding epizootic [P4]

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The American lobster (*Homarus americanus*) is a major commodity throughout the species' range; however, epizootic shell disease (ESD) has become an increasing threat to the lobster fishery. Environmentally-induced physiological stress has been identified as a potential major contributor to ESD host susceptibility. Conditions wrought by climate change often leave native biota such as lobsters poorly adapted to new conditions, likely resulting in physiological stress that could be related to the expanding range of ESD. Our research will use generalized additive models (GAMs) informed by more than three decades of observation across the species' range to determine the relative importance of a variety of potential biotic and abiotic stressors as contributors to disease prevalence. Additionally, we are developing a website featuring an interface that will allow fishermen and resource managers to enter information on ESD sightings. Submitted observations will be logged onto a user-configurable map which will allow geographic extent of ESD to be tracked over time. We will also incorporate environmental monitoring data supplied by our management agency partners that will graphically display current and historic disease prevalence alongside information on those variables that we find to significantly influence ESD presence. This research will identify stressors that drive ESD patterns, providing a resource for managers and stakeholders to detect and adapt to environmental changes and the accompanying spread of ESD. We will present preliminary results to engage researchers and resource managers in discussions on ESD in American lobster.

A new conceptual model for Shell Disease in the American lobster (*Homarus americanus*) [P5]

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Epizootic shell disease is a bacteria-induced degeneration of the cuticle of the lobster that can lead to disfigurement, decreased health, and subsequent mortality. It has already decreased the value of the US lobster fishery by upwards of US\$30 million annually, and is increasing in the most productive fishing grounds. Laboratory experiments and knowledge gained from the lobster fishery have provided a basis in identifying various critical factors in determining the progress of shell disease in lobsters. Temperature, bacterial activity, diet, and initiation of disease onset all play a significant role. More importantly, the length of the molt cycle and subsequent recovery from disease post-molt can be critical to determining disease severity and potential mortality due to shell disease. This knowledge provides the basis for a conceptual model, originally developed for human-parasite interactions, that is applied to lobster shell disease as a means to advance epidemiological modeling. This new stacked Individualized Health Trajectory model is a graphically adept means to understand the outcomes of a disease that is multifactorial in nature. The continued use of a laboratory model system to further study this disease will be important to be able to appropriately control the multitude of complicating factors and to create hypothesis driven predictive experiments.

The polychaete *Histriobdella homarus* and other epibionts on the European lobster [P6]

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The concentrations and interactions among epibiontic organisms found on *Homarus gammarus* have not been much studied. In this study the eggs and gills of *H. gammarus* from the Swedish west coast are analysed quantitatively for epibionts using vacuum micro-filtration and fluorescence microscopy. A number of species have been found so far, of which several are still to be identified at species level. A common epibiont is the small polychaete *Histriobdella homarus* (also found on the American lobster) as well as e.g. different mites, nematodes, copepods, amphipods, ostracods and foraminiferans. A large lobster can have over 20 000 *H. homarus* among its old eggs that are ready to hatch. The mean abundances of *H. homarus* per *H. gammarus* egg in 2007, 2008 and 2009 were 0.3, 0.6 and 0.5, respectively. The eggs and gills of lobster harbour an interesting food web and nematodes have been found feeding on *H. homarus*. The species-rich ecosystem found on lobster calls for joint studies including the American lobster and spiny lobsters.

A theoretical basis for the occurrence of gynandromorphy and ovotestes in clawed lobsters [P7]

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Intersexuality in the form of bilateral gynandromorphy has been observed rarely in homarid lobsters of the genus *Homarus* and *Nephrops* since the 1700's. In these cases, externally visible sexual dimorphism corresponds to internal development of an ovary and a testis, on opposite sides of the body. In many cases, gynandromorphy of this type co-occurs with striking bilateral colour dimorphism where one side of the animal may be orange, blue, or rarely, white. Although the mechanistic basis for gynandromorphy and colour dimorphism has not been investigated due to rarity of occurrence in lobsters, the condition is most likely associated with a non-disjunction event or a loss of chromosomes determining sex (and colour) during anaphase of the first division of the fertilised zygote. In these cases, respective sides of the body inherit the anomaly, causing bilateral dimorphism. Similar events occurring during anaphase in the 2, 4, 8 or subsequent cell stage lobster embryo will lead to progressively small regions of the body which contain the anomaly. Bilateral gynandromorphy contrasts the recently reported occurrence of ovotestis in *Homarus*. Here, intersex lobsters present externally as a male, but contain an ovotestis, containing elements of both male and female gonadal tissues. Although not studied directly in lobsters, evidence from other crustaceans suggests that such pathology relates to disrupted signalling to the germinal component of the testis from the androgenic gland. While gynandromorphy is likely to relate to rare mitotic failure, the development of ovotestes may be associated with exposure to environmental signals (including parasites or anthropogenic contaminants) with the ability to disrupt endocrine signalling.

Testing for the presence of PaV1 in oceanic phyllosomata and nektonic pueruli of *Panulirus argus* [P8]

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Previous studies have revealed the presence of *Panulirus argus* virus 1 (PaV1) in recently settled pueruli of *Panulirus argus*. As there is no evidence for vertical transmission of PaV1, infected pueruli probably acquire waterborne PaV1 at some point before settling. To our knowledge, testing for PaV1 in oceanic phyllosomata and nektonic pueruli has not been previously done. During two oceanographic cruises (R/V Justo Sierra) conducted in November 2012 and April 2013, hundreds of phyllosomata and pueruli of *P. argus* were collected in the shallow layer (0.5-16 m in depth) of open oceanic waters along nine transects perpendicular to the Caribbean coast of Mexico, up to ~100 km from the shoreline. PCR assays were used to test for the presence of DNA of PaV1 in 408 individuals: 51 phyllosomata in intermediate stages (VI–VII), 118 phyllosomata in advanced stages (VIII–X), and 239 nektonic pueruli. All phyllosomata tested negative for PaV1 and only one puerulus from the April cruise (0.25% of total organisms and 0.42% of total pueruli) tested positive for PaV1. The positive DNA fragment (499 bp) was bi-directionally sequenced and compared by multiple alignment against Genbank nucleotide archive. Homology with the PaV1 genome was 98%. These results suggest that pueruli may indeed acquire PaV1 from the water. However, as the infected puerulus was collected ~46 km offshore at a depth of <1 m over a water column 1,800 m deep, this raises other questions: why do phyllosomata not acquire PaV1? For how long are waterborne PaV1 particles infective and how far can they go?

Rickettsia-like organisms in Caribbean spiny lobsters: a putative concomitant infection associated to *Panulirus argus* Virus 1 (PaV1) [P9]

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Rickettsia-like organisms (RLOs) are obligate intracellular Gram-negative bacteria, responsible for massive mortalities in many aquatic animals including fishes, crustaceans and mollusks. These organisms have been reported in spiny lobsters (*Panulirus argus*) infected with the virus PaV1. Histological studies from the hepatopancreas were performed to determine the presence of RLOs in spiny lobsters from two localities of the Mexican Caribbean (Puerto Morelos and Bahía de la Ascension) during cold and warm seasons. A prevalence of 5.08% was obtained in lobsters from Puerto Morelos and 11.59% in lobsters from Bahía de la Ascension. Tissues of healthy lobsters did not present any rickettsial inclusions, suggesting that lobsters infected with PaV1, and specifically those heavily infected, are more susceptible to acquire them, as the number of colonies of RLOs was significantly associated to severity of PaV1 infection. Moreover, RLOs infection seems to be dependent on the life stage of lobsters, as juveniles appeared more susceptible to infection with RLOs than sub-adult lobsters. This could be due to ontogenetic differences in their immune response. However, the presence of RLOs was not dependent on sex and season. At present, only histological studies have been carried out and there are no conclusive data about the identity of RLOs infecting spiny lobsters, underlining the need to implement molecular tests to accurately identify these bacteria.

Prevalence and genomic variations of *Panulirus argus* Virus 1 (PaV1) in spiny lobsters from some Caribbean locations [P10]

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The prevalence and genetic variability of the pathogenic *Panulirus argus* virus 1 (PaV1) from multiple locations of the Caribbean has been reported recently. In the present study we document the prevalence and genetic variability of PaV1 in lobsters from sampling sites over southwest Cuba and the Caribbean coast of Mexico, two locations with high contributions to regional catches that were not included in previous studies. The prevalence of PaV1 ranged from 0 to 30% in the study area. DNA sequence analysis showed high variability among sites with the smaller sequence from Cuba, suggesting that the Cuban variant could be more pathogenic. The implications of these results in the context of larval connectivity are discussed.

Development of a qPCR assay for analyzing variability in viral load of *Panulirus argus* Virus 1 (PaV1) across lobster size scales [P11]

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Real-time quantitative polymerase chain reaction (qPCR) is a tool commonly used to help diagnose and characterize viruses. This highly sensitive technique has been implemented in studies measuring gene expression, detecting viruses, and determining dose-response levels in marine invertebrates. We are currently developing a qPCR assay to gauge the dose-response relationship in Caribbean spiny lobster, *Panulirus argus*, exposed to *Panulirus argus* Virus 1 (PaV1). Landings of this valuable fishery recently declined by 30% for reasons unknown. However, PaV1 is believed to have played a role. PaV1 infections show symptomatic variability across lobster size scales, often being lethal in small juvenile lobsters yet latent in adult lobsters. The drivers of this variability in PaV1 are largely unknown. The qPCR assay will be used to ascertain the effect that viral load of PaV1 may have on individual lobsters. Studying and quantifying the impact that PaV1 has on its host will provide insight into the virulent nature of this disease.

Population and Community Ecology

Evaluation of *Palinurus elephas* settlement at deep water by artificial lobster's collectors [P12]

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In the last fifty years the Mediterranean rocky bottoms between 30 and 90 meters had a healthy population of European spiny lobster (*Palinurus elephas*). Nowadays this species is only exploitable close to some marine reserves and in fishing grounds with a moderate fishing pressure. In the Balearic archipelago the lobster fishery is still profitable, but the population shows signs of over-exploitation. Over the last two decades, the oscillations in landings are a clear sign that the catches depend on the annual recruitment. Since the fishing effort is exerted largely in a single cohort, a proactive management is necessary, but this requires knowing in advance the annual settlement strength. To avoid the problem of standardizing the settlement index obtained by Underwater Visual Censuses (UVC), an array of artificial collectors were deployed (2011-2013) around a large exploited area in Balearic Islands. In order to investigate the settlement plasticity, 12 collectors units were deployed down to 70 m depth. Only one shallow station (-25 m) showed a similar result than the deep station (-70 m), whereas in three other shallow stations no lobsters were found. In general, the settlement index obtained by artificial collectors showed lower values than UVC. During 2012 no lobsters were found in the artificial collectors array. The observation of newly settled lobsters at -70 m denotes high settlement plasticity and this capacity must open our mind for understanding the dynamics of the species, whereas the strong annual variability of the settlement requires us to manage stocks carefully.

Settlement of *Panulirus interruptus* postlarvae in Bahía Tortugas, B.C.S., Mexico and its relationship to the ocean environment [P13]

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The red lobster *Panulirus interruptus*, is a crustacean that supports an important lobster fishery along the western coast of the Baja California peninsula. In the decade from 1993-2004 they averaged 1294 t, and they contributed about 1700 t recorded in 2009. Evidence shows that abundance of the post-larval settlement of *P. interruptus* is related to the catch volume that will be obtained five years from now. However, the analysis and understanding of the various ocean environment phenomena behind recruitment variability could replace the use of postlarval and early juvenile settlements in forecasting commercial catch if it is assumed that the natural mortality rate at the puerulus stage depends largely on abiotic environment. Since 1993 and for 106 consecutive months, a time series of postlarval spiny red lobster abundance was obtained from artificial collectors in the mid-western coast of the Baja California peninsula. Postlarval time series, temperature, sea level and upwelling rates, and southern oscillation were analyzed. Timing regularity agreed with the time series analyzed, so the postlarval recruitment series were rebuilt by using the minimum parameters and the Fourier model from abiotic variables, thus obtaining a predictive model. The Pearson correlation between the observed and expected values was 0.61, representing an improvement over previous predictive models, which could help forecast the varying recruitment abundance and consequently predict future commercial catch based on ocean variables.

Stomach content of early juvenile spiny lobster *Panulirus interruptus* in Bahía Tortugas, BCS, Mexico [P14]

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Panulirus interruptus is a fishery that makes up to 95% of the commercial catch of the Baja California peninsula. Stomach content analyses of adults from this species have shown an omnivorous diet, but that of juveniles is poorly understood. Our work analyzes the stomach content components of 163 juvenile specimens from 5 to 30 mm in carapace length captured with artificial collectors monthly for one year. The 14 trophic elements identified according to their relative importance were: shellfish, unidentified organic matter (UOM), algae, invertebrate eggs, foraminifera, annelids, seagrass, sponges, insects, bryozoans, nematodes, radiolarians, and pollen grains. Mollusks and crustaceans were the dominant components, and the remaining groups were casual. The niche overlap between sizes was estimated using the simplified Morisita index, and similarity between seasons of the diet was calculated with the Jaccard similarity test. The change in diet was gradual as they grew older; diet overlap within size intervals was moderate with values from 0.35 to 0.46. Diet similarity was higher in autumn and winter (0.9), and the lowest similarity occurred in the spring (0.55). In other seasons the similarity value was approximately from 0.60 to 0.70, indicating overall a similar diet in all seasons. In conclusion, juvenile *P. interruptus*'s diet was omnivorous with a moderate overlap within size intervals and similar to that reported in adults of this genus, with little seasonal variation.

Variability in condition of recently settled pueruli and first-stage juveniles of Caribbean spiny lobster (*Panulirus argus*) [P15]

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The non-feeding postlarva (puerulus) of *Panulirus argus* actively swims from oceanic waters toward coastal benthic habitats to settle and eventually molt into the first juvenile stage, which resumes feeding. Because energetic expenditure may depend on pre-metamorphosis condition of phyllosomata and/or distance travelled, the condition of settled pueruli and the ensuing first-stage juveniles likely varies over time, potentially affecting their survival. Across 12 consecutive seasons (autumn 2010–summer 2013), we collected pueruli (n/season: 20–45) and first-stage juveniles (n/season: 12–35) from collectors deployed in Puerto Morelos, Mexico, and measured their carapace length (CL, mm) and weight (W, mg) to examine seasonal variation in the ratio W/CL (an index of condition) of both stages. Both CL and W were overall significantly lower in pueruli than in first-stage juveniles. Seasonal variability in condition was separately examined for each stage via an ANCOVA after controlling for the covariate (CL) effect. Mean condition of pueruli was relatively stable across seasons except for a significantly lower value in winter 2011. In contrast, mean condition of first-stage juveniles varied widely across seasons, with higher values in autumn 2010–spring 2011 and lower values in autumn 2011–winter 2012. These results suggest that, within any given season, pueruli already exhibit variable condition upon starting to swim and/or come from a wide range of distances from the coast, but after molting into first-stage juveniles and resuming feeding, their foraging activity and feed intake are likely affected by local factors such as food availability and predation risk.

Population biology of the blue spiny lobster (*Panulirus inflatus*) from the Pacific south coast of México [P16]

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The blue spiny lobster (*Panulirus inflatus*) is restricted to the Pacific coast of Mexico, where it constitutes an important fisheries resource. Fishing regulations for *P. inflatus* include a minimum legal size (75 mm carapace length, CL) and a 4-month closed season (July to October). The present study was conducted in the southern state of Oaxaca, where fishers use compressor diving and hooks to catch lobsters, and whole lobsters are locally sold. From November 2008 to November 2009, monthly samples were obtained from the commercial catch in Puerto Ángel, Oaxaca. In all, 1730 individuals of *P. inflatus* were sexed (789 females, 941 males) and their CL (mm), tail length (TL, mm) and weight (W, g) were measured to examine their size distribution, morphometric relationships, sex ratios, proportions of ovigerous females, and size at first reproduction (CL₅₀) of females. All mean dimensions (CL, TL and W) were larger for males than for females, but the TL increased more rapidly with increasing CL in females than in males, showing a clear morphometric difference between sexes. Sex ratio was 1:1 throughout the year except in February 2009, when males predominated. Ovigerous females were present throughout the sampling period but in greater proportions from July to November 2009 (i.e., the closed season). The estimated CL₅₀ of females was 76.98 mm CL, corresponding to a weight of 223.34 g W. These results suggest that biological characteristics of *P. inflatus* are similar to those observed in other tropical species and that its fishing regulations are biologically sound.

Population biology of painted spiny lobster (*Panulirus echinatus*) in the São Pedro and São Paulo Archipelago, Brazil [P17]

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The main fishery target lobster species in Brazil are *Panulirus argus*, *Panulirus laeviscauda*, and *Panulirus echinatus*, the painted lobster. Due to increasing demand from the international market and the overfishing of *P. argus* and *P. laeviscauda*, there has been a considerable increase in the catches of painted lobster. With the aim of generating biological information to help promote sustainable exploitation of this resource, the population of *P. echinatus* from São Pedro and São Paulo Archipelago was analyzed in six scientific expeditions during the dry and rainy seasons of 2008 and 2009. Total length and sex of 2,287 lobsters were determined. Males were significantly larger and heavier than females due different ways of energy allocation between sexes. Total lengths and weights were correlated with sea surface temperature that accelerate metabolic processes and directly affect the ecdysis. The value of 6.58 g/trap/day was considered high for lobster catches on the Brazilian coast, probably because it is a remote and preserved area. Catch per unit effort (CPUE) values were higher in the dry than rainy season. The high concentration of calcium carbonate in the water in the rainy season favors the ecdysis, in which the lobsters hide in deep regions to protect themselves from predators. The sex ratio was 4.2:1 (male-female) and may be related to differentiation in migratory reproductive behavior. Although *P. echinatus* is exploited commercially in Northeast Brazil, there are no regulations for its capture. Therefore, these results are important because they help in developing strategies for management and conservation of this species.

Why do young Japanese spiny lobsters aggregate in sea anemone colonies? [P18]

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Though immature benthic stages of the Japanese spiny lobster (*Panulirus japonicus*) generally inhabit algal beds, fishermen in Ooita Prefecture, Japan, report that young lobsters aggregate in sea anemone colonies, which grow densely on small boulders in Nagoya Bay, by Saiki city. Lobsters with carapace lengths ranging from approximately 15 to 65 mm hide during the daytime under small boulders densely covered by sea anemones, *Entacmaea actinostoloides*. The algal community around these colonies, which are at a water depth of about 8 m, is extremely sparse, and the lobsters are not found under boulders at nearby sites outside the sea anemone colonies. Field observations indicate that the dense sea anemone colonies on small boulders provide alternative shelter for young lobsters in this area, which lacks bottom irregularities and has a poor algal community. We discuss the reasons why the young lobsters aggregate in the sea anemone colonies in relation to seasonal changes in the lobster population and spatial differences in bottom environmental features (algal bed, substrate, water depth) around the colonies.

Fauna caught in collectors for spiny lobster postlarvae (*Panulirus* spp.) in the southeastern Gulf of California [P19]

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The composition of the fauna caught in modified Sandwich collectors for postlarvae of *Panulirus inflatus* and *P. gracilis* was studied, given that some of these organisms may represent the primary food for the smallest juveniles of these lobsters. Samplings were made during 2010 y 2011 in four stations within the Mazatlan Bay, southeast Gulf of California (Mexico). A total of 20,632 organisms were collected. The community was constituted by 30 families, 35 genera and 35 species. The most representative groups were Amphipoda (73.3%), Brachyura (15.9%), Caridea (4.4%), and Opisthobranchia (1.2%). Ecological analyses (Shannon-Winner, Margalef, Simpson and Morisita indices) showed a greater abundance of fauna in collectors deployed in the Antepuerto station (Mazatlan harbor entrance) but a greater diversity in the Ensenada Puerto Viejo station (Mazatlan Bay). The groups with stronger relationship with spiny lobsters from the southeast Gulf of California were anomurans, carideans, pycnogonids, fishes, brachyurans, and stomatopods.

A mark-recapture study with natural marks in juvenile Mexican lobsters, *Panulirus inflatus* [P20]

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From July 2011 to June 2012, 210 juvenile spiny lobsters (*Panulirus inflatus*) were marked and released in the Mazatlan Bay, southeastern Gulf of California. The juveniles were collected by hand using free diving and were marked in the laboratory. Using scissors large enough to clip the uropod in one motion, individual marks were made to easily recognize these juveniles. Regenerated uropods showed recognizable distortions that remained visible for several weeks. A total of 18 juveniles were recaptured (8.6%). The recaptured lobsters showed good development and growth. The longest time between mark and recapture was 66 days, with an increment in size of 4.6 mm carapace length (CL). The absolute growth rate was estimated in 5.3 mm CL per month. Some organisms molted without showing growth in size.

Lobster in a Bottle – A novel technique for predation observation [P21]

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Determining the impact of predators on juvenile spiny lobsters living on reefs is very important for understanding recruitment processes that ultimately help to determine the size of fished lobster populations. In this study a novel video device was used on reefs to make 24 hour observations of attempted predation on live juvenile *Jasus edwardsii* housed in a transparent container. The container consists of a transparent and perforated plastic bottle which was illuminated at night with infrared light to allow continued video recording with an infrared sensitive camera. The technique proved to be a significant advance on our earlier efforts to use conventional tethering methods, which were greatly influenced by predators being attracted to divers deploying the tethered lobsters (up to 85% of all recorded predation events). In contrast, the lobster housed within the transparent bottle was observed to be subjected to multiple predation attempts over 24 hours. The majority of predation attempts were recorded during the day (57%) followed by dawn (18%), night (15%) and dusk (10%). Video observations identified rock cod (*Lotella rhacinus*, 38%), conger eel (*Conger verreauxi*, 29%) and adult spiny lobster (*Jasus edwardsii*, 14%) as major nocturnal predators. During day we identified distinct predator behavioural patterns, such as guarding the potential prey (kelpfish -*Chironematus marmoratus*, blue cod - *Parapercis colias*) or continuous striking attempts by the spotted wrasse - *Notolabrus celidotus*. The results confirmed the importance of methodology for in situ predator observations, and provided initial data on the predation pressures on reef-dwelling juvenile spiny lobsters.

Distribution and abundance of Family Nephropidae in the southern Gulf of Mexico [P22]

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We collected 381 organisms belonging to 4 species of the family Nephropidae: *Nephropsis aculeata* S. I. Smith, 1881; *N. rosea* Bate, 1888; *N. neglecta* Holthuis, 1974; and *Acanthacaris caeca* (A. Milne-Edwards, 1881). This material was collected during 9 oceanographic cruises conducted in the southern part of the Gulf of Mexico onboard of R/V *Justo Sierra* of the Universidad Nacional Autónoma de México since 1999. First two species were the most abundant (214 and 135 individuals, respectively). Both species presented highest abundances in the Campeche Bank at 500-599 m depth interval. Abundance showed significant statistical differences among depth intervals and season in both species. *N. aculeata* females $F(3, 102) = 9.3261$, $p < 0.05$, males $F(2, 105) = 10.5307$, $p < 0.05$; *N. rosea* females $F(2, 132) = 3.6479$, $p < 0.05$, males $F(2, 80) = 3.1679$, $p < 0.05$; and seasons: *N. aculeata* females $F(3, 102) = 3.3763$, $p < 0.05$, males $F(2, 105) = 6.5317$, $p < 0.05$; *N. rosea* females $F(3, 131) = 4.1953$, $p < 0.05$. *N. aculeata* and *N. rosea* females with spermatophore were more abundant in autumn (22.5%) and spring (17.3%), respectively. Males with spermatophore of both species, *N. aculeata* (12%), and *N. rosea* (13.9%) were more abundant during spring. It suggests that these species have different temporal peaks of reproductive activity.

Population traits of the flatback lobster *Stereomastis sculpta* in the Gulf of Mexico [P23]

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The distribution and abundance of flatback lobster *Stereomastis sculpta* in the Gulf of Mexico was analyzed during two research cruises conducted on board the R/V JUSTO SIERRA of the Universidad Nacional Autónoma de México during autumn 2008 and summer 2009. Samples were obtained with a commercial shrimp trawl net (18-m mouth aperture, 4.5-cm stretched mesh body, 1.5-cm stretched mesh cod-end) in a depth range of 300-1200 m. A total number of 416 organisms were collected (248 females, 168 males). Mean density (7.2 ind/ha) was higher in autumn than in summer (3.2 ind/ha). Highest densities in both cruises were recorded at 700 m depth. Cephalothoracic length range for both sexes was 17.8 to 66.7 mm with a mean of 43.4 mm. Female size range was slightly larger (17.8-66.7 mm, mean = 44.4 mm) than males (20.3-61.9 mm, mean = 38.6 mm). Significant differences in mean size were found ($F_{7,408} = 3.89$, $p < 0.05$) between 100-m depth strata. Size showed a negative relationship with depth. Size of massive maturation was estimated at 55 mm CL. Oviparous females were more abundant in summer than in autumn with 12 and 6% of total number. This suggests a reproduction peak during summer, which should be corroborated with further studies.

Lobsters from the deep: Nephropidae and Polychelidae from the upper continental slope of the Yucatan Peninsula [P24]

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The continental slope around the Yucatan Peninsula (Mexico) is a steep escarpment from which little information on crustaceans in general is available. Deep-sea lobsters were collected during six research cruises of the R/V *Justo Sierra* aimed to survey the benthic biodiversity from this escarpment between depths of 250 and 1071 m (upper slope). Lobsters were caught in bottom trawl nets, benthic skimmers, and baited traps. Individuals were sexed and their carapace length (CL, mm), total length (TL, mm) and weight (W, g) were measured. In all, 417 lobsters were collected from four species of Nephropidae [*Nephropsis aculeata* (n = 238), *N. rosea* (n = 75), *Acanthacaris caeca* (n = 28), *Thaumastocheles zaleucus* (n = 2)] and three species of Polychelidae [*Polycheles typhlops* (n = 56), *Stereomastis sculpta* (n = 13), *Cardus crucifer* (n = 5)]. The largest species was *A. caeca* (62.4 ± 27.3 mm CL, mean ± SD) and the smallest *C. crucifer* (19.2 ± 4.3 mm CL). Among species within each family, there were significant differences in mean size and little overlap in bathymetric distribution. The shallowest distributions corresponded to *N. aculeata* (262–550 m) and *P. typhlops* (393–704 m) and the deepest to *N. rosea* (521–1071 m) and *T. zaleucus* (821–1071 m). Morphometric relationships (CL vs. TL, CL vs. W) were obtained and compared between sexes within species and between species within families. The present study increases knowledge on crustacean biodiversity of this little-known region.

Lobsters in Antiquity

History of utilization of Cape rock lobster *Jasus lalandii* by humans along the west coast of South Africa from pre-historic times to the present [P25]

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A chronological record of the exploitation of the Cape rock lobster *Jasus lalandii* by humans along the west coast of South Africa is provided, from pre-historic times to the present, based on available literature. Excavations of shell middens in caves and shelters at the coast suggest increased reliance on marine shellfish (limpets, mussels, whelks, chitons, rock lobsters) in a 'megamidden' period between 3000 and 2000 BP. This coincides with increased human habitation in the area after 3500 BP. Rock lobster remains in shell middens comprise calcareous mandibles and exoskeleton fragments, and lobster size has been estimated from preserved mandibles. Human occupation waned after the megamidden period, but pre-colonial foragers (500–1000 BP) relied on large numbers of rock lobsters as part of their diet. The latter part of this period is characterized by opportunistic short occupations during a period of high marine productivity. The arrival and expansion of European settlers in the 15th and 16th centuries effectively ended traditional foraging in the area. In the 19th and 20th centuries lobsters were 'easily caught in vast numbers all the year round' and were known as 'food for the poor'. Commercial exploitation began in 1875, when a processing plant was established in Cape Town to can lobsters for export to Europe. The fishery expanded rapidly from the early 1900s and peaked in the early 1950s at about 17 000 tons. Commercial landings have since declined to <10% of what they were at the height of the commercial fishery.

Reproduction, Development and Physiology

Spermatophores produced by electro-stimulation of male lobsters (*Homarus americanus*) vary in size and content [P26]

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Variation in the quality of ejaculate produced by male *Homarus americanus* has been previously described, but never quantified. We subjected 141 males (size range: 60 mm CL to 109 mm CL) to an electro-stimulation technique to obtain ejaculate for analysis of size and composition. Gonopods were electrically stimulated, producing the ejaculate which is a single tubular spermatophore composed of an inner tube or 'pocket' of spermatozoa surrounded by acellular material that hardens into a sperm plug. Each spermatophore was weighed, then placed in a small amount of sea water and photographed under a dissecting microscope with transmitted light. Spermatophores were then fixed in Bouin's solution, rinsed and stored in 70% ethanol. For histology, fixed spermatophores were dehydrated (graded ethanol), cleared in xylene, then embedded in paraffin wax. Blocks were sectioned longitudinally at 5 μ m thickness and sections were mounted on glass slides and stained with modified Masson's trichrome. The composition of each spermatophore was determined using two different methods. The first method utilized the two-dimensional image taken of the entire structure, while the second utilized multiple serial histological images of the spermatophore. Image analysis software was used to measure the area of the entire spermatophore, then of the internal sperm "pocket," to calculate the relative composition of the spermatophore (% sperm). Not all males produced a spermatophore with this technique; 52% percent of the males produced a spermatophore from each gonopod, 24% of males produced only one spermatophore, the remainder produced none. Preliminary results suggest that while spermatophore weight increases with male size, there is no relationship between male size and spermatophore composition.

Temperature accurately predicts fecundity in a regional lobster population [P27]

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Throughout northern Europe, fecundity in the European lobster, *Homarus gammarus*, exhibits extensive spatial variation. While this has been previously attributed to differences in egg production estimates as a result of dissimilar sampling strategies between studies, we show significant correlations between female fecundity and local sea-surface temperature that suggest spatial variation in fecundity does occur and is environmentally driven. Using general linear models based on physical fecundity counts made by previous studies on 1,090 ovigerous females from 11 locations in the UK, Ireland and Norway, we showed a highly significant positive correlation between mean annual temperature range and female fecundity at the minimum landing size (MLS), and a negative correlation between mean annual temperature and size-specific fecundity. Temperature data for Cornwall, UK, was used to predict fecundity at MLS (intercept) and size-specific fecundity (slope), and the results compared to those obtained by physical egg counts on 52 ovigerous females from lobsters from Cornwall. Predicted fecundity at MLS was within 2% of the observed value, and the predicted size-specific fecundity slope within 12% of the observed value. We propose that temperature-correlated fecundity predictions provides a useful tool for estimating egg production among lobster populations within the extent of geographic and temperature ranges of existing fecundity assessments. Further, these findings suggest that adaptive evolution may have occurred among *H. gammarus* populations, limiting the extent to which non-native lobsters should be used in stocking schemes, as well as having worrying implications for the conservation of lobster populations in the wake of oceanic warming.

Mapping and navigating the reproductive anatomy in Mediterranean Slipper lobsters, *Scyllarides latus* [P28]

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Lobsters belonging to the family Scyllaridae, although known and described for centuries, have historically been devoid of scientific information especially when compared to that of clawed and spiny lobsters. Despite its commercial importance in many areas throughout its Mediterranean-Atlantic range, descriptions of the reproductive biology of Mediterranean slipper lobsters (*Scyllarides latus*) remain limited and fragmented. The goal of the present ongoing study is to improve the general knowledge of anatomical reproductive structures in *S. latus*. We hope to provide a more comprehensive look at the structure and function of the reproductive anatomy. Here, we describe and document the reproductive tracts for six adult lobsters (3 males, CL_{avg}= 90 mm; 3 females, CL_{avg}=92 mm) through systematic dissections and the use of hi-resolution images and selected drawings. Histological work will also help to further impart a better understanding of the function of many of these structures. Overall, our findings provide the first detailed look at the comparative reproductive anatomy and will be useful in future physiological studies of this commercially important Mediterranean species.

The effect of size on spermatophore production and fertilization success in the Caribbean spiny lobster, *Panulirus argus* [P29]

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The average size of spiny lobsters (family Palinuridae) has decreased worldwide over the last 30 years. Market forces coupled with existing minimum size limits compel fishers to target the largest individuals. Disproportionately, males are targeted as a consequence of their increased growth and general protections for ovigerous females. As highlighted in several decapod fisheries in recent times, sperm limitation can have serious repercussions for population reproductive success. In the Caribbean spiny lobster *Panulirus argus* little is known about the effect of reduced male size on fertilization success or the role that individual size plays in gamete and larval quality. We conducted a series of laboratory experiments to test the relationship between male size and spermatophore production over multiple mating events, and to determine whether spermatophore reduction and female size affected fertilization success or larval attributes in *P. argus* in the Florida Keys, Florida (USA). We found that larger males recharged their sperm stores at a faster rate than smaller males and that male size was closely correlated to fertilization success. Where spermatophores were experimentally reduced, fertilization success dropped indicating that where large males are removed sperm limitation is likely. Maternal effects on egg and larval quality were observed. These results indicate the importance of maintaining large males in populations of *P. argus* in terms of fertilization success and that by removing these individuals through fishing we may be severely reducing reproductive success.

Mate choice, mate competition, and the contrasting reproductive biology of temperate and tropical spiny lobsters [P30]

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Sperm limitation of reproductive success is common in decapod crustaceans, favoring mating systems in which females compete for large males of high reproductive value. We investigated this phenomena in two species of spiny lobsters – one temperate, one tropical - with contrasting reproductive systems: the Southern Rock Lobster (*Jasus edwardsii*) and the Caribbean Spiny Lobster (*Panulirus argus*). We hypothesized that female mate selection should be more pronounced in the temperate *J. edwardsii* than in the tropical *P. argus* because *J. edwardsii* matures later, has a shorter mating season, and produces just one clutch of eggs per year that benefit from significant maternal investment of resources. As hypothesized, experiments conducted in large mesocosms revealed that female *J. edwardsii* cohabited with large males more often than expected by chance during their receptive period, but not at other times. Large female *J. edwardsii* competed with other large females for access to large males; small females did not compete for males. Large male *J. edwardsii* cohabited in dens with the largest unmated females whereas small males exhibited no mate size preference. In contrast, the proportion of female and male *P. argus* that co-occupied dens with the opposite sex was no more than expected by chance. Cohabitation patterns in the wild supported these laboratory findings for both species. Our results demonstrate the tight connection between contrasting reproductive strategies and the specificity of mate choice in spiny lobsters that are consistent with predictions based on environmental seasonality in temperate versus tropical ecosystems.

Use of jellyfish as the sole food for rearing phyllosomas of the scyllarid lobster *Ibacus ciliatus* [P31]

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Phyllosomas of scyllarid lobsters are known to associate with jellyfish and salps in natural waters, suggesting that they utilize a wide variety of gelatinous zooplanktons as prey. In fact, phyllosomas of *Ibacus novemdentatus* demonstrate higher growth and survival rates when they feed on jellyfish compared to when they feed on clams and brine shrimp. To investigate the efficiency of jellyfish as food also for *I. ciliatus* phyllosomas, 22 newly hatched phyllosomas were kept individually and fed only jellyfish *Aurelia aurita* and *Chrysaora pacifica* throughout the rearing period. Of 18 phyllosomas (81.8%) that survived to the 7th instar, 9 (40.9%) directly metamorphosed into nistos, whereas 4 (18.2%) developed to an additional instar (8th instar) before metamorphosis (the other 5 died during development). The average duration from hatching to metamorphosis into nistos was 66.8 days (range: 65–70) in the case of 7th instar phyllosomas and 79.3 days (range: 76–82) in the case of 8th instar phyllosomas. Although nistos originated from both instars, only those from 7th instar phyllosomas could successfully molt into juveniles. In conclusion, we obtained 5 juveniles (22.7%) in the present study. This is the first report of complete development from hatching to the juvenile stage in *I. ciliatus*; rearing was successful only till the nisto stage in previous studies in which clams and brine shrimp were used as food. Our method of using jellyfish as food may effectively improve the growth and survival of phyllosomas, particularly those belonging to the genus *Ibacus*.

Metabolic adjustments of *Panulirus argus* to thermal maxima limits [P32]

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The tolerance limit to temperature has been measured through the evaluation of critical thermal maximum limit (CTMax) that assumes that this condition does not provoke any permanent physiologic damage. The present study was done in attempt to evaluate the effect of CTMax test on oxygen consumption (VO_2) of *Panulirus argus* during recovery period. Wild juveniles were collected by Scuba diving in Sisal, Yucatan, Mexico. Lobsters of CTMax group were exposed at temperature increments of $1^\circ\text{C}/\text{min}$ until they lost their muscular control. The control group was manipulated in the same form that CTMax lobster but without the increment of temperature. Immediately after the tests lobsters were placed into the flow through respirometric chambers where animals remained for 24 h without disturbance. Manipulation and temperature exposures provoked increments on VO_2 of lobsters of 230 and 313%, control and CTMax groups, respectively. Control group reached their VO_2 value 4.5 h after manipulation while the CTMax group reached their maximum rate 5.63h after high temperature exposure. Differences between VO_2 of lobster exposed to CTMax and manipulated indicate that nine h after CTMax exposure were necessary to lobster recovery. Those results suggest that the actual tests used to evaluate the thermal tolerance of lobsters really allow the lobsters to return to their original physiological condition validating the methodology. At the same time those results put in evidence that 1 min of exposure to thermal limits provoked a dramatic change of metabolism of lobsters suggest a high thermal sensitivity of juveniles of this species.

Effects of temperature and salinity in dark and light condition on QO_2 of phyllosoma larvae of *Panulirus interruptus* [P33]

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In this study we examined the oxygen consumption (QO_2) of *Panulirus interruptus* phyllosoma larvae one day after hatching in response to a combination of different temperatures (11, 17, 22, 27 and 31°C) and salinities (22, 28, 33.5 and 42 ups), in conditions of light and darkness. The oxygen consumption of larvae ($\mu\text{l O}_2 \text{ mg}^{-1} \text{ h}^{-1}$) was measured with polarographic equipment in closed chambers. A three-way ANOVA was applied to the data, and a highly significant ($p < 0.001$) effect was obtained for all three main factors (temperature, salinity and light-darkness) on the QO_2 of the larvae. Also, there were significant interactions between temperature and salinity ($p < 0.001$), and between salinity and light-darkness ($p = 0.016$), but not between temperature and light-darkness ($p = 0.697$). The data were graphed as a response surface. The value for QO_2 in hatching conditions (22°C and 33.5 ups) was 1.8 and 3.7 times greater than in conditions of 11°C and 33.5 ups, and 11°C and 42 ups, respectively. QO_2 values ranged between 0.12 and $0.86 \mu\text{l O}_2 \text{ mg}^{-1} \text{ h}^{-1}$ while Q_{10} values ranged between 1.04 and 3.34. These results show that phyllosoma-1 of *P. interruptus* display an ability to compensate their QO_2 in temperature and salinity conditions different from those of hatching (22°C and 33.5 ups).

Connectivity and Larval Studies

Canadian Fishery Research Network, Project 1.3: Factors influencing recruitment and early survival of lobsters [P34]

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The recruitment of the American lobster (*Homarus americanus*) is influenced by abiotic and biotic factors including larval dispersal and settlement. Larval deposition on the seafloor is a critical stage of the lobster life cycle and its success depends on stage IV survival skills to avoid mortality. Besides searching for particular habitat conditions, lobster larvae are vulnerable to predators and will adopt a cryptic behavior to increase survival. The first descent towards the bottom is observed 2 to 6 days after metamorphosis. They then seek for a shelter on the seafloor. The lobster industry has identified research priorities to better understand the biology of the resource, including recruitment processes. Hence, a better knowledge of key ecosystem processes and their influence on the status and productivity of lobsters is needed to better manage stocks. Within that frame, the industry has identified parameters that need to be addressed to better understand recruitment. The objectives of our research group are to investigate the effect of temperature, sedimentation and predation on the behavior of stage IV larvae. The project's goal is to train graduate students for an industry in need of knowledge, expertise and new ways to understand and predict the health of lobster stocks.

Light traps as a tool to sample pelagic larvae of American lobster (*Homarus americanus*) [P35]

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We built a simple inexpensive light trap and tested its efficacy at catching pelagic larvae of the American lobster *Homarus americanus* in the field and the laboratory. We were particularly interested in assessing the potential of using these traps to research pelagic-benthic coupling, and therefore contrasted the abundance of postlarvae in the light traps to spatial variability in postlarval settlement. In laboratory experiments, 55% of postlarvae were caught by the light traps, and 24% of postlarvae placed inside the light traps escaped, over a 24-hour period. In the field, light traps caught lobster larval stages I and IV. Catches of lobster postlarvae were lower than in previously published larval tow studies when standardizing for the amount of time in the water, but were roughly similar to these when standardized for the number of work hours required. The light traps also caught other invertebrates, such as northern krill and all larval stages of green crabs and Atlantic rock crab, as well as some fishes. The abundance of postlarvae was significantly related to spatial variability in settlement, but unsurprisingly that of stage I larvae was not. Our results suggest that light traps may eventually provide a tool to sample lobster larvae and postlarvae, which may be particularly useful to study pelagic-benthic coupling as this passive sampling device better lends itself to the simultaneous sampling of many areas than do larval tows. However, we believe further lab and field experiments should be conducted to improve the efficacy of this tool in American lobster research.

Spatial variation and abundance of *Panulirus* spp. phyllosomas off the coast of Quintana Roo, Mexico [P36]

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Spiny lobsters (*Panulirus argus*) are an immensely important fishery resource throughout the Caribbean basin and in Quintana Roo. However, our present ability to link larval distributions and abundance to particular geographic areas is difficult given the lack of spatio-temporal knowledge and the complex life-history of the phyllosoma stage. We set out to provide better resolution for the spatial distribution and abundance of *Panulirus* spp. phyllosomas along the northern portion of the Mesoamerican Reef in Quintana Roo. Phyllosoma collections were obtained in March-April 2006 on an oceanographic cruise (R/V Gordon Gunter) where samples were collected at 49 different stations using a MOCNESS (1-m² diameter, 335µm mesh) system over five distinct depth intervals: 0-25, 25-50, 50-75, and 75-100m. A total of 1,129 phyllosomas were identified taxonomically from the families Scyllaridae and Palinuridae. The highest abundances of phyllosomas were recorded between 0 and 50 m depth with 68% of all phyllosomas concentrated around Banco Chinchorro. Additionally, early phyllosomal Stages (I-III) of the genus *Panulirus* accounted for 34% of catches and were also concentrated near Banco Chinchorro. Only 2% of all catches consisted of late Stage (IX and X) phyllosomas of the genus *Panulirus*. Our results highlight the spatio-temporal dynamics during the phyllosoma life stage, and help to delineate a more comprehensive picture of the connectance as well as the potential utility for the management of this fishery including the protected areas of Quintana Roo.

Effect of temperature on development rate of larvae from cold-water American lobster (*Homarus americanus*) [P37]

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The duration of the larval phase of the American lobster influences the distance larvae drift, and thus the potential settlement and recruitment patterns of lobsters to local populations and fisheries. The duration of larval stages is influenced by temperature, with warmer temperatures resulting in faster development and shorter stage duration. The quantitative relationship between temperature and duration of larval stages has been previously investigated, but only for lobsters originating from relatively warm-water regions. We examined the effects of temperature on stage duration for lobster larvae originating from a cold-water region, the northern shore of the Gaspé Peninsula in the northern Gulf of St. Lawrence, Canada. We reared larvae individually using a new experimental apparatus with automated movement of culture containers to facilitate water exchange. We compared observed duration of larval stages for these cold-water source larvae to durations in previous studies that used warmer-water source larvae. We observed 38% shorter development times at the coldest temperature used (10°C) and 47, 50, and 100% longer development times at warmer temperatures (14, 18 and 22°C, respectively) than at the same temperatures in previous studies of warm-water larvae, suggesting potential geographic variation in the functional relationship between temperature and larval development time. Given these results, future research should examine this question in more detail, to enhance understanding of lobster ecology and population dynamics across the species' range.

Potential importance of interactions between mean and variability of water temperatures to realized development times of American lobster larvae [P38]

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American lobster larvae have been reared at constant temperatures to examine the effects of temperature on larval development time, and then to estimate larval drift and potential fisheries recruitment. However, in nature individual lobster larvae are exposed to varying temperatures, which might result in different development times than would be predicted from mean temperature values alone. To examine the potential importance of thermal variability on development time of lobster larvae, a model was developed to simulate development of lobster larvae from hatch through larval stages I-IV, under different combinations of mean and variance in temperature, reflecting those experienced by larvae in nature both historically and in the future. The model generated daily temperatures experienced by larvae based on these thermal regimes, and then predicted development times based on equations describing the relationship between development and temperature established from previous studies of warm- and cold-water adapted larvae. For warm-adapted larvae, higher variability resulted in shorter development times at very cold and very warm mean temperatures, and longer development times at medium-range mean temperatures, than lower or no variability. For cold-adapted larvae, higher variability had opposite and smaller overall effects relative to its effects on warm-adapted larvae, perhaps because these larvae are adapted to have similar developmental performance over a wider range of temperatures. Results show that variability of water temperature needs to be considered when estimating development times and drift of lobster larvae in nature, and that future climate change could affect these processes in ways not considered thus far.

Settlement of postlarvae of the spiny lobster *Panulirus inflatus* in the southeastern Gulf of California [P39]

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Studies on the settlement of post-larval lobsters are important because they allow to develop recruitment indices which are useful to define seasons of greatest abundance, to determine appropriate monitoring stations, and to predict the expected levels of catch in the commercial fishery in future years. Between 2010 and 2013 we studied the settlement patterns of *Panulirus inflatus* in Mazatlan Bay, southeast Gulf of California. Pueruli and postpueruli of *P. inflatus* were monthly collected from modified 'Sandwich' artificial collectors in six sampling zones, although some zones were discontinued during the study because they were not considered suitable for continuous monitoring. Temperature, salinity and oxygen were also recorded. A total of 3333 post-larvae (49% puerulus and 51% post-puerulus) were collected: 458 during 2010-2011 with an average catch per unit effort (CPUE) of 7.8 postlarvae/collector/month, 2110 in 2011-2012 with an average CPUE of 62.8 postlarvae/collector/month, and 765 during 2012-2013 with an average CPUE of 13.6 postlarvae/collector/month. Using Pearson's correlation, we found a moderate correlation between the abundance of post-larvae and temperature.

Hitching rides and stealing bites? Phyllosomas and large gelatinous zooplankton [P40]

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There has been conjecture that spiny lobster larvae (phyllosomas) might attach themselves to large gelatinous zooplankton for assistance with locomotion and possibly to feed on them. This hypothesis is partly extrapolated from *in situ* observations of phyllosomas of slipper lobsters attached to, and most probably consuming, large cnidarian medusae. Spiny lobster phyllosomas have never been directly observed in the wild, and their small size, transparent morphology and offshore habitat makes direct observations of the nature of any association with large gelatinous zooplankton unlikely. Furthermore, these large gelatinous organisms, such as colonial radiolarians and siphonophores, disintegrate when sampled in net-tows, which means that if phyllosomas do adhere to them, they are never observed to do so in net hauls. In this study we report the collection by net-tow of a large and robust zoid of a salp, to which six mid- and late-stage phyllosomas were attached (*Panulirus cygnus*, stages VI, VII, and IX). To our knowledge, this is the first record of spiny lobster phyllosomas being captured attached to another animal. To determine if the phyllosomas were feeding on the salp, high-throughput sequencing analyses were performed on DNA extracts from the midgut glands of the phyllosoma. DNA was successfully amplified from four of these six phyllosomas and each of these phyllosomas contained a majority of salp DNA reads (\bar{x} =64.5% ±15.9). These results indicate that these animals do feed on large gelatinous hosts.

Seasonal variation in size of nektonic pueruli of *Panulirus argus* and *P. guttatus* [P41]

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During autumn 2012 and spring 2013, two oceanographic cruises were conducted in oceanic waters of the Caribbean Sea up to ~100km away from the Mexican shoreline. To collect larval stages of lobsters (Achelata), a midwater trawl that operated at depths of 5–15m and a neuston net that operated at depths of ≤1m were simultaneously towed, exclusively at night, in 63 (autumn) and 34 (spring) sampling stations over the same study area of ~30470 km². In all, 1110 nektonic pueruli of *P. argus* (autumn: 128, spring: 982) and 60 of *P. guttatus* (autumn: 22, spring: 38) were caught. All *P. guttatus* and 95.8% of *P. argus* pueruli were caught in the neuston net, indicating a tendency to swim close to the sea surface. Pueruli were photographed with a reference scale under a microscope to measure their carapace length (CL) using image software. As previously known, pueruli of *P. guttatus* were substantially larger (CL range: 7.52–11.00 mm) than pueruli of *P. argus* (4.33–7.55 mm CL). However, in both species mean size was significantly smaller in autumn (*P. guttatus*: 8.34 ± 0.21 mm CL, *P. argus*: 5.62 ± 0.07 mm CL, mean ± 95% CI) than in spring (*P. guttatus*: 9.68 ± 0.18 mm CL, *P. argus*: 6.01 ± 0.03 mm CL). If the pueruli of both species collected in our study area were subjected to a similar environmental variability (e.g. temperature, food availability) during their previous larval development, then these results would appear to suggest a similar larval duration for *P. guttatus* as for *P. argus* (~5–6 months).

Pueruli settlement of the red spiny lobster (*Panulirus interruptus*) at Bahía Asunción, Baja California Sur, Mexico, and its relationship with oceanographic factors [P42]

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This study examines the relationship between pueruli settlement of *Panulirus interruptus* and environmental factors in a site representative of the most important stock off central Baja California. The settlement pattern was characterized by using artificial collectors, which were sampled during the first quarter of each lunar month between June 2010 and May 2013. The catch per unit effort (number of pueruli per collector) was used as an index of abundance, from which seasonal variability and between years was detected. The influence of physical environment on the pueruli settlement was analyzed by using surface temperature (SST) and an Upwelling index (UPI) from NOAA/NMFS/SWFSC web sites, and an *in situ* monthly average of SST from daily records at the Bahía Asunción pier. Recruits occurred on collectors with highest frequencies between June and August. The settlement peak coincides with low UPI values, when upwelling is weakening, during the warmer period in the year. However, peaks varied slightly between years influenced by El Niño/La Niña events. For example, under strong cool conditions during the 2011 La Niña, very low settlement indices occurred, which will probably result in very low catches 5 years later. Settlement increased toward average values when neutral conditions returned, whereas under El Niño warm conditions higher than average indices were observed. Because pueruli settlement is determinant in the population dynamics, research must be strengthened to generate long-term time series and understand the role of environmental factors in determining pueruli survival and recruitment in order to improve the fishery management.

How puerulus behavior affects settlement success: interactions between settlement cues and oceanographic processes in southern rock lobster [P43]

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Larval behavior plays an essential role during transport and settlement and its inclusion into larval dispersal models could change our views on dispersal. The mechanism by which the puerulus stage of southern rock lobster, *Jasus edwardsii*, move inshore appears to be a combination of the onshore advection and active onshore swimming. Using field and laboratory experiments we examined whether the pueruli used chemical cues and underwater noise for orientation. Additionally, we examined environmental and biological time series data which might explain the settlement trends over more than 20 years using Dynamic Factor Analysis (DFA) and Generalized Least Squares (GLS) models which are suitable tools to explore correlations on time series analysis. Our preliminary results suggest that a complex range of factors affect settlement strength. Experiments on puerulus behaviour around settlement suggested that: 1) chemical cues from kelp do not affect / attract puerulus; and 2) underwater noise could be detected and it could be an attractant under certain conditions. Additionally, the DFA and GLS suggest: 3) a higher proportion of stage one pueruli are collected close to the new moon during periods of low nocturnal lighting, 4) settlement in South Australia and Victoria appeared to be explained by larger scale processes related to larval supply and transport, 5) in Tasmania local oceanographic and biological processes could be relatively more important. Overall, these results are showing the complexity of settlement process where larval behavior and local oceanographic process could be more relevant in the southern populations.

Genetics

Improving the stocking and sea-ranching practices for *Homarus gammarus* through the application of next-generation genetic-sequencing and transcriptomic analysis [P44]

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A new class of genetic sequencers have vastly decreased the time and costs involved with genome sequencing and gene identification. This is of particular benefit to research with non-model organisms (including lobsters) for which existing genetic-maps and references do not exist. Practically, this also allows the experimental application of sequencing techniques to investigate biological responses at a genetic resolution. By sequencing the target's transcribed RNA (its transcriptome) a snap-shot of the genetic activity from a particular cell, tissue, individual or group of individuals can be taken. By comparing transcriptomes we can then describe the underlying genetic activity that control physiological or behavioural changes. The European Lobster, *Homarus gammarus*, is both of commercial and ecological importance to the coastal waters of Great Britain. The fishery is worth an estimated £3m annually to the economy in Cornwall alone, where the National Lobster Hatchery (NLH) aim to enhance and sustain exploited wild populations. The organisation's stock-enhancement and sea-ranching programs aim to mitigate potential threats from combined human and environmental pressures. Using Illumina™ sequencing facilities, I plan to analyse the transcriptomes of cultured juvenile *H. gammarus* in order to understand how they respond to various hatchery and semi-wild rearing conditions. By doing so we aim to understand the genetic ecology of juvenile *H. gammarus* and identify which conditions and treatments stimulate (or inhibit) their growth and development. With this information we can better understand the optimum requirements of juvenile *H. gammarus*, thereby informing future practice and optimising stocking and ranching success.

Genetic evidence from the spiny lobster fishery supports international cooperation among Central American marine protected areas [P45]

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Marine protected areas (MPAs) have become an important ecosystem-based management approach to help improve the sustainability of the spiny lobster fishery (*Panulirus argus*). Information concerning levels of connectivity of spiny lobster populations among MPAs is severely lacking. The main objective of this study is to use genetic techniques to uncover spatial patterns of connectivity among MPAs in the Central American region of the Caribbean Sea. We specifically test the hypothesis that levels of genetic differentiation and connectivity may differ between spiny lobster populations located in MPAs within advective and retentive oceanographic environments. We found that levels of connectivity are high among spiny lobster populations residing in MPAs in Central America. Despite the high levels of connectivity among spiny lobster populations residing in Central American MPAs, overall F_{ST} was low ($F_{ST} = 0.00013$) but significant ($P = 0.037$). In the Mesoamerican Barrier Reef (MBRS), northern MPAs contained significantly more individuals that were genetically determined outliers or migrants than southern MPAs ($P = 0.008$, $R^2 = 0.61$). The increased number of outliers in northern MBRS MPAs may have contributed to the higher levels of genetic differentiation observed in northern MPAs. Direct genetic testing of larvae and adults will be required to confirm this hypothesis. The high levels of connectivity among MPAs provide additional evidence of the importance of international cooperation among MPAs. However, the uncertainty regarding the ecological and physical drivers of genetic differentiation in Northern MPAs implies that managers should hedge against uncertainty.

Genetic analyses reveal population structure among discrete size classes of Caribbean spiny lobsters within two Biosphere Reserves in Mexico [P46]

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Management efforts to improve sustainability of Caribbean spiny lobster (*Panulirus argus*) fisheries require knowledge of population dynamics and connectivity. This species constitutes the main economic source for the communities in two Biosphere Reserves (BR) in Mexico: Sian Ka'an (SKBR), located on the Mexican Caribbean coast, and Banco Chinchorro (BCBR), a false atoll 30 km off the coast. In both BR, free-diving fishers catch lobsters at depths ≤ 20 m but using different techniques: $\sim 20,000$ casitas in SKBR, and hand-held snares and loops in BCBR. In 2012, the SKBR-BCBR lobster fishery was certified as "sustainable" by the Marine Stewardship Council. The initial assessment included a bank-by-bank approach to analyse the status of the stock within the entire unit of certification given uncertainty in the origin of the local lobsters and the inherent difficulty in defining the stock boundaries. The key assumption in this approach is that stock status is determined by the standing adult population and not by the level of recruitment. We used microsatellite markers to investigate population connectivity of *P. argus* (1) spatially between the two BR and (2) temporally within each BR by genotyping lobsters in discrete size classes. No significant population structure was found between BCBR and SKBR ($P = 0.139$) but there was a significant level of population structure among discrete lobster size classes ($F_{ST} = 0.0054$; $P = 0.0052$), suggesting temporal variation in the genotypes of new recruits. Testing this hypothesis would require genotype analyses of postlarval recruits to each BR over time.

Aquaculture, Nutrition and Population Enhancement

Growth rate of juvenile Caribbean spiny lobster, *Panulirus argus*, fed a semi-humid diet [P47]

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The on-growing of tropical spiny lobsters is an important industry in many parts of Asia. Much progress has been made in the last decade to better define the nutritional requirements of post-larval and juveniles. The aim of this study was to evaluate the growth of juvenile *Panulirus argus* with a semi-moist diet, made with a mixture of squid, crab, vitamins, and gelatin as a binder. Food had 33 g kg⁻¹ moisture, high protein content (880 g kg⁻¹ dw), low lipid content (33.6 g kg⁻¹ dw) and ash (80 g kg⁻¹ dw). The content of soluble protein was 15 mg ml⁻¹. The profile shows that the essential amino acids have a content of 39 g in 100 g of protein⁻¹. Concentrations of 23 % and 5 % omega 3 and omega 6 fatty acids were found in the lipid fraction, and a value of 11 % of DHA. Juveniles of *P. argus* showed a growth in 100 days of culture of 3.4 g week⁻¹, the daily growth rate was of 0.64 %. The high content of total and soluble protein, as well as polyunsaturated fatty acids may be associated with beneficial effects on the growth of juvenile *P. argus*. The food could be used as reference for the development of research conducted to know the nutritional requirements of this species in different culture conditions.

Physiological condition of juvenile *Panulirus argus* fed diets containing by-catch from shrimp fisheries [P48]

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The semi-culture of wild juvenile lobsters is an important economic activity in the Asia-Pacific region. In Mexico, *Panulirus argus* sustains a relevant fishery, indicating a potential for aquaculture. The aim of this study was to test the effect of three diets prepared with the by-catch from shrimp fisheries in combination with artificial shrimp feed in three inclusion levels (35, 20 and 0%), all with 50% protein content (dry weight), on the physiological condition of juvenile lobsters. The experiment lasted 120 days in outdoor tanks. Hemocytes count, hemagglutination activity, osmotic pressure, and plasmatic concentration of proteins and acylglycerides were evaluated. An ANOVA was performed to determine the effects of diets on the hemolymph components. No differences were found between juveniles fed with the three diets, indicating a similar physiological condition. Although no significant growth was observed, the values of the physiological parameters were similar to those reported in wild juveniles, indicated that the diets used allowed proper maintenance. Low levels of lipids in the diets (1.13% dry basis) could be the cause of the observed low growth. The results of this work show that the by-catch from shrimp fisheries may be useful for preparation of diets for juvenile *P. argus*. Further research is needed to determine the nutritional requirements of the species and the feasibility of semi-culture of *Panulirus argus*.

On the occurrence of juvenile spiny lobsters, *Panulirus inflatus* and *P. gracilis*, in niester plastic baskets for oyster culture in the Ceuta lagoon complex, Sinaloa, Mexico [P49]

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The occurrence of juveniles of the spiny lobsters *Panulirus inflatus* and *P. gracilis* was examined from January to September 2013 at the culture zone of the Japanese oyster (*Crassostrea gigas*) in the Ceuta lagoon complex, Sinaloa, México. The oyster culture method used was that of a long line with suspension basket modules. Each module was made of 5 niester plastic baskets with a flotation device of expanded polyurethane. A total of 830 juvenile lobsters corresponding to both species were found in 1,397 modules: 517 *P. inflatus* (62%) and 313 *P. gracilis* (38%). The trend in species proportion indicated that *P. inflatus* predominated, with over 50% juveniles throughout the study period with the exception of July, when the proportion of *P. gracilis* was 57%. This investigation is important because it contributes to the knowledge on juvenile stages of lobsters in this area and shows the first records of *P. inflatus* and *P. gracilis* in an estuarine lagoon complex of the state of Sinaloa.

Fisheries and Fisheries Technology

From nets to bottom traps: is exploitation of Norway lobsters a suitable option for Corsican common spiny lobster fishermen? [P50]

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In Corsica (NW Mediterranean), most of the fishing activity is composed of small-scale artisanal fisheries, and takes place on the western coast. The common spiny lobster (*Palinurus elephas*) is the main target of Corsican netters. However, its populations have been declining since the 1950's, questioning the sustainability of this activity. We therefore tried to assess whether the fishing effort, currently mostly focused on common spiny lobsters, could be moved towards other commercially-interesting deep crustaceans, such as the Norway lobster (*Nephrops norvegicus*), through diversification of artisanal fishing practices. With the help of local fishermen, we set up Scottish traps for Norway lobsters at depths of 300 to 400 meters, on sandy and muddy bottoms of both eastern and western coasts. Despite several tests using different baits and soak times at various depths or seasons, catches on the western coast were low. On the other hand, on the eastern coast, experimentation showed interesting yields, and large mean size (i.e. high commercial value) for both sexes. While more studies are needed to confirm these results and improve knowledge of Norway lobster stocks, trap fishing of this species on eastern coast of Corsica could be a suitable alternative for diversification of artisanal fisheries.

Common trends in two Scottish lobster populations [P51]

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Dynamic factor analysis (DFA), a multivariate time series analysis technique recently applied to fisheries data for the first time, is used to explore common trends and the effects of sea surface temperature (SST) and wind speed (WS) on short, non-stationary multivariate time series of catch rates of the European lobster (*Homarus gammarus*) in Scottish fisheries. Catch rates of undersized and legal lobsters at three locations in the Hebrides and two locations in the Southeast of Scotland were generally highest in autumn (August-October) with strong seasonal trends during the period 1990-1997; therefore, de-seasonalised time series were analysed. From the DFA analysis, significant relationships between catch rates (undersized lobsters in one location and legal lobsters in two locations) and SST were observed for the Hebrides. At all locations in the Southeast, catch rates (both undersized and legal size lobsters) were related to SST. The results suggest, by observations on the most important trends, that (i) catch rates in the Hebrides have been steadily decreasing, (ii) those in the Southeast have been increasing during the studied period. DFA identified two common trends not revealed by traditional approaches, and proved to be a robust technique in the study of multivariate time series for the European lobster fishery.

Assessing the use of traps versus hook and diving method in the spiny lobster fishery of the Mexican Pacific [P52]

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Traditionally, the spiny lobster fishery along the tropical Pacific coast of Mexico is based on hookah diving system and the use of metal hooks to extract lobsters. Although the use of hooks is illegal, artisanal fisheries throughout the region maintain this practice. The Mexican Official Standard published in 1993 establishes minimum legal sizes, closed seasons and a prohibition on capturing ovigerous females, but these regulations are not generally observed. The main objective of this research was to evaluate the carapace length (CL) of lobsters caught with the traditional method of fishing versus lobster traps in two fishing areas of the Mexican Pacific: Jalisco and Oaxaca. In both areas, captures were conducted with the two catch methods over a same time period. A linear model was used to compare CL of lobsters between catch methods, sampling areas, and sex of organisms. The results showed that CL of lobsters was larger in Jalisco than in Oaxaca, but that in both areas the CL of lobsters was above the minimum legal size for the region. Traps captured more males than females and lobsters caught with this method were larger than those obtained by the traditional hook and diving method. Although the traditional method can work if regulation measures are strictly observed, traps capture live organisms resulting in a higher quality product and provide the possibility of returning to their habitat sublegal lobsters and ovigerous females.

The status of lobster fisheries in Rio Grande do Norte, Brazil [P53]

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In the Northeast of Brazil, mainly in the states of Ceará, Rio Grande do Norte (RN) and Pernambuco, lobster fishing is one of the most important socio-economic activities. This resource produced revenue of about US\$ 71 million in annual exports between 2000 and 2009. Furthermore, about 15,800 fishermen depend directly on the lobster fishery and about 184,000 people are indirectly involved in this activity. Due to the importance of RN on the national scenario of lobster fishing, a data collection of lobster catch was carried out in landings between the years 2001 and 2010. Monthly data set was provided by the Brazilian Institute of Environment and Natural Resources (IBAMA). Annual catches ranged from 98.49 to 415.29 tons between 2001 and 2005, with a considerable decrease in 2006 (168.56 t) and a gradual increase until 2010 reaching 233.87 t. The boat fleet in RN is considered artisanal, in which 39.12% of catches is carried by median motor boats, 24.59% by small motor boats and 17.17% by small sail boats. Lobsters fisheries conducted at RN utilize the following techniques: 44.6% compressor, 23% gillnets and 21% free diving. This fishery resource is considered in overfishing due to increased fishing effort and excessive catch of juveniles. Despite the increase in catches after 2006, overfishing of lobster in RN caused the devaluation and reduced the exportation of this resource and consequently increased the internal demand. Moreover, this activity is performed by artisanal ways and uses predatory and illegal techniques.

Diving accidents with lobster fishermen in the Northeast of Brazil [P54]

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The objective of this study was to conduct a survey of diving accidents arising from lobster fishing with logged compression the Navy Hospital of Natal in Rio Grande do Norte, and to identify the profile of casualties and major decompression illness treated in this institution. We conducted a detailed study of the records of diving accidents during the period from 2003 to 2008, based on medical records. From 2003 to 2008, 50 diving accidents were treated, all accidents involved male casualties. Fifty-eight percent of accidents were due to decompression sickness (DCS) type II and 42% were of type I. Eighty percent of patients were aged between 26 and 45 years. The majority of accidents occurred after at least 90 min under water at a depth ranging from 30m to 50m. Although there is a need for further research on this topic, the findings of this study should be taken into consideration by the state authorities, with regard to the need to reflect on what can be done to permit rapid hyperbaric treatment within six hours after such accidents.

Monitoring the catch of red lobster *Panulirus interruptus* in Baja California, Mexico [P55]

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During the 2012-13 fishing season for red spiny lobster (*Panulirus interruptus*), 579 tons were captured in the state of Baja California, Mexico (4% less than during the previous season). Of the total catch, 8% was recorded in the northern zone of the state, 34% in the center zone, 14% in the southern zone, and 44% in Isla de Cedros. During the last season (September 2012 to February 2013), the effort applied in this fishery was above 900,000 trap-lifts from 15 organizations holding commercial fishing permits and 3 holding fishing concessions. The minimum legal size for *P. interruptus* in Baja California is 82.5 mm carapace length (CL). The monitoring of the commercial capture revealed a latitudinal gradient in the average carapace length (CL), from bigger in the northern zone to smallest in the southern zone of the state. In a sample of 2069 lobsters from the commercial catch, the average lobster size was 85.57 mm carapace length (CL), the maximum size was 157 mm CL, and the mode was 84 mm CL. Of these lobsters, 38% were male and 62% were female. In a sample of 5287 lobsters from a fishery-independent biological monitoring, 41.5% were males and 58.5% were females. The size range of these lobsters was 44–155 mm CL with a mode at 81 mm CL, and 22.6% exceeded the minimum legal size.

Remote, real-time monitoring of puerulus settlement using an underwater camera system [P56]

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Trends in puerulus settlement are used to predict future recruitment to commercial lobster fisheries. Settlement indices are generally derived from a monthly count of pueruli resident on collector strata. However the representativeness of monitoring settlement indices at this coarse temporal scale is unclear. A remote underwater camera system has been developed that is capable of delivering still images to a remote server (via the 4G mobile network), from multiple cameras positioned on the sea-floor. This cost-effective camera platform utilises common off-the-shelf components and features: a surface buoy housing a power system (photovoltaic panel, battery, and regulator), a single board computer, a modem and a 4G transmitter; cables to the seafloor providing power and communications (internet cable); and up to 4 analogue cameras and 12V LED lights positioned on the seafloor. The computer can be accessed remotely to adjust capture intervals, spontaneously capture images, and update or troubleshoot software. In field tests with the camera system incorporated in puerulus collectors, discernable images of southern rock lobster puerulus on collector substrates were captured allowing a cost-effective means of conducting fine temporal-scale monitoring of puerulus settlement behaviour.

Habitat and Ecosystem Issues for Fisheries Management

Investigating lobsters and their habitat maps through the eyes of robots [P57]

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We did a case study on the potential for investigating the western rock lobster and their habitats in offshore marine environments using the AUV, 'Sirius'. We found that the results from the survey support previous laboratory and field studies documenting greater lobster activity in darkness and the preference for fine scale complexity in terrain; with reef and kelp-dominated mixed-algae assemblages being a key feature at a broad scale. However, the unique outcome from the AUV survey is that, in the absence of diver interference or luring lobsters to baited pots, the AUV captured adult lobsters in natural foraging and sheltering habitats. This non-invasive survey technique enabled a pilot level assessment of the locomotive behaviour and habitat use of adult lobsters.

An industry-based approach to regional-scale monitoring of benthic ecosystems [P58]

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Knowledge of the relationships between exploited species and the habitats that support them is critical to effective fisheries management. However, the acquisition of the spatially explicit habitat information required is typically expensive. We describe a novel camera system capable of collecting geo-referenced oceanographic information including video of benthic habitats and demersal fish assemblages. The systems, based on inexpensive components and open-source software are fully programmable and capable of long deployment times (months). Low per unit costs and a small and robust design allow widespread deployment of multiple units and encourage diverse research applications. Within the Western Rock Lobster Fishery, camera units have been attached to the lobster pots of commercial fishers, with no added cost or interruption to their fishing operation. The combination of spatially specific catch data with fine scale habitat information has refined understanding of the influence of benthic habitats on lobster demographics. In addition, the collated habitat information will provide a map of the key habitats fishers operate in across the extent of the fishery. In addition, these systems are capable of collecting a range of other important data including spatially specific environmental data (*i.e.* water temperature and depth) and data in finfish communities. This increased understanding of the way habitats influence the demographics of exploited species and continuous system of monitoring habitat changes will enhance the capacity of fisheries management to adapt to issues such as climate change. These technologies have far reaching applications across other trap based fisheries.

Demersal assemblages of crustacean fishing grounds off the Portuguese South coast [P59]

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Off the Portuguese South coast, muddy areas of the deep shelf and slope continental margins are exploited by a trawl fleet targeting decapod crustaceans such as the deep-water rose shrimp *Parapenaeus longirostris* and the Norway lobster *Nephrops norvegicus*. As in many crustacean trawl fisheries worldwide, a high number of other species is caught as by-catch, part of which is landed, while large amounts are discarded at sea. Catch data from bottom trawl surveys carried out for selectivity purposes in 1993, in crustacean fishing grounds covering the entire South coast at depths between 150 and 700 metres, were analysed for species abundance and distribution. As a result, the occurrence of more than 100 taxa of crustacean, fish and cephalopod species was evidenced forming spatially distinct assemblages closely aligned with depth. A sharp biological transition was noticed as one progressively moves from the continental shelf, where the deep-water rose shrimp is mainly captured together with small Pandalidae, towards the shelf edge and slope, where rose shrimp and Norway lobster co-occur, and further down to deeper slope areas, where Norway lobster is dominant and rose shrimp is replaced by Aristeidae. Corresponding transitions in fish and cephalopod composition were also observed. Simultaneously, a depth-related size distribution was observed for some of the species. By contributing to the understanding of the ecological context within which fisheries take place, these results explain the dynamics of the fleet, including the existence of species-oriented landing profiles, as well as the spatial variability in by-catch and discards patterns.

Effects of mosquito control pesticides on spiny lobster (*Panulirus argus*) pueruli [P60]

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Pesticides are routinely applied by truck-mounted sprayers and aircraft to control adult mosquito populations in the Florida Keys, USA. The application of pesticides in an island archipelago with broad intertidal mangrove shorelines and numerous canals poses a high risk for aquatic contamination, but information about the local environmental concentrations of these pesticides and their effect on aquatic organisms is limited. We measured the toxic effects of three common pesticides to the puerulus stage of the Caribbean spiny lobster (*Panulirus argus*). Initial observations indicate that permethrin (technical formulation Permanone 30-30) and naled (technical formulation DIBROM® 14) both cause short-term mortality (LC-50 at 96hr) and may delay metamorphosis, but the relevance of these results to expected environmental concentrations still needs to be evaluated. Research on the effects of malathion (technical formulation Fyfanon ULV) are in progress. Additional field studies are planned to determine the environmental concentration of these pesticides in the Florida Keys and evaluate if the level of aquatic contamination affects lobsters.

Stock Assessment

Spatial patterns in productivity of American lobster *Homarus americanus* in Atlantic Canada [P61]

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The “Lobster Node” of the Canadian Fisheries Research Network comprises a 5-year collaborative project between lobster harvesters, academics and government scientists on the question of lobster stock structure and connectivity in Atlantic Canada. The project involves five research components, four of which are based on stages of the life cycle: larval production, larval drift, larval settlement, and movement of juveniles and adults. The fifth component aims to elucidate genetic stock structure. The objective of the first component is to estimate spatiotemporal variation in larval production based on the abundance and characteristics of ovigerous females. Data is being collected by fishermen on the abundance, size, and clutch quality of ovigerous females with the objective of one fisherman every ~50 km of coastline sampling weekly throughout the spring fishing season 2011-2013. Data on ovigerous female abundance and size will be analysed to assess 1) large-scale spatial patterns in productivity (are there areas where egg production is particularly high or low?), 2) the scale of spatial patterns and variability in productivity (is there significant local variability or are patterns consistent over large spatial scales?), and 3) how consistent spatial patterns in productivity are among years. Data on clutch quality will be analysed in a similar manner as outlined above, but with the objective of identifying areas where high proportions of females are unable to produce full clutches and there may be problems with reproductive failure.

Developing Southeast US spiny lobster stock assessment in a meta-population model [P62]

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Spiny lobster (*Panulirus argus*) is widely distributed in tropical and subtropical waters of the Atlantic Ocean, and it has been largely captured throughout its range. Traditional spiny lobster stock assessment in the Southeast US assumes the target population as an isolated population. However, limited knowledge of the stock-recruitment relationship is an obstacle to satisfactory results. New evidence indicates that the Southeast US spiny lobster stock is demographically open: its US recruitment highly depends on post-larval transport from upstream Caribbean stocks, and the spawning stock biomass in the Southeast US water contributes to recruitment in downstream areas, such as North Carolina and Bermuda. In this study, a meta-population model will be developed to evaluate the connectivity effect between the Southeast US and its surrounding stocks on the aggregated meta-population dynamics. The developed model can be further applied to examine the regional consequence of spiny lobster resources responding to local management policies. Hopefully, the approach developed in this study will provide an alternative method to improve the quality of spiny lobster stock assessment in the Southeast US.

A stock evaluation model for future management of Caribbean spiny lobsters in Banco Chinchorro (México) with the use of casitas [P63]

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Large reproductive adults of *Panulirus argus* are being depleted across the Caribbean region. In Banco Chinchorro, Mexico (BC), an oceanic atoll and biosphere reserve where fishing for *P. argus* is allowed, fishers currently use snares to extract lobsters mainly from coral reef habitats, resulting in high fishing pressure on adult lobsters. Although catch rates and total landings have been relatively stable for the last decade, they were much higher in the past. In 2010, an inter-institutional steering committee was established to analyse alternative fishing practices and develop new management ideas to reduce fishing pressure on reproductive adults while increasing the biomass of the lobster stock in this biosphere reserve. Based on knowledge obtained from other fisheries elsewhere in Mexico and adjacent Latin American countries, preventive measures were developed, including the controlled deployment of “casitas” (large artificial shelters) in the atoll lagoon. In addition to increasing juvenile survival, casitas are valuable tools for local stock assessments and to obtain information on lobster growth rates and migrations. An ecosystem-specific lobster population model was developed as an analytical tool for projecting the potential outcomes of the commercial fishery at BC by changing the fishing technique from reef collection to casitas collection. The model was capable of examining changes in commercial profit, lobster population biomass, catch rates, and egg production. A responsible use of casitas within a well regulated biosphere reserve, incorporated in a cooperative based socio-economic scheme, is perceived as a useful initiative to reduce fishing pressure on large adults in this area.

Tag-induced mortality and tag retention in the European lobster *Palinurus elephas* [P64]

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An experiment was conducted to study tag-induced mortality and tag retention at molt in juvenile *Palinurus elephas*. Two types of tags were implanted: T-tag from Floy Tag (TT) and Streamer tag from Hallprint (ST). Sixty nine juvenile lobsters were randomly assigned to one of three groups (TT=27, ST=27 and control=15) and accommodated in two closed systems: one with individual aquaria and another with individual plastic mesh boxes inside a large tank. T-tags were implanted on the dorsal side between the carapace and the abdomen using a tagging gun. Streamer-tags were also implanted between the carapace and the abdomen, passing the needle coupled to the tag across the body ventrally. There was no mortality associated with tagging, all lobsters survived and exhibited normal behavior after (search for food, grooming). Mortality at molt was high but not related to the tag groups. Lobsters in the small tanks could not complete the molt, presumably due to particular conditions of the system, although no factor could be pinpointed during the experiment. Lobsters in the plastic boxes for at least two weeks prior to the molt all survived and completed the molt successfully. One of the T-tags was lost at the molt. In conclusion, both types of tags are well tolerated but streamer tags are harder to implant in larger animals. T-tags have a higher chance of being lost at molt.

Estimation of age and growth of the spiny lobster *Panulirus inflatus*, using a matrix of transition and growth simulation [P65]

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One of the most important features in population dynamics is the individual growth. In this study, we estimated the age and growth of spiny lobster *Panulirus inflatus*. The study analyzed the fishery data off South of Sinaloa from November 2007 to June 2010 (four fishing seasons). Biological samples were obtained every week during the study period. Data were obtained through the commercial catch, which is carried out by crawfish hammocks. The age groups were estimated based on length frequency analysis. Four candidate growth models were compared using multi-model inference approach; consequently based on Akaike information criterion, Akaike's differences, and Akaike's weights the Gompertz growth model was the best candidate model. The species showed rapid growth, and the fishery management must be different to those used in the northwest Mexican Pacific.

Management

Passive management vs Active management: the lobster fishery in Mexico [P66]

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In Mexico, the lobster fishery is managed based on passive management; the Mexican government proposed management rules based on passive management, such as are expressed in the law (National Fisheries Chart). Passive management means that the lobster fishery is managed without specific management plans detailing all aspects of the management process; consequently, the management rules are generically applied to different species in the Gulf of Mexico, Mexican Pacific and Mexican Caribbean. Although Marine Stewardship Council certified the lobster fishery in the northwest Mexican Pacific, the rules must be improved in the Mexican south Pacific, Gulf of Mexico, and Mexican Caribbean. The passive management is based on maximum allowable catch, minimum legal size, and restrictions of fishing activities. However, supported on adaptive management the management regime must change toward active management, which implies a complete management procedure with clear set goals or objectives for the lobster fishery in different regions, management schemes to keep the total harvest or exploitation rate within prescribed limits or targets, and methods for assessing whether the goals or objectives have been met. Comparatively, the biological knowledge and population dynamics of lobsters are better known in all regions of Mexico.

(Late submission: Habitat and Ecosystem issues for Fisheries Management)

Size-at-age and body condition of juvenile American lobster (*Homarus americanus*) living on cobble and mud in a mixed-bottom embayment in the Bay of Fundy [P67]

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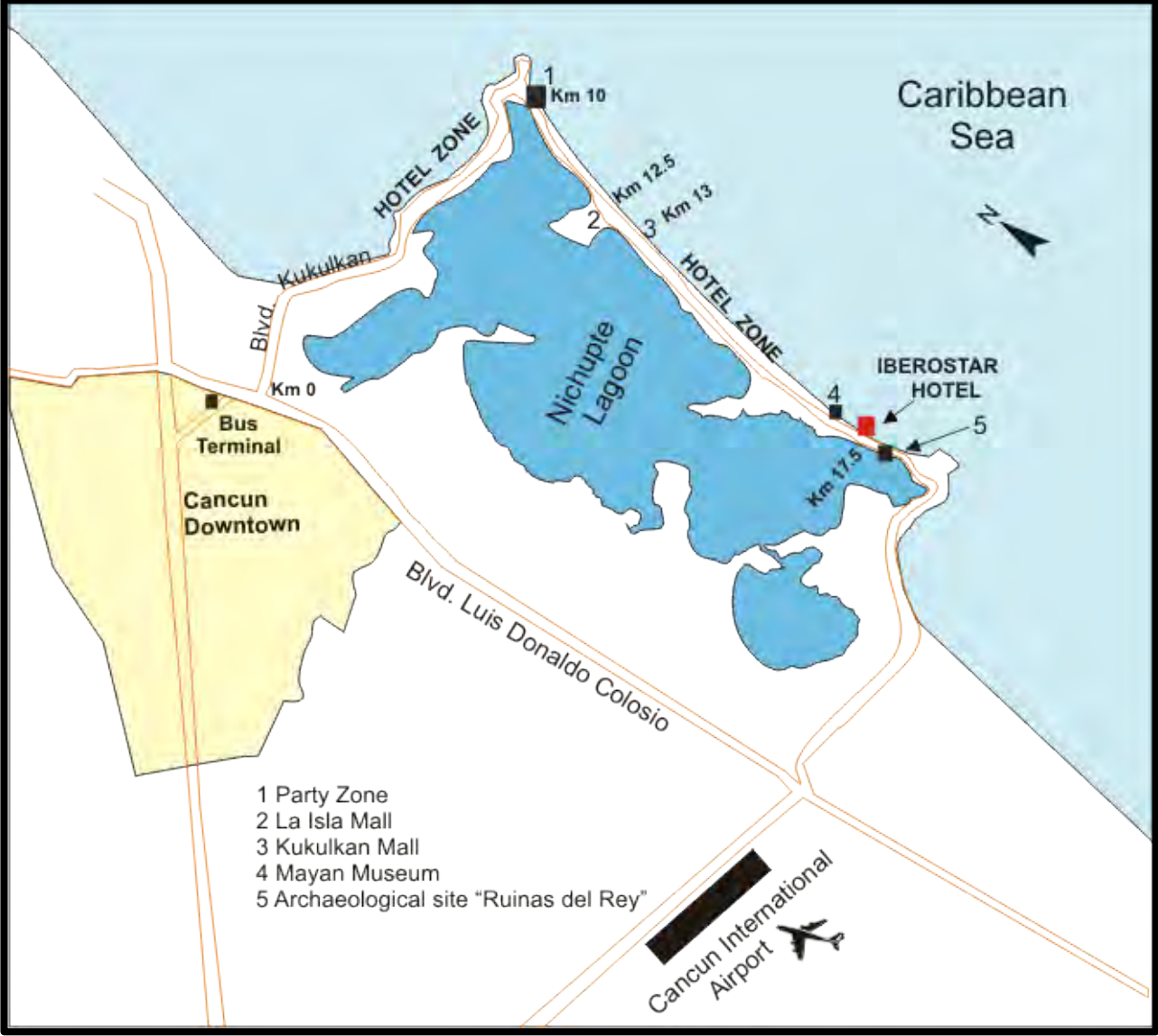
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American lobsters, *Homarus americanus*, prefer structurally complex cobble bottom for settlement and early development, but this habitat is sparse and some juveniles are likely forced to exploit other habitats, such as mud bottoms. Growth and condition of juvenile lobsters may vary between cobble and mud habitats, due to differences in food and shelter these provide. In this study we used cobble-filled cages to sample juvenile lobsters on cobble and mud in a mixed-bottom embayment in the Bay of Fundy, and we compared their growth using a recently developed age determination technique and their body condition using length-mass relations as well as RNA/DNA ratio and protein content of abdomen muscle. Surprisingly, individuals 3 and 4 years of age were larger and heavier when inhabiting mud versus cobble, suggesting greater growth of juveniles in the less-preferred habitat. Perhaps as a consequence of this faster development on mud bottom, it was also found that for a similar carapace length lobsters on mud were slightly lighter than those on cobble. RNA/DNA ratio and protein content did not differ between juvenile sampled from the two habitats. Our results suggest that mud bottom may represent a more important habitat for young lobsters than is currently appreciated. We hypothesized that mud bottom has become a more important juvenile habitat in recent years due to (1) a reduction in predatory ground fishes caused by overfishing and (2) high lobster abundance, which may be forcing some juveniles to move from saturated cobble patches to secondary habitats, such as mud.

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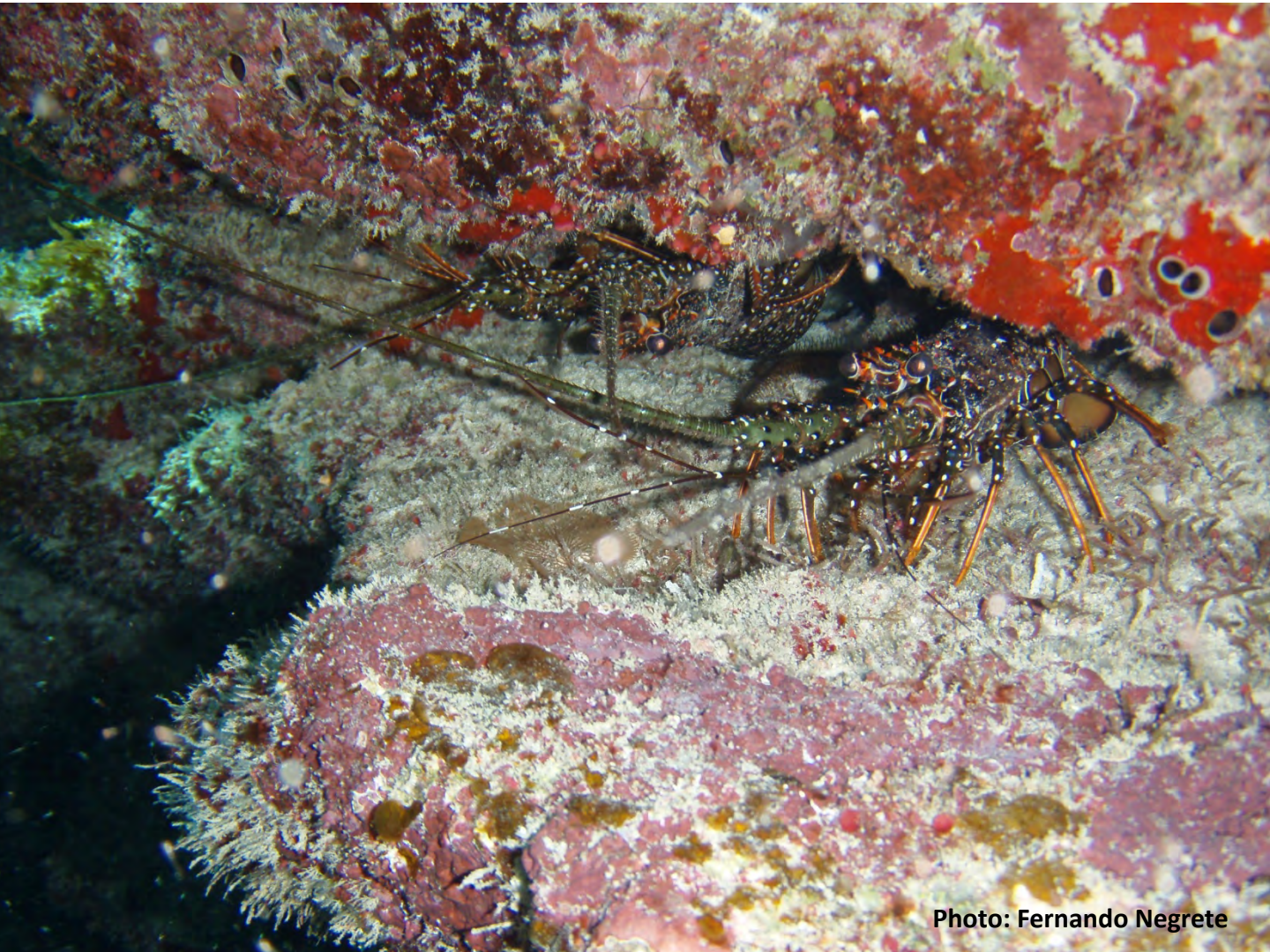


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