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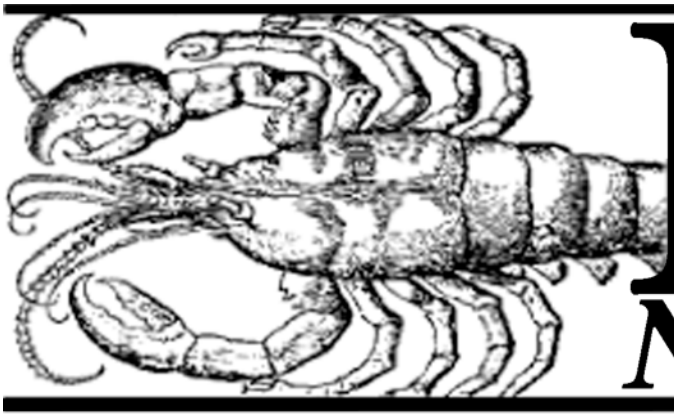

The Lobster NEWSLETTER

UPDATES & ANNOUNCEMENTS

On lobsters, coral reefs, and mariachis: An overview of the 10th ICWL

From: Patricia Briones-Fourzán & Enrique Lozano-Álvarez

The 10th International Conference and Workshop on Lobster Biology and Management (ICWL) was held in Cancún, Mexico, 18–23 May 2014. This was the first ICWL ever held in Mexico. The Iberostar Cancún Hotel proved to be a great choice of venue, featuring a very nice conference center with a stunning view and several restaurants and bars that provided many opportunities for social interactions. In total, there were 182 registered participants from 24 countries of origin. A special mention is due to Bruce Phillips, who convened the first ICWL in Perth, Australia, in 1976 and has since attended all other ICWLs, and to Ray George, who at 85 made the long trip from Albany (Western Australia) to Cancún so as not to miss the 10th ICWL!

The Meet & Greet was held Sunday evening and provided an opportunity to, well, greet old friends and meet new people in a relaxed atmosphere. The conference was officially opened on Monday morning by Dr. Elva Escobar, Director of the Institute of Marine Sciences and Limnology of Universidad Nacional Autónoma de México, and the attendees were welcomed by Dr. Anastazia Banaszak, Head of the Reef Systems Unit at Puerto Morelos. Mark Butler presented the Paul Kanciruk Student Travel Award to the two winners, David Ernst (University of North Carolina, USA) and Gudjon Mar Sigurdsson (University of New Brunswick, Canada).

After the opening ceremony, Bruce Phillips and Mónica Pérez-Ramírez delivered a plenary talk on the main conference topic, "*Lobsters in a Changing Climate*". Throughout the week, four additional plenary talks were given by Rick Wahle ("*The American Lobster – Poster child of a changing ecosystem*"), Ehud Spanier and Kari Lavalli ("*History of utilization of lobsters by humans*"), Jim Penn ("*Research for management of lobster fisheries, its history, recent developments and future challenges*"), and Juan Carlos Seijo ("*Individual fishing grounds in the community co-managed spiny lobster fishery of Punta Allen, México: Lessons learned*"). All five plenary talks attracted lots of attendants and set the stage for five days full of interesting lobster presentations.

There were 200 presentations (133 oral and 67 posters) in 14 sessions divided into two concurrent streams. [Summarized in later sections of this issue. -ed.] It was mainly thanks to the work and effort of the session chairs that the conference ran without a glitch!

The poster session was held on Tuesday evening, with 67 posters and a full attendance. The atmosphere was lively and friendly, with tasty hors d'oeuvres and lots of wine, margaritas, and mojitos. On Wednesday, after the morning session and group photos (taken under an overcast sky), about 100 participants got on several buses to the nearby Puerto Morelos Coral Reefs Natural Protected Area for the free afternoon activity. Luckily, the rain stopped just in time and after a short boat trip they all donned their masks and snorkels and jumped into the water to skin dive in the coral reefs in order to observe the local marine fauna, including a few spiny lobsters. Upon returning to the coast, we all enjoyed a lovely afternoon with plenty of beer and tequila and a wonderful lobster meal in a peaceful, beautiful beach setting. This was certainly one of the highlights of the conference.

Another highlight was the official conference dinner on Thursday evening, which, of course, featured lobster tails. Before dinner was served, and with David Díaz acting as official raffle aide, items donated by participants were raffled to help replenish the Paul Kanciruk Student Travel Award. A beautifully handcrafted bottle of Tequila, probably the most coveted prize, went to Kathy Castro. During dinner, a folkloric ballet company performed several colorful and lively dances from different regions of Mexico, accompanied by a Mariachi group unusually led by a lady. To wrap up their performance, the dancers invited some attendees to dance "La Raspa", a pretty energetic dance with much hopping, spinning, and clapping. To keep the evening's energy going, the Mexican students asked the audio technician to plug in one of their mp3 devices —turning him into an improvised DJ— and performed an impromptu group dance. Just about everybody jumped to the floor to dance salsas and other tropical rhythms until it was time to go. That was fun!

The closing ceremony was on Friday afternoon. There was a tribute to Ehud Spanier organized by his long-time collaborators and friends Kari Lavalli and Jason Goldstein, which included a hilarious video and PowerPoint presentation on Ehud's accomplishments (which, seriously, are pretty extensive). Afterwards, a summary of the conference was delivered, showing that 36 species of lobsters were featured in the presentations, and confirming that the proceedings of the 10th ICWL would appear in 2015 as a supplementary issue of the *ICES Journal of Marine Science* with selected papers from the conference. Then the awards for Best Student's Oral and Poster Presentation were given, respectively, to Tonje Knutsen Sørdalen (University of Agder, Norway) and Miriam Palestina Martínez (Universidad Nacional Autónoma de México). Each Award consisted of the 2013 lobster book edited by Bruce Phillips, donated by Wiley-Blackwell, and a cash prize donated by the Latin-American Association of Carcinology (ALCARCINUS) and the Mexican Academy of Sciences. We hope that these awards, together with the Paul Kanciruk Travel Award, will continue to be presented in future ICWLs so as to encourage many students from all over the world to attend these conferences. Finally, it was time to hand over the Conference Plaque to the conveners of the 11th ICWL, Rick Wahle, Jason Goldstein, and Kari Lavalli!

We could not have held this conference without sponsors, so we sincerely thank our major sponsors UNAM and CONACYT, platinum sponsors INAPESCA and ChakTunChe Arts & Crafts, gold sponsors OLRAC SPS (South Africa) and Colectividad RAZONATURA, silver sponsors Clearwater Seafood (Canada) and CONANP, and custom sponsors ECOSUR, Universidad Marista de Mérida, ALCARCINUS, Wiley-Blackwell (USA), Mayan Star Fisheries, Snorkeling Adventure, Integradora de Pescadores de QR, and Academia Mexicana de Ciencias. We continue to receive many compliments on the colorful logo and t-shirts of the 10th ICWL designed and produced by Mexican artist Jorge Quiñones-Alvarado.

On behalf of our colleagues and staff we thank all attendees, whose excellent presentations and discussions, as well as their *joie de vivre*, turned the 10th ICWL into such a memorable scientific and social event.

¡Muchas gracias y hasta luego!

Patricia Briones-Fourzán & Enrique Lozano-Álvarez
Conveners of the 10th ICWL
Universidad Nacional Autónoma de México
Instituto de Ciencias del Mar y Limnología

Themes for 2015

- The Individual Lobster
- Population Dynamics
- Ecosystems and Food Webs
- The Business of Lobstering

The Rodd Charlottetown Hotel
Charlottetown, Prince Edward Island Canada
www.peifa.org/lobster-2015

Symposium Convener:

The Prince Edward Island Fishermen's Association

Symposium Coordinators:

Andrea Battison, CrustiPath, andrea@crustipath.com
Ian MacPherson, Prince Edward Island Fishermen's Association
Carl Wilson , Maine Department of Marine Resources

Announcing the 11th International Conference and Workshop on Lobsters

June 5-9, 2017
Portland, Maine USA

Steering Committee Chairs: Rick Wahle & Kari Lavalli

For inquiries, please contact richard.wahle@maine.edu or klavalli@yahoo.com

Additional information will be sent to Lobster Newsletter subscribers... stay tuned!

10th ICWL SESSION SUMMARIES

Session 1: Climate Change

Chair: Nick Caputi

The Climate Change session followed the keynote address by Dr Bruce Phillips on 'Lobsters in a changing climate' which provided an overview of how climate change was affecting lobster stocks around the world. The session had 10 papers from scientists from six countries which examined climate change effects on lobster stocks with five papers on spiny lobsters and five on clawed lobster species.

Some of the key themes from the session were:

- Environmental factors (water temperature, winter storms) that had climate change trends were responsible for seven years of below average puerulus settlement in the western rock lobster fishery of Western Australia.
- In Tasmania, Australian, declines in puerulus settlement have occurred in the southern rock lobster 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. There was a similar story in south-western coast of Japan where large brown algae communities have changed dramatically, probably because of ocean warming. This is likely to be detrimental to the recruitment and survival of early benthic stages of the Japanese spiny lobster.
- Laboratory measurements of *Sagmariasus verreauxi* pueruli energy metabolism were undertaken to define their thermal tolerance which are considered against wild coastal recruitment data and spatially explicit ocean warming scenarios. They showed evidence that physiological thermal tolerance constraints are already limiting post-larval recruitment.
- Laboratory experiments of ocean acidification on larvae and juvenile European lobster (*Homarus gammarus*) resulted in deformities in larvae and juveniles when pH<7.9.
- The effect of physiological investigations into the impact of climate change drivers on the early development of *Nephrops norvegicus*.
- Behavioural disturbances affecting food recognition, food search and CO_2 avoidance were also outlined for *N. norvegicus*.
- Climate change was also implicated in dramatic decline of American lobster (*Homarus americanus*) fisheries in southern New England over the past two decades that are related to excessive summer warmth and shell disease.
- In Maine the effects of climate change have resulted in much higher abundance of American lobster stocks which has resulted in changes in the spatial distribution of the stock. This has resulted in an evolution in the fishermen's territorial behavior.
- A biological monitoring program over 40 years on the spiny lobster (*Panulirus argus*) in Cuba was used to detect changes in biological parameters such as growth, size at maturity and the effect of sea surface temperatures and lobster biomass.
- A poster was presented on interactive effects of ocean warming and acidification on the physiology of *H. gammarus*.

Nick Caputi
Western Australian Fisheries and Marine Research Labs
nick.caputi@fish.wa.gov.au

Session 2: Aquaculture

Chair: Andrew G. Jeffs

A total of 17 oral and poster papers covering clawed, spiny, slipper and deep-water lobsters were presented in the *Aquaculture, Nutrition and Population Enhancement* session. Resolving ongoing difficulties with the successful larval rearing of lobsters was a common theme, with presentations on an examination of the importance of suspension feeding in American clawed lobster, the use of jellyfish for feeding slipper lobster larvae, and the use of novel tank coatings in attempting to overcome biofilm problems in long duration larval rearing of spiny lobsters.

The grow out of lobsters was the focus of three presentations and three posters covering novel approaches to feed development for the European clawed lobster, an investigation of the environmental impact of sea cage grow out of spiny lobsters in South East Asia using modeling methods, and the development of prepared diets for Caribbean spiny lobster.

Steps toward the development of initial methods for the aquaculture of a variety of lobster species was covered by presentations on the on-growing of Caribbean spiny lobster in Cuba using wild-caught early juveniles, the harvesting of juvenile spiny lobsters in oyster farms in the Gulf of California and the rapid growth of large scale pueruli catching for aquaculture in parts of Indonesia, as well as their subsequent grow-out using sea cage methods.

New research projects aiming to advance aquaculture for the European spiny lobster and the southern deep-water scampi were also described and reflected the widespread desire to establish commercial aquaculture of a range of lobster species globally. Likewise, advancing methods for enhancing wild populations of European and American clawed lobsters was the subject of four presentations, covering research on large scale hatchery rearing for release, the use of sea-based containers for rearing larger juveniles for release, the effectiveness of releasing post-larval lobsters both at sea and in tank experiments.

Overall, the session reflected the significant technological challenges facing every aspect of widespread efforts to develop effective methods for increasing the production of lobsters through efficient aquaculture and enhancement.

Andrew G. Jeffs
Leigh Marine Laboratory
University of Auckland
a.jeffs@auckland.ac.nz

Carly L. Daniels
The National Lobster Hatchery, United Kingdom

Greg G. Smith
Institute for Marine and Antarctic Studies
University of Tasmania

Lobster, from *Fish from American Waters* for Allen & Ginter Cigarettes, 1889
www.metmuseum.org

Session 3: Behavior

Chair: Michael Childress

Lobsters remain one of the fascinating groups of benthic invertebrates for their complexity of behavioral adaptations. We were reminded of this fact during the Behavioral Ecology session of the 10th International Conference and Workshop on Lobster Biology and Management. Five papers were presented on the topics of aggression, conspecific attraction, orientation and seasonal movement. Most of the papers focused on proximate causation of behaviors, but inferred important ultimate consequences to lobster fitness and evolution.

Thomas Landley with co-authors J. Goldstein and W. Watson found that juvenile American clawed lobsters showed only moderate seasonal changes in movement along an estuary with a strong salinity gradient suggesting that factors such as habitat quality or familiarity may override salinity and temperature cues for movement. David Ernst with co-authors K. Gentry and K. Lohmann provided the first experimental evidence for Magnetite-based magnetoreceptors in Caribbean spiny lobsters. They found that animals subjected to strong, pulsed magnetic fields showed higher orientation than unpulsed control animals and their orientation was significantly different depending on whether the pulse was parallel or anti-parallel to the geomagnetic field's horizontal component. Andrew Kough and co-authors C. Paris and E. Staaterman found that postlarval Caribbean spiny lobsters also show oriented swimming behaviors with a circatidal pattern. Their trajectories changed during ebb and flood tides such that shoreward movement would be maintained. They also found that wind direction influenced the trajectories and suggested that wind direction may be an important cue for settlement of postlarvae.

Patricia Briones-Fourzan and co-authors R. Dominguez-Gallegos and E. Lozano-Alvarez found that aggression in spotted spiny lobsters is related to sex, size and social context. Males were more aggressive than females, larger individuals were more aggressive than smaller individuals, aggression was higher at night, and higher when competing for space within a crevice shelter. Aggression in large males was reduced if interacting with smaller females but females carrying eggs were not more aggressive than those without eggs. Michael Childress and co-authors K. Heldt and S. Miller found that attraction to conspecific cues in juvenile Caribbean spiny lobsters as measured by a Y-maze choice test has significantly decreased since 2005. While the ultimate reason for this loss of conspecific attraction is not yet known, the potential consequences to a fishery that relies on

aggregation in traps or casitas warrants further investigation.

These five papers clearly indicate that lobsters rely on a wide range of abiotic and social cues for critical behaviors associated with settlement, habitat selection, orientation, and shelter sharing. Rapid changes in nearshore water conditions and corresponding loss of essential benthic habitat are, therefore, likely to have significant impacts on the behavioral ecology of lobsters.

Michael Childress
Clemson University
mchildr@clemson.edu

Session 4: Disease

Chairs: Donald Behringer & Grant Stentiford

Many thanks to Patricia, Enrique, and the entire organizing team in Mexico for a fantastic conference! From the science to the socials it could not have been better. The old guard was well represented, albeit a bit grayer or balder, but there was also a great abundance of students and other new faces. Once again, the Diseases and Parasites session stood out with a remarkable 23 (15 oral and 8 poster) presentations! Not surprisingly, diseases of the local Caribbean spiny lobster dominated the session, but there was a broad diversity of presentations representing pathogens and lobsters from around the globe.

Don Behringer kicked things off with a report of work on the Caribbean spiny lobster virus PaV1 and the surprising infection dynamics among adult lobsters. Adults are often found infected with PaV1, but most infected adults remain subclinical, are non-infectious, and do not pass infection to their offspring (vertical transmission). Rebeca Candia-Zulbarán then described her work with our conference hosts that showed the Caribbean spiny lobster avoids the chemical cues of PaV1 and recently killed conspecifics to a similar extent. Ruth Pérez-Campos then turned the PaV1 focus to the fishery in Mexico with a presentation on the prevalence of PaV1 among lobster tails originating from two fishing cooperatives. Charlotte Davies took us into the first health break with a fascinating talk describing the fundamental differences in the structure of the carapace between *Homarus americanus* and *Homarus gammarus*, and how it affects susceptibility to shell disease.

Following the health break Rubén Muñoz de Cote-Hernández introduced us to a highly prevalent trematode infestation he and colleagues discovered among Caribbean lobsters in Bahía de la Ascensión. Cristina Pascual-Jiménez then brought our attention back to PaV1 where she, Juan Pablo Huchin-Mian, and Nancy Herrera-Salvatierra gave a great series of talks on the immunological and physiological responses of Caribbean spiny lobsters to PaV1. Christina's presentation compared the immunological response of lobsters to experimental and natural infections with PaV1. The differences she found underscore the importance of interpreting results from experimental studies with caution. The work by Juan-Pablo and colleagues suggests the resistance to PaV1 observed in larger lobsters may be due to the response of hemocytes to the presence of the virus, while Nancy described how the decrease in enzymatic activity is the likely cause of decreased digestive capacity as infections progress. Rossanna Rodríguez-Canul followed with a presentation on the potential for the cultured white shrimp *Litopenaeus vannamei* to act as a reservoir for PaV1. The co-chair of the session, Grant Stentiford, took us into the lunch break with a stimulating introduction to the phenomenal possibilities in disease research available with the use of eDNA technology. The technology stands to fundamentally change the way we approach research on pathogens.

After a hearty lunch, Kathy Castro and Kathleen Reardon took us back to New England, USA for a pair of talks on managing and monitoring shell disease. Kathy's talk stimulated much discussion as it presented a novel approach to potentially treating lobsters with shell disease. The oral presentations then came home to roost in the Caribbean with three final talks on PaV1. Oswaldo Huchim-Lara presented an interesting geospatial analysis of PaV1 prevalence in the eastern Yucatan and I presented our research team's work on the genetic diversity of PaV1 in the Caribbean. The take home message from the latter being that northern Caribbean countries harbor the highest prevalence of PaV1 and it is among them that PaV1 genetic similarities are greatest. The Diseases and Parasites oral session then came to a 'theoretical' close with an intriguing presentation by Andy Kough on modeling work aimed at understanding how PaV1 may have become distributed around the Caribbean based upon the physical oceanography and mode of pathogen dispersal.

The poster session was another marvelous opportunity to mingle with colleagues and talk lobster science. Among the broad mix of posters were some intriguing Disease and Parasite session contributions including a report by Miriam Camelo-Marrufo et al. of rickettsia-like organisms and PaV1 co-infecting Caribbean spiny lobsters and the discovery by Lozano-Alvarez et al. of a Caribbean spiny lobster puerulus 46 km from shore that was infected with PaV1. Other poster presentations on PaV1 included

the description of a quantitative PCR assay for future studies on PaV1 by Abigail Clark et al. and the genetic analysis of PaV1 variability among Caribbean sites by Yanis Cruz-Quintana et al. Shell disease was well represented in the poster session with a new conceptual model for shell disease by Anita Kim et al. and a presentation on the use of generalized additive models by Kesei Tanaka et al. to analyze decades of environmental data on shell disease with the hope of determining the factors promoting shell disease. Lastly, co-chair Grant Stentiford presented a thought provoking exploration into gynandromorphy and ovotestes among clawed lobsters and the potential parasitic or anthropogenic endocrine disruptors driving it.

Leaving the science, sun, sand, and cervezas of Cancun was indeed painful, but we left knowing it will be but a quick three years until we gather again in New England. In the meantime, I challenge all of us to capitalize on newfound collaborations and come to the 11th ICWL with a pound full of great talks and posters!

See you in Portland in 2017!

Donald Behringer
University of Florida
behringer@ufl.edu

Grant Stentiford
Centre for Environment, Fisheries & Aquaculture Science
grant.stentiford@cefas.co.uk

Lobster on a Piece of Charcoal, date unknown
Totoya Hokkei (Japanese, 1780-1850)
www.metmuseum.org

Session 5: Fisheries Technology

Chair: Win Watson

Shaun Ogilvie described some of the new methods that are being used by the Maori-owned Waikawa Fishing Company. They are seeking to develop fishing strategies that will make the scampi fishery in New Zealand more sustainable. This same group is also investigating ways to raise scampi from the eggs obtained from local broodstock.

Amos Barkai and his colleagues have been developing a new electronic logbook called Olrac. He described some of the pros and cons of this system and presented some results obtained using Olrac aboard vessels fishing for lobsters off the coast of South Africa. He made a good case for using such a system to monitor a variety of lobster fisheries. Real time reporting of catch is particularly relevant in the *Panulirus gilchristi* fishery where fishing vessels may remain at sea for over a month and land 7-10 tonnes per trip.

Anthony Pere and his colleagues in Corsica are attempting to understand short and long term fluctuations in the spiny lobster fishery in the NW Mediterranean. They reported the results of their analyses of the relationship between catch, and some of the factors that might have influence catch, from 1950-2011. One dramatic change in the fishery corresponded to the shift from wood traps to trammel nets in the 1950's and 1960's. However, it was more difficult, given the widespread temporal and spatial variability, to assign a cause to fluctuations in exploitation rates.

In some areas of the world, such as the Yucatan, Mexico, the preferred method for capturing lobsters involves diving using a hookah. This method can be dangerous and each year a number of fishermen are treated for decompression sickness. Oswaldo Huchim-Lara and his colleagues monitored the dives and equipment of six fishermen to determine what practices might put the divers at the most risk. They determined that divers would benefit from using systems that did not lead to contaminated air, as well as trying to avoid exceeding recommended bottom times and decompression tables.

One of the major design features of the American lobster trap is an escape vent that will allow sublegal lobsters to escape, while retaining legal lobsters. Kathy Castro and her colleagues tested a new escape vent that was the same height, but not as wide, as those in current use. They found that more sublegal lobsters escaped with the shorter escape vent, but

there was no difference in the retention of legal lobsters.

Casey Butler and Tom Matthews developed estimates of lobster mortality in lost traps. This study builds upon previous studies documenting the 18% loss of traps in Florida's *Panulirus argus* fishery. Lost traps persisted for between one and two years and an average of eight lobsters died in each lost trap annually. Given the estimated 85,000 ghost fishing traps, there were an estimated 637,000 lobsters that died in ghost traps. The high ghost fishing mortality of lobsters was an inevitable consequence of the high number of traps used in the fishery, the lack of escape panels in traps, and the use of pressure treated wood as biodegradable panels.

For a number of years several New England States have been using traps without escape vents as tools to monitor the American lobster fishery. Win Watson's group found that ventless traps typically captured 10 times more lobsters and provided a better index of the abundance of lobsters on the bottom than standard traps. They found ventless traps saturated after about 24 hours, likely due to the bait losing its attractiveness.

The cause of seasonal and annual fluctuations in lobster catch has been debated for many fisheries, on many occasions. Hector Lizarraga-Cubedo and his colleagues in the UK used an extensive range of statistical methods to try and link fluctuations in two Scottish lobster populations to several environmental factors. They found that water temperature, winds, and air pressure were the best predictors of year-to-year variability, although in some areas density-dependent processes could be important as well.

Settlement collectors have added a great deal to our ability to monitor lobster populations and recruitment, but traditionally these collectors have only been used in shallow, more accessible, locations. Graeme Ewing and his colleagues in Tasmania developed and tested a sturdy crevice-type puerulus collector that could be deployed and fished by commercial fishermen in challenging environments. These collectors were effective and even captured puerulus at depths of 100 m, which might make it possible to extend both the time and areas where they are deployed in the future.

Win Watson
Department of Biological Sciences
University of New Hampshire
win@unh.edu

Session 6: Marine Protected Areas

Chair: Racquel Goñi

The marine protected area (MPA) Session of the 10th ICWL was short but juicy. Four scientific inquiries concerning four lobster species in four MPA systems were presented.

Kerry E. Maxwell (Fish & Wildlife Research Institute, Florida, USA), using acoustic telemetry, showed that although *Panulirus argus* had achieved a persistent population in the large Western Sambo Ecological Reserve, the design of the MPA needed to be improved to encompass the unprotected grounds used by females to spawn. Billy Ernst (Dpt. Oceanografía, Univ. Concepción, Chile) presented a modeling framework with a biophysical, pelagic component and a size structured, benthic component developed to assess the effectiveness of an MPA for the *Jasus frontalis* fishery of the Juan Fernandez Archipelago.

On a different note, Tonje Sørdalen (University of Agder, Norway) exposed the results of the first quantitative study of parental assignment on a wild lobster population, in this case *Homarus gammarus* in a Norwegian MPA - fishery system. The preliminary results support females' preference for large males as mates. The results also showed a clear pattern of size assortative mating in the MPA, but because of the size selective fishery, no such pattern was observed in the exploited area. Raquel Goñi (Instituto Español de Oceanografía, Palma, Spain) reported results of a study investigating the mechanisms of biomass recovery of *Palinurus elephas* in a newly created Mediterranean MPA adjacent to a 24-year old MPA. Results indicate that density-dependent competition in the old-MPA plays a key role in the recovery process. In particular, and in line with the results of T. Sørdalen with *H. gammarus*, competition among males appears to underlie preferential emigration of small and medium size males from the old- to the new MPA.

Racquel Goñi
Instituto Espaniol de Oceanografia
raquel.goni@ba.ieo.es

Session 7: Habitat & Ecosystems

Chair: Lynda Bellchambers

Habitat and ecosystem issues have not, in many cases, been the traditional focus of fisheries management agencies. The aim of the *Habitat and Ecosystem Issues for Fisheries Management* session was to highlight the importance of research being undertaken in these

areas and its application in Ecosystem Based Fisheries Management (EBFM). The session included presentations from round the world across three main themes, the influence of habitat on the abundance and distribution of lobsters, potential ecosystems impacts of fishing and the impacts of pesticides and chemicals on lobster survival and development.

The session commenced with a presentation from one of the chairs, Lynda Bellchambers, on the research and management initiatives that have been implemented in the western rock lobster, *Panulirus cygnus*, fishery to address habitat and ecosystem issues and how these processes have improved the understanding of ecological processes and assisted with the implementation of EBFM and Marine Stewardship Council (MSC) certification.

Several other speakers in the session presented research on the influence of habitat on the distribution and abundance of a range of lobster species at different life stages and the importance of these relationships in understanding trends in fishing effort, designing sampling programs, and designing and implementing effective spatial management. Renae Hovey and co-authors presented spatially explicit habitat distribution maps across the geographic range of *Panulirus cygnus*, in Western Australia. She illustrated how spatial modelling techniques, in conjunction with broad scale bathymetry, can be used to upscale fine scale habitat data to understand the spatial arrangement of habitats across a species geographic range. When combined with species distribution and abundance data, these types of tools are invaluable for understanding patterns in fishing effort and intensity. Dr Ernesto A. Chávez and colleagues examined the relationship between habitat complexity and the abundance of spiny lobster (*Panulirus interruptus*) on the west coast of Baja California and used simulation modelling to explore optimum socio-economic fishing strategies under three possible scenarios.

Juan Figueroa and co-workers presented a paper on the influence of habitat complexity on recruitment processes and abundance of *Panulirus gracilis* (green spiny lobster) in Ecuador. His results suggest that spatiotemporal fluctuations in the abundance of *P. gracilis* is highly correlated with habitat complexity (substratum cover, rugosity, size and height of shelters and depth). Similarly, Gloria Verónica Ríos-Lara et al. presented research on the benthic habitat preferences of the late juvenile stage of *Panulirus argus* on the central coast of Yucatán, México. Her results indicated that areas with the highest diversity index also had the highest lobster densities.

Kristin Dinning and colleagues presented research examining if postlarval American lobsters prefer settling on cobble, mud or sand habitats and the potential impact of locating preferred habitats on development and growth. Her results indicated that postlarvae prefer to settle on cobble, followed by mud, and lastly sand. However, growth was only impaired when lobsters delayed settlement over sand. Benjamin Gutzler et al. compared the nutritional condition, relative mortality, and activity of spiny lobsters (*Panulirus argus*) in casitas and natural shelters in the Florida Keys. Juvenile lobsters in casitas displayed higher rates of mortality than lobsters in natural shelters, however, lobsters in casitas were in better condition.

The second theme of the session was the potential impact of fishing on the ecosystem and the importance of identifying, monitoring and where possible mitigating potential impacts to ensure the long term sustainability of fisheries and marine ecosystems. In this theme, Matthew Pember et al. presented research being conducted in a deep water closed area in Western Australia to determine the potential impacts of fishing for the western rock lobster, *Panulirus cygnus,* on the ecosystem. His results illustrate that after only 3 years of protection lobster populations in the closed area have increased although wider ecosystem impacts are not yet evident. Similarly, Kim Ley-Cooper and co-authors presented research conducted on the Caribbean spiny lobster (*Panulirus argus*) in the Sian Ka'an Biosphere Reserve, Mexico (SKBR). His research indicates that offshore, deeper water areas not subject to fishing act as refugia for lobsters and enhance fishing yields in the inshore commercial fishery. Jan Hesse et al. presented a paper on the impacts of decreased adult lobster, *Jasus edwardsii*, abundance on juvenile recruitment on reefs in New Zealand. The results of his study suggest 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 the removal of adult lobsters though fishing.

However, it is not just the intensity of fishing that influences the scale of potential ecosystem impacts but the fishing method. This point was illustrated by Sandra Mallol et al. in their presentation on the impact of fishing gear used in the *Palinurus elephas* trammel net fishery. A comparison of traditional trammel nets and an experimental trammel net, made of different material, showed a significant reduction in the catch rates of habitat forming species and undersized lobsters however there was also a 40% drop of commercial lobster catch rates with the experimental trammel net. This illustrates the

importance of considering both the intensity of fishing and method of fishing on habitat, target and non-target organisms when exploring possible mechanism for mitigating the potential impacts of fishing on the wider ecosystem.

The final theme in the session was the impact of chemicals and pesticides on lobster survival and development. Ann-Lisbeth Agnalt and co-workers presented a study on the effects of delousing chemicals containing teflubenzuron on the European lobster (*Homarus gammarus*). Delousing chemicals resulted in higher mortality of lobster and the range of deformities found in surviving juveniles may potentially affect localised recruitment. Similarly, Dounia Daoud et al. presented a paper on the effects of exposing stage V juvenile lobsters to sediment spiked with pesticides found in Canadian soils. The highest sublethal concentrations had obvious negative effects on growth and development of the juvenile lobsters.

Lastly, I would like to thank all speakers in the *Habitat and Ecosystem Issues for Fisheries Management* session for their interesting and thought provoking presentations all of which made my job easy and generated lively discussions over a beer or two in the bar. I look forward to further discussions at the next ICWL!

Lynda Bellchambers
Western Australian Fisheries and Marine Research Labs
lynda.bellchambers@fish.wa.gov.au

Members of the 10th ICWL Planning Committee look on as conference co-chair Patricia Briones-Fourzán addresses the opening session. Many thanks to them and their colleagues and students for hosting such a wonderful event!

Session 8: Population & Community Ecology

Chair: Kari Lavalli

The Population and Community Ecology session included five oral presentations and 15 poster presentations spanning topics from settlement to potential competition amongst sympatric species to adult distribution and predation. The oral session was started with our hosts (Patricia Briones-Fourzán and Enrique Lozano-Álvarez) and their collaborators (Iris Segura-Garcia and Simon de Lestang) talking about the dietary partitioning of the sympatric species of *Panulirus argus* and *P. guttatus*. While both species occur in the Caribbean, *P. guttatus* is typically considered an obligate reef dweller that would forage on food resources found within their home reefs and *P. argus* is considered to be more cosmopolitan, living on both reefs and adjacent areas and foraging across wide home ranges. The study presented sought to determine if habitat and lifestyle differences led to dietary differences via the use of carbon and nitrogen stable analysis of gut contents and bivariate ellipses determination of niche space. The study found that *P. guttatus* primarily consumed carnivores on the reef while *P. argus* consumed herbivores and primary producers. Because dietary overlap was negligible, the authors suggested that the combination of dietary and habitat partitioning allows for the coexistence of these two species within the Caribbean.

From the Caribbean, we then jumped to the northwest Atlantic, where Tracy Pugh and Robert Glenn spoke about their long-term, stratified (for depth and habitat), ventless trap survey in a 700 km^2 portion of Massachusetts Bay that ranged in depth from 3 to 50 meters. This presentation focused on data from 77 randomly selected stations with 12,385 trap hauls during 2005 to 2006. Over 96,000 lobsters were sampled in habitats categorized as featureless (mud) or complex (boulders, cobble). The authors concluded that depth was the main determinant of population size structure and abundance with shallow stations having the most abundant and smallest size distributions of lobster. Habitat correlated to the physiological state of lobsters with featureless bottom having a high percent of lobsters that were culls or newly molted. This study suggests that depth partitioning occurs among life history stages of the American lobster, while intact and hard-shelled lobsters may exclude damaged and newly molted lobster from the best habitats from which to escape predation.

David Díaz, Anabel Muñoz, Sandra Mallol, and Raquel Goñi took us to the western Mediterranean where

they explored settlement rates of the pueruli of the European spiny lobster, *Palinurus elephas*, to determine if they could accurately predict recruitment strength from these rates. From 13 locations in the northwestern Mediterranean and using a series of settlement indices ranging from 10 to 14 years in duration, the authors attempted to tease apart which global or regional climate indices and which environmental factors were important to settlement strength. Via principal component and correlation analyses, they found that only regional climate and zonal wind patterns were important in this portion of the Mediterranean basin. Now that this is understood, investigators should be able to model regional climate conditions and wind patterns to predict settlement strength in any given period of time, and then use that settlement pattern to create recruitment models.

Gudjon Mar Sigurdsson, John Tremblay, and Rémy Rochette took us to the Bay of Fundy to discuss a study attempting to quantify the abundance and spatial pattern of coastal lobster settlement. They used settlement collectors in a nested design over two regions (south New Brunswick and southwest Nova Scotia) to examine patchiness in settlement as one moved from a large to an extremely small spatial scale. They used a variance component analysis and calculated the variance in numbers of settlers at different spatial scales and then used both of the values generated to compare to results generated from a Monte-Carlo simulation that assumed random settlement across the sampling site. At larger spatial scales, they found significant patchiness; however, at smaller spatial scales, settlement was less patchy and, as a result, they were able to assess which areas might be more predictive of settlement in the future.

Daniel Skerritt, Clare Fitzsimmons, and Nicholas Polunin took us to the Northumberland Strait to investigate movement patterns of the European clawed lobster, *Homarus gammarus* via acoustic telemetry. They tagged 43 lobsters ranging in carapace length (CL) from 65 to 98 mm and followed their movements in an area >1 km^2 for 42 days during the summer (May-June) and 35 days during the fall (Oct-Nov). They found that all lobsters cluster along the edges of rocky habitat, but that females were less likely to leave these areas of complex habitat and had highly restricted home ranges of 20-40 m in diameter. In contrast, males had larger home ranges (30-60 m diameter) and were more willing to move into featureless habitat. The authors suggested that these results may be important in identifying appropriate reserves for lobster in the U.K.

Two posters covered attempts to link settlement to future recruitment in *Palinurus elephas* and *Panulirus interruptus* populations in the Mediterranean and Bahia Tortugas, respectively. Both assessed the use of artificial collectors to collect settlement data: in *P. elephas* populations, David Diaz and his colleagues found that the artificial collectors in both deep and shallow stations were not as effective as underwater visual surveys by divers, but in *P. interruptus* populations, Jorge Carillo-Laguna and colleagues found that collector data coupled to abiotic factors (temperature, upwelling rates, southern oscillation) were useful to form predictive models.

Four posters looked at potential diet and condition of pueruli and early juveniles of *P. interruptus*, *P. argus*, *P. inflatus*, and *P. gracilis*. Carillo-Laguna and colleagues found that *P. interruptus* juveniles, ranging in size from 5 to 30 mm CL, had moderate diet overlap within specific size intervals, and this overlap varied seasonally, being higher in autumn and winter and lower in spring. Using CL and weight as an index of condition, Rogelio Martinez-Calderón and colleagues found that the condition of *P. argus* pueruli was significantly lower than first-stage juveniles. However, in general, pueruli condition was more stable across all seasons, while that of first-stage juveniles varied widely and was likely the result of local factors influencing food availability and predation rates. David Becerra-Arroyo and Raúl Pérez-González examined the possible food sources available to *P. inflatus* and *P. gracilis* post-larvae in Sandwich collectors. These collectors had rich communities representing 30 taxonomic families, 35 genera, and 35 species, mostly of other arthropods, which likely provide a diverse diet for settled postlarvae. Raúl Pérez-González and colleagues marked 210 juvenile *P. inflatus* and recaptured 18 within a two month period; these 18 lobsters allowed them to estimate an absolute growth rate of 5.3 mm CL per month.

Taku Yoshimura and colleagues suggested that dense sea anemone colonies on small boulders provided predator-free refuge for young benthic stages of *Panulirus japonicas* and were likely the reason that these stages are only found associated with the sea anemones rather than bare boulder. Jan Hesse and Andrew Jeffs explored better ways to study *in situ* predation on juvenile spiny lobsters, *Jasus edwardsii*, over 24 h periods by housing the juvenile in a transparent container. They determined that this "lobster in a bottle" technique substantially decreased diver induced attraction to the juveniles while placing them out on tethers in the environment. They were then able to assess predation risk during a full day/night cycle and determined that the majority of attacks were during the day, followed by dawn. Video allowed identification of predators: rock cod, conger

eel, adult spiny lobster, kelpfish, blue cod, and spotted wrasse.

Basic demographic data were accumulated by Rogelio Martinez-Calderón and colleagues on two data-poor spiny lobsters: *P. inflatus* from the Pacific coast of Mexico and by Francoise de Lima and colleagues on *P. echinatus* in the Sao Pedro and Sao Paulo archipelago off Brazil. Both posters provided sex ratios, size distributions, morphometric measurements, proportions of ovigerous females. The Brazilian survey also gave seasonal catch per unit effort (CPUE) data. *P. inflatus* sex ratios were 1:1 throughout the year, except in February when males predominated; males were larger than females. Female *P. inflatus* mature at 77 mm CL and are ovigerous in greatest proportions from July to November, the closed season in Mexico. Male *P. echinatus* were also larger than females, and sex ratios were male-skewed. CPUE rates for this species were higher in the dry season than in the rainy season. Both of these studies were expected to help management of the species.

Similarly, basic distribution and abundance data were collected for two *Nephropsis* species by Ana del Angel and colleagues, for *Stereomastis sculpta* by Adolfo Gracia and colleagues, and for several species of both Nephropidae and Polychelidae by Patricia Briones-Fourzan and colleagues. All three studies recorded depth information, likely reproductive seasons, and size distributions for species that are not well studied.

In short, this session showed that there is still much to learn about basic population ecology of lobster species, particularly as the increasing demand for lobster worldwide pushes fishermen to exploit new species that are not currently well studied. This is especially true for those found in Central and South America.

Kari Lavalli
Boston University
klavalli@yahoo.com

Salsa dancing 101

Session 9: Lobsters in Antiquity

Chair: Ehud Spanier

This session included a keynote address, seven oral presentations and one poster. The keynote address by Ehud Spanier and Kari Lavalli compared the distribution of lobster species, especially in shallow waters, to that of anatomically modern humans emerging some 200,000 years before present (YBP). Various human civilizations were examined from ancient times up to the first half of the 20th century. While there is evidence of consumption of lobsters by prehistoric societies, presence of lobster remains in prehistoric middens depends on environmental conditions. When middens are exposed to rainfall, lobster shells and hard parts will eventually be dissolved. Thus, finding lobster remains is a rare occurrence, and one must rely on art, historical writings, or oral traditions to understand patterns of usage.

Lobsters appeared in carvings in the ancient era and in later classical writings, mosaics, and art works of various civilizations. There are indications that in all areas lobsters were both more abundant and larger than they are today. Apart from the Mediterranean, indigenous peoples tended to harvest lobsters at a sustainable rate, even when other taxa may have been overexploited. It was not until European contact, with alterations in fishing techniques and development of transport methods for live and cooked lobster over long distances, that overfishing began to deplete stocks. Certainly by the late 1800s, some coastal stocks around the world exhibited size reductions and reduced numbers. Despite regulatory attempts, nearly every lobster stock has been heavily fished, and it is unrealistic to expect a recovery to the near-pristine levels of lobster numbers and sizes reported some 400 to 500 years ago. High landings today come at the cost of a highly mechanized fishing fleet, use of a large number of pots or nets, and smaller sizes of landed lobster. Recognizing these changes is critically important to understanding the anthropogenic selection pressures imposed upon lobster species for future management schemes.

Johan Groeneveld reviewed the history of utilization of Cape rock lobster *Jasus lalandii* along the west coast of South Africa from pre-historic times to the present. Preserved calcareous mandibles in middens confirm that lobsters were exploited by early hunter-gatherers over the past 15,000 years. Coastal zoo-archaeolgical findings suggest increased reliance on marine shellfish, including lobsters 3000 - 2000 YBP. Pre-colonial foragers (500–1000 YBP) relied on large numbers of rock lobsters as part of their diet. 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. Commercial landings have since declined to <10% of what they were at the height of the commercial fishery.

Clive Jones and Bruce Phillips spoke about the history of utilization of lobsters by humans in Australia. The mainland and inhabitants of Tasmania and Torres Islands have lived in Australia for millennia and had and continue to have a close association with the sea and fishing. Some documentation of this history has been recorded, including scant references to lobsters. Recent documented history of lobster utilization by European settlers and their descendants indicates that fishing, mainly for four species of spiny lobster and several species of slipper lobster began in earnest in the late 1800s. All commercial lobster fisheries are currently managed through various output or input controls, and are sustainable.

Ehud Spanier, Marco Bianchini, Jason Goldstein, Rebecca Kibler and Kari Lavalli spoke about aspects of the history of lobster utilization in the Central and Eastern Mediterranean and Red Sea**.** These areas host a variety of clawed, spiny, and slipper lobsters that are commercially significant to the region. Although historical information is patchy, evidence indicates that the utilization of lobsters in ancient times ranged from the prohibition of lobster consumption by the Jewish religion, to that of epicurean status in the Roman world. Lobster remains in Mediterranean prehistoric middens are very rare and only a partial claw of *Homarus gammarus* was found recently in an early Iron Age site, dated to the late 7th century BCE in northern Sardinia.

One of the earliest known illustrations of a lobster in the Levant region was a bas-relief in the Deir el Bahri temple in Egypt depicting the expedition of Queen Hatshepsut to the Red Sea in the 15th century BCE. Lobsters were also expressed in art forms and writings and appeared in many 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 CE), also referred to the migration and molting of lobsters. Naturalists and philosophers from the Roman-Hellenistic period, together with illustrative records (mainly mosaics), indicated that lobsters were a well-known food source exploited by fishermen who understood their biology and behavior. The popularity of lobsters in the Mediterranean basin as a gourmet food increased over time and eventually led to overfishing in the Modern Era.

David Díaz, Sandra Mallol and Raquel Goñi addressed the history of the utilization of the European spiny lobster *Palinurus elephas* in the western Mediterranean, particularly in Spain. The Romans built pens for the purpose of holding live lobsters. The northern coasts of the Iberian Peninsula were the first fishing grounds to be commercially exploited for live spiny lobsters, which were exported by sea to France and the UK at the end of the 19th century. When yields from this area declined, fleets moved to fishing grounds in West Africa. Evidence of overexploitation, noticed already by the late 19th century, triggered the implementation of seasonal restrictions and a special fishing tax, which failed to decrease overfishing.

Gro van der Meeren, Even Moland, Ann-Lisbeth Agnalt, Alf Ring Kleiven, Esben Moland Olsen and Ellen Grefsrud reviewed the long and winding history of the fishery, management, and culture of *H. gammarus* in Norway. Lobster in Norway was not highly regarded as a source of food, as it was considered a scavenger that might consume sailors lost at sea. Instead it was utilized as fertilizer and for consumption by the poor who lived in fishing villages. Commercial fishing commenced in the early 1600s with export to the Netherlands and England. Since 1850, annual landings have varied between 300-600 tons (t) and peaked at 1,300 t in 1932, possibly driven by benign climate and increased market opportunities. Despite fishing regulations introduced in the mid-20th century, official landings have dramatically declined, and remain at a level of 30 to 50 t.

Kari Lavalli dealt with the history of lobster utilization in the Americas, which hosts a variety of lobster species. Since peopling of the Americas was relatively recent, no written records exist of ancient use of lobsters, nor are their remains found in the oldest middens (>12,000 YBP). However, there are more recent findings of lobster remains (~3,000 to 2,500 YBP) in some middens and many written records from European explorers. Midden analyses, oral histories, artwork and written histories, provide indications that the ancient inhabitants of northeastern seacoast of North America likely fished for clawed lobster and those from the west coast fished for spiny lobster. Similar records exist for the variety of peoples occupying coastlines of South and Central America. In all cases, Europeans describe lobsters as being incredibly numerous inshore and very large, and they used them as food when their ship stores were low or when they could not acquire sufficient fish. Europeans colonizing coasts of North America considered lobsters as food for the poor, for emergencies, for fertilizing crops, and as bait for cod. However, in the 1800s, lobster emerged as a food for the wealthy during their summer vacations. Greater demand led to a host of changes towards more efficient capture methods, preservation by canning,

and live transport. By the end of the 1800s, lobsters on the east and west coasts were considered overfished and had suffered serious size and weight declines. This did not occur in the southeast, mostly because lobster stocks there do not rely upon local reseeding and recruitment and instead receive new recruits into the population from South American stocks.

Jason Goldstein, Don Behringer and William Keegan presented a historical overview of lobster use by pre- and post-Columbian cultures in the Caribbean and Mesoamerica that hosts several spiny and slipper lobster species. Mesoamericans indigenous cultures incorporated lobster as part of their diet and material culture. Native cultures likely designed and constructed traps specifically for lobsters while others may have harvested lobsters from boats. 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.

Finally Andrew Jeffs reviewed the history of lobster utilization in New Zealand where two species of spiny lobster are found in the coastal waters. Both species of lobster have been extensively harvested since the first arrival of Polynesian seafarers around 1200 years ago. For the indigenous Maori people, lobster held special significance as an important coastal food item, as a trading item, and as an animal with spiritual values. Early records and oral histories indicate that lobster fishing was highly regulated within Maori communities through cultural rituals and taboos. Following European colonization, 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.

Sadly, this session was unable to find contributors from other regions of Europe (France, England, Scotland, Ireland, and Wales), and the Netherlands, East Asia (India, China, Japan, Indonesia), and South America (Brazil, Chile) to provide a truly worldwide history of exploitation of lobsters, but we hope that this current summary will spur interest in others pursuing such a history and contributing to our larger work.

Ehud Spanier
The Leon H. Charney School for Maritime Studies
University of Haifa
espanier@univ.haifa.ac.il

Kari Lavalli
Boston University

Jason Goldstein
University of New Hampshire

Terracotta vase, ca. 460 BCE
Greek, Attic
www.metmuseum.org

Session 10: Stock Assessment

Chair: Nelson Ehrhardt

The stock assessment session consisted of thirteen presented talks and five posters from participants hailing from six countries focusing on nine lobster species, making this session a fine reflection of the challenges associated with stock assessment of lobster taxa representing a diverse array of life histories. The session also reflected the great deal of progress made in the last several years with the inclusion of sophisticated modeling techniques and enhanced cooperation with harvesters.

The first talks featured *Homarus americanus*. Marissa McMahan and co-authors found that growth rates of juvenile American lobsters at her Gulf of Maine study sites have increased significantly in recent years, likely due to increased temperatures in New England waters and release from predatory pressure. Noah Oppenheim and co-workers described a new forecasting model that predicts landings up to eight years in advance on a management area scale using the young-of-year settlement survey the American Lobster Settlement Index. Marthe Larsen Harr et al. described the research objectives of the five-year 'Lobster Node' of the Canadian Fisheries Research Network, which encompass large-scale patterns in fishery productivity and recruitment variability. The focus of her studies is lobster reproductive ecology. She found that the recent downward trend in female size at maturity is not strongly correlated with climate trends and is examining the hypothesis that the decline may be an evolutionary response to size-selective harvesting.

The Caribbean spiny lobster, *Panulirus argus*, was the focus of several talks and posters. Elizabeth Babcock presented her assessment work in Belize, which recently implemented logbook requirements in the

Glover's Reef reserve. Nelson Erhardt presented his meta-analysis of recruitment and harvesting variability relative to oceanographic changes throughout the range of the species with interesting correlations detected. In another talk, Nelson discussed efforts to use an enhanced age-length key to better estimate stock indices. Kim Ley-Cooper and his collaborators found that short-term fluctuations in fishery productivity in Yucatan, Mexico may be caused by behavioral responses to strong, short-term weather events. He also presented a model suggesting a transition from reef collection to casita fishing could reduce overfishing in Banco Chinchorro, Mexico. Eloy Sosa-Cordero described the variability present in two major fishing areas in Mexico's east coast. Recognizing the complexity of large scale larval dispersal potential in this species, Nan Yao proposed a new metapopulation model for the U.S. stock in the Florida Keys.

The lone Mediterranean representation in this session was from Margarida Castro, who described her work on tagging with *Palinurus elephas* in Portugal. She and her colleagues found that streamer tags were retained more frequently during molting, whereas t-tags were easier to implant. Mortality was not a significant concern for either tag type.

Not to be outdone, folks from the Pacific presented their work on a wide variety of species in the Northern and southern hemispheres. From the west coast of Mexico, Armando Vega-Velázquez provided an update to the stock assessment program for *Panulirus interruptus*, which is thriving under a MSY-based management structure according to surveys and fishery indices. Another species on Mexico's Pacific coast, *Panulirus inflatus*, was the subject of a poster given by Karen Frankly Castro-Gutiérrez, who described four models being considered for stock assessment. Looking down under, Ian Tuck presented his work on a new acoustic survey methodology applied to the deep sea lobster, *Metanephrops challengeri* in New Zealand as a way to augment traditional video surveys. Enhanced information about burrow occupancy and emergence from shelter should help increase the accuracy of their survey efforts. From Western Australia, Nick Caputi provided updates to the successful story of western rock lobster (*P. cygnus*) management. Because egg production currently exceeds threshold limits by a healthy margin, a relaxation of management benchmarks such as maximum size and retention of gravid females is being considered. Zia Kordjazi and co-authors showed that current tag-recapture methods may not be sufficient to accurately assess populations of southern rock lobster (*Jasus edwardsii*), and suggested that studies with a greater than three year duration may be necessary in the future. Timothy J. Emery presented his work with his colleagues on handling impacts to growth in *J. edwardsii* in Tasmania using a von Bertalanffy model approach with mark-recapture data. He estimates that there is ~1% loss in landed biomass due to damage during handling.

Noah Oppenheim
School of Marine Sciences
University of Maine
noah.oppenheim@maine.edu

Session 11: Reproduction & Development

Chair: Jason Goldstein

The *'Reproduction, development, and physiology'* themed-session of the 10th ICWL featured seven presented talks and eight posters with presenters from Mexico, the USA, Canada, Japan, the UK and Norway. Clawed, spiny, and slipper lobsters were highlighted in these informative sessions and were focused on two major themes: (1) reproduction and mating dynamics; and (2) physiological constraints with respect to growth, development, and thermal tolerance.

Julien Gaudette (Canada) opened the oral session with an overview and reassessment in the way we view size-at-maturity in American lobsters (*Homarus americanus*). Through a comparison of recent and historic empirical data, Gaudette and colleagues determined that female maturity ogives appear to be shifting downward. This raises questions about how male:female size ratios influence mating opportunities and therefore egg production in this species. Accompanying these findings, Tracy Pugh and Win Watson (USA) presented data that examined male mating success with females of varying sizes in a series of lab-based trials. Preliminary results suggest that differences in size in addition to female-skewed sex ratios can negatively impact reproductive success. For example, males > 40% smaller than the female only passed a spermatophore in 25% of trials.

A related poster presentation by Pugh et al. looked more closely into spermatophore morphology in H. americanus using a variety of techniques including electro-stimulation and histology. Their preliminary results suggest that although spermatophore weight increases with male size, there is no relationship between male size and spermatophore composition. To round out this discussion, Jason Goldstein and co-workers (USA) investigated small, immature female lobsters and their propensity to reproduce. Over 200 lobsters were examined by confirming the presence of

sperm in the seminal receptacle. Surprisingly, more sexually immature than mature females were sperm positive. Combined, these talks suggest a changing and variable mating system that warrants further research.

In their poster, Charlie Ellis and David Hodgson (UK) estimated the temperature-dependence of fecundity in *H. gammarus* using general linear models (based on physical fecundity counts). Their fecundity analysis of over 1,000 ovigerous lobsters from 11 locations in the UK, Ireland and Norway, showed significant positive correlations between mean annual temperature range and female fecundity at the minimum landing size. They also reported a negative correlation between mean annual temperature and size-specific fecundity. That is, as temperature warms the number of eggs per kg of female declines. These results suggest that temperature-correlated fecundity predictions can be a useful tool for estimating egg production under a variety of environmental regimes, including increases in sea water temperature.

With respect to reproductive dynamics and spiny lobsters, the poster by Mark Butler, Alison MacDiarmid, and Rod Bertelsen (USA) investigated the reproductive systems in two contrasting lobsters: southern rock lobster (*Jasus edwardsii*) and Caribbean spiny lobster (*Panulirus argus*), a temperate and tropical species, respectively. Experiments conducted in large mesocoms revealed differences in reproductive attributes (e.g., mating seasons, cohabitation, maternal investment of eggs, male-female sizes) between these two species and emphasize predictions that vary based on environmental seasonality. In another poster, Mark Butler and Gaya Gnanalingam (USA and New Zealand) looked into the effect of lobster size on spermatophore production and fertilization success in the Caribbean spiny lobster, *Panulirus argus*. Mark and Gaya quantified the relationship between male size and spermatophore production in successive mating events, and how reductions in spermatophores along with female size influenced fertilization success in *P. argus*. Their results (large males have shorter sperm recharge rates) underscore the importance of keeping large males in the population.

A second group of talks and posters focused on the physiological limitations and development of phyllosoma larvae and early juvenile stages of spiny lobsters. Working with early-stage phyllosomas of *Panulirus interruptus* Antonio Silva et al. (Mexico) examined changes in oxygen consumption in response to different combinations of temperature (11,17, 22, 27 & 31℃) and salinity (22, 28, 33.5 & 42 psu). Likewise, Alí Espinosa-Magaña, Patricia Briones-Fourzán, and others (Mexico) tested the hypothesis that the timing of first feeds for early-stage *Panulirus argus* juveniles (prior to the non-feeding puerulus stage) is critical to their survival. More than 150 wild-caught pueruli were allocated to eight different feeding treatments ranging from 'fed daily' and starved. They measured the feeding threshold at which 50% of starved juveniles can recover. Their results suggest that early benthic juveniles of *P. argus* can tolerate long periods of starvation without significant damage.

Kaori Wakabayashi and Yuji Tanaka (Japan) described the intimate relationship between slipper lobster phyllosomas (two *Ibacus* species) and jellyfish to more fully understand how phyllosomas may utilize such gelatinous zooplankton for food, transport, and shelter. In a series of behavioral assays (including video), Kaori and Tanaka determined that phyllosomas were able to identify distinct areas of jellyfish that allowed them to cling and feed. Phyllosomas demonstrated similar behaviors on other jellyfish as well, suggesting the co-evolution of such larvae with gelatinous zooplankton. In a related poster presentation Kaori investigated the efficiency of jellyfish as food for slipper lobster (*Ibacus ciliates)* phyllosomas, fed on two species of jellyfish (*Aurelia aurit & Chrysaora pacifica).* A total of nine animals (out of 22 in total) directly metamorphosed into the nisto postlarval stage, implying that jellyfish may be a viable diet constituent in the culture of slipper lobster.

In their poster, Miriam Palestina-Martínez et al. (Mexico) evaluated the effect of thermal maxima on oxygen consumption in *Panulirus argus*. Juveniles were exposed to temperature increments of 1℃/min until they lost their muscular control, after which they were evaluated in respirometry chambers. Their analysis suggested that ~ 9 h were necessary for recovery. Additionally, after only 1 min of exposure to thermal limits, a dramatic change in metabolism is evident, suggesting a high thermal sensitivity of juveniles of this species. In another poster, John Garland and Roger Uglow (Canada) explored the range in cardio-ventilatory activity exhibited by *H. americanus* when exposed to acute changes in ambient water temperature (2-8℃). The implications of thermal tolerance for the range in *H. americanus* in its natural and commercial environment were discussed. Ellen Grefsrud, Ann-Lisbeth Agnalt and Eva Farestveit (Norway) described the development of the gastrolith (calcium deposits in foregut) and the changes that ensue over the moult cycle in *Homarus gammarus*. The authors used x-ray radiography to show that that the gastroliths dissolved within 12 h post-ecdysis, reappeared at about day-17, and increased in size until the next molting period.

Knowledge of these developmental changes will be important indicators for how lobsters deal with environmental stress.

Jason Goldstein
Department of Biological Sciences
University of New Hampshire
j.goldstein@unh.edu

"Live long, and prosper"

Session 12: Larval Connectivity

Chair: Mark Butler

Larval connectivity and the factors that potentially impact larval survival and settlement success were again a topic of great interest at the latest lobster conference in Cancun. There were seven oral presentations and eleven poster presentations within the Connectivity Session.

The well-attended oral session on connectivity began with four presentations on studies of the effects of environmental factors and parental stock source on settlement behavior in the American clawed lobster (*Homarus americanus*). Leo Barret (Université du Québec à Rimouski, Canada) and colleagues led off the session with an examination of the settlement behavior of *H. americanus* larvae in relation to the incubation temperature, origin of the stock, and presence of thermoclines. Sedimentation of coastal nursery habitats is an issue off the coast of New Brunswick (Canada) and may contribute to low lobster recruitment in the Northumberland Strait, which prompted laboratory studies on the effect of sedimentation on choice of substrate by settling *H. americanus* conducted by the second speaker in the session, Benoît Bruneau (Université de Moncton, Canada) with co-authors.

The paucity of data on the effect of temperature, light, and flow on swimming behavior of *H. americanus* larvae that are available for incorporation into detailed biophysical models of clawed lobster was the motivation behind laboratory studies by Ryan Stanley (Memorial University of Newfoundland, Canada) and his co-authors who investigated the swimming behavior of *H. americanus* (stages I-IV) from two source populations in vertical columns and horizontal flume chambers in response to temperature, light, and water velocity. Both temperature and light significantly affected rate of movement for all larval stages, but in particular they noted marked decreases in swimming activity by intermediate stage larvae as compared to early and late stages. Two posters by Brady Quinn (University of New Brunswick, Canada) and colleagues and another by Gilles Miron et al. also explored the effects of environmental factors (e.g., elevated seawater temperature, sedimentation, predation) on larval clawed lobster development and patterns of recruitment. Quinn and colleagues wrapped up the series of talks on *H. americanus* with a presentation on the initial results of their oceanographic modeling of larval drift across the Atlantic Shelf of North America from Cape Cod (US) to the Strait of Belle Isle (Canada). Although their model does not yet include larval swimming behavior or response to environmental parameters as demonstrated by the previous presenters, theirs is a step toward understanding the potential spatial connectivity of clawed lobsters over large spatial scales. Also important to such models are the initial patterns of female stock abundance, clutch size, and clutch quality which were the subject of a poster presented by Marthe Larsen Haarr and her co-workers.

The patterns of population connectivity in six species of clawed (Nephropidae) and spiny (Panlinurdae) lobsters spread among remote islands, seamounts and shelf habitats in the SW Indian Ocean and South Atlantic was the subject of the presentation by Johan Groeneveld (Oceanographic Research Institute, South Africa) and co-authors. They combined information from studies of genetic connectivity with life-history and oceanographic information to infer larval dispersal patterns and the taxonomic status of previously-recognized species. A lack of barriers to dispersal and gene flow over thousands of kilometers suggests that *Jasus paulensis* and *J. tristani* should be synonymised as *J. paulensis*. Three closely-related *Palinurus* species have evolved in the SW Indian Ocean. *Palinurus barbarae* is widely distributed on offshore seamounts in the Indian Ocean, whereas along the continental shelf-edge of SE Africa the inter-relationship of strong directional currents, eddies, hydrographical boundaries, and life-history

adaptations have resulted in a panmictic distribution of *P. gilchristi* in contrast to a more constrained, genetically structured population distribution of *P. delagoae*. They showed that the distribution of the clawed lobster *Metanephrops mozambicus* also exhibits considerable population substructure over short geographical distances along the coasts of Mozambique, Madagascar, and South Africa. Our expanding knowledge of the seasonal and regional patterns of postlarval settlement onto artificial collectors of several species of palinuridae (*P. inflatus, P. interruptus, P. guttatus*) on the east and west coasts of Mexico was explained in posters by Armando Vega-Bolaños et al., David Becerra-Arroyo et al., and Ashanti Canto García et al. Although most artificial collectors used to collect postlarval lobsters mimic the structural features of settlement habitat, a poster by Gudjon Mar Sigurdsson and co-authors explored the potential use of light traps for collections of postlarval *H. americanus*. How postlarvae orient to coastal nurseries and whether chemical or auditory cues or oceanographic regimes are involved in this process, was the subject of a poster on *Jasus edwardsii* settlment by Ivan A. Hinojosa and colleagues.

A presentation by Andrew Jeffs (University of Aukland, New Zealand) and colleagues opened with the provocative title: *"Hot n' hungry lobster larvae: Can a warming ocean explain a decline in spiny lobster recruitment?"* They used morphometric and biochemical analyses to assess the nutritional condition of larval *Panulirus cygnus* sampled from two pairs of anticyclonic and cyclonic eddies to investigate the potential role of eddy systems in the survival and settlement of postlarvae in Western Australia. Although the larvae differed in nutritional condition, those differences could not be explained by differences in diets identified using molecular genetic analysis of larval gut contents. Their results suggested that warmer water temperatures within anticyclonic eddies may exceed the temperature optima of larvae required to accumulate nutritional reserves indicating that larvae may be vulnerable to changes in oceanic climate - tying into the climate change theme of the conference. Related to this study, a poster by Richard O'Rorke and colleagues confirmed that larval *P. cygnus* found associated with gelatinous zooplankton (e.g., salps, cnidarians) are actually feeding on them as long suspected.

The oral session concluded with a presentation by colleagues Andrew Kough, Claire Paris and I in which we described results of a multi-scale, biophysical model of Caribbean spiny lobster larval dispersal that combines empirical estimates of larval behavior and gamete production to predict the spatio-temporal patterns of larval connectivity throughout the Caribbean from Venezuela to Florida. We were encouraged that the model predicted well the seasonal patterns of postlarval lobster postlarvae arrival on coastal collectors at two sites each in Mexico and the Florida Keys, thus providing an empirical validation of its usefulness. Our results indicate that the Caribbean is a kaleidoscope of regions: some dominated by self-recruitment and others dependent on postlarvae from populations sometimes thousands of kilometers away. We also explored how various spatial arrangements of marine protected area networks influence the recruitment of lobsters in the Caribbean. Those simulations demonstrated that MPA locations chosen based on their merit as international or domestic larval exporters usually maximized recruitment to the Caribbean as a whole. Moreover, the model indicates that supposed high-flow larval dispersal corridors actually result in larval wastage, in contrast to other areas that function as coastal pelagic larval nurseries. These findings thus provide the first-ever validated description of sources, sinks, and dispersal corridors of larval *P. argus* throughout the greater Caribbean, information that is crucial for the proper international management of this iconic Caribbean species.

Mark Butler
Department of Biological Sciences
Old Dominion University
mbutler@odu.edu

Lobster Fishermen, 1940-41
Marsden Hartley (American, Maine, 1877-1943)
www.metmuseum.org

Session 13: Management

Chair: Jim Penn

The management session at ICWL 10 involved 13 papers and 1 poster covering a wide range of lobster fishery topics.

Jim Penn provided a keynote address on the history of lobster management across the world and covered recent developments in more complex systems using the Western Australian *Panulirus cygnus* fishery as a case study. The presentation reported that the majority of large fisheries were still managed using limited entry, except for the scampi trawl fisheries and the South African/Australasian spiny lobsters fisheries where catch quota management was in place. The evolution of limited entry into sophisticated effort control systems and the recent conversion to ITQs in the case study was used to assess the positive and negative impacts of the alternative systems and the values associated with fishing rights under these systems.

Mónica Pérez-Ramírez and Bruce Phillips presented a paper reviewing the Marine Stewardship Council certification processes and the benefits being experienced in the Mexican red lobster and Western Australian fisheries. Outcomes from certification were found to differ between regions ranging from direct market benefits in Europe to improved understanding of ecological impacts to the image of fisheries more generally.

A group of presentations on recent developments in the Australasian lobster fisheries were provided, including: The impact of quota leasing on the behaviour and risk taking by fishermen in the Tasmanian lobster fishery presented by Tim Emery et al. The presentation highlighted some unanticipated negative social impacts of the management system being applied which had resulted in deaths at sea. Also on the Tasmanian fishery, Caleb Gardner et al. described innovative research on the translocation of wild stocks which increased growth and suggested that high rate of return on investment could be achieved, but adoption had been delayed by industry debate. The underlying causes of industry opposition and ways forward were discussed. Unusual changes in the distribution of fishing over a 40 year period in the South Australian fishery were outlined by Adrian Linnane and Rick McGarvey. The presentation showed a significant refocussing of effort onto areas with more consistent recruitment occurred following ITQ implementation, despite much higher CPUEs elsewhere. The case study considered economic impacts and options for finer spatial scales of management which may be required where fisheries operate over broad geographic regions.

A paper by Kevin Sullivan on management procedures (MPs) being adopted in the New Zealand fisheries reported a system which facilitated the rebuilding of depleted stocks and then maintaining them above target levels based on CPUE indices from commercial fishing. Significantly improved CPUEs and economic returns were reported to have flowed from the MP system and more conservative harvest levels adopted.

Paulo Prodöhl and Deborah Bailie reported on a particularly novel use of DNA profiling in the Northern Ireland lobster fishery to assess the impact of the "V" notching mature female lobsters in terms on long term sustainability of the resource. A co-operative program between fishermen and the University has resulted in genetic tagging of 26,000 lobsters and an ability to track their progeny over time to investigate stock recruitment benefits of the "V" notch program.

A series of papers on the management issues in Latin American lobster fisheries were presented: René Schärer provided a history of management events in the Brazilian lobster *P. argus* fishery, which have led to depleted catches and much illegal fishing. The presentation covered the development of UNEP based Fishery Improvement Plan and proposed the use supply chain controls on exports to counter illegal fishing and support the fishing communities which have historically relied on the lobster stocks. Rafael Puga et al. provided a comprehensive review of the management systems applied to the Cuban *P. argus* fishery, which is the largest in the region and has a long history of research. The impact of environmental factors on the productivity of the Cuban stock over the history of the fishery was presented and the role of management in addressing these impacts was discussed.

Lester Gittens provided a presentation on the management developments in the Bahamas *P. argus* lobster fishery since 2006 and planning for a comprehensive management program involving government, fisher organisations, the private sector and NGOs. The fishery was reported to have undergone peer reviewed stock assessment, including attempts to quantify illegal fishing, and is currently working on improving management to ensure sustainability. Stephen Box reported on the difficult socio-economic situation in in the Honduran lobster fishery, where the Miskito people rely on income from lobster fishing, but use scuba which is causing significant health risks to fishermen. The presentation described an innovative strategy to convert the dangerous scuba fishery to free dive fishery by creating an exclusive area for fishing by the Miskito people around a series of offshore cays.

Enrique Morales-Bojorquez provided a poster describing the passive management approach used historically to successfully control fishing effort and

catches in Mexican lobster fisheries. The poster described the new needs management to become more adaptive and set out clear objectives for regional management of lobster stocks to keep harvest rates within prescribed limits as these fisheries move toward environmental certification.

Jim Penn
Western Australia Fisheries and Marine Research Labs
jimpenn@iinet.net.au

Session 14: Genetics

Chair: Johan Groeneveld

The genetics session comprised five oral and three poster presentations. The first two orals were by students, and focussed on the use of next generation sequencing to determine population genetic structure of spiny lobster *Jasus edwardsii* on the east coast of Tasmania (Villacorta-Rath et al.), and American lobster *Homarus americanus* along the Atlantic coast of Canada (Benestan et al.). Both studies used single nucleotide polymorphism markers (SNPs), and found strong evidence of population structure. Using SNPs allows for the use of a large number of markers to elucidate population structure, compared to far fewer markers in the case of mitochondrial DNA or microsatellite analyses. A much higher resolution can potentially be achieved. Weak but significant genetic differentiation was found among Canadian *H. americanus* at sampling locations over a geographically small scale, and individuals could be assigned to local populations with 89% success. The fine-scale structure observed in this study is in accordance with the homing behaviour and restricted movements of *H. americanus* observed by several tagging studies. In addition, this study found that the assignment test can be used to estimate dispersal, a promising new approach to defining management units. Next-generation genetic sequencing and transcriptomic analysis is also planned for *H. gammarus* in European waters (poster by Bates).

In the third oral presentation, 16 polymorphic microsatellite loci were used to assess the effects of rearing and release strategies on the population structure of a regional *H. gammarus* stock in Cornwall (UK) (Ellis et al.). The extent of multiple paternity was also examined, using the same 16 loci. The light-sensitive molecule (cryptochrome or CRY) that mediates the entrainment of daily rhythms was the topic of the fourth oral presentation (Watson et al.). CRY was sequenced for *H. americanus*, and proved to be similar in structure to CRY in other crustacea, falling in the CRY2 family. Antibodies against CRY were used to localize CRY-immunoreactive neurons throughout the central nervous system, including the ventral nerve cord. The final oral presentation provided first evidence for interbreeding between introduced *H. americanus* and the local species, *H. gammarus* in Norway (Jørstad et al.). DNA profiling of a *H. americanus* egg-bearing female and its fertilized eggs revealed surprising results: for all loci examined, the male fragment sizes in the eggs have only been found in specimens of *H. gammarus*. Hatching of additional eggs in the laboratory and further DNA profiling of larvae and juveniles confirmed that the offspring were hybrids between the two species.

Genetic analysis of *P. argus* among Central American marine protected areas found high levels of connectivity, supportive of international cooperation among managers of these areas (first poster by Truelove et al.). Although no population structure was found between *P. argus* at Sian Ka'an and Banco Chinchorro Biosphere Reserves in the Mexican Caribbean, there was significant structure among discrete size classes, suggesting temporal variation in the genotypes of new recruits (second poster by Truelove et al.). This suggests that the parent populations may vary year-on-year, depending on interannual variability in ocean conditions and their effects on larval dispersal patterns and survival.

Johan Groeneveld
Oceanographic Research Institute
South African Association for Marine Biological Research
jgroenveld@ori.org.za

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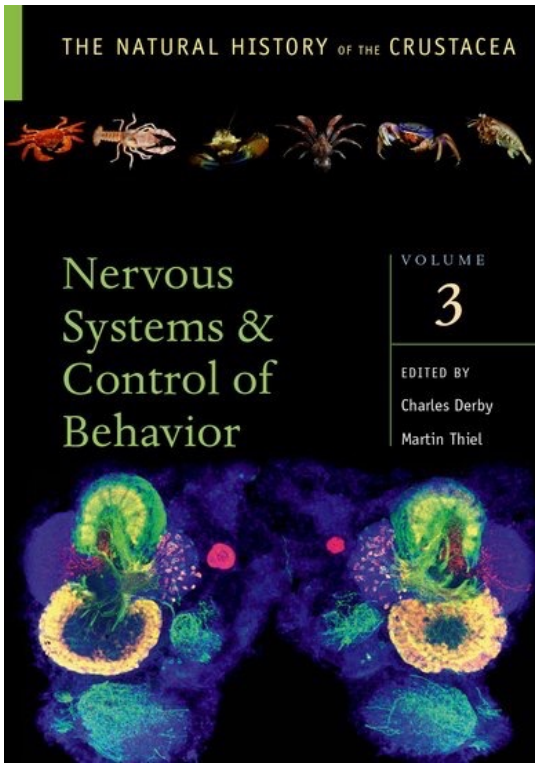
Copper bowl with lobster, 12th-15th century CE
Peruvian, Chimú
www.metmuseum.org

BOOK ANNOUNCEMENT

A new book on crustaceans: *Nervous Systems and Control of Behavior*

Edited by Charles Derby and Martin Thiel



Crustacean Nervous Systems and Control of Behavior is the third volume of the series *The Natural History of the Crustacea.* This volume is on the functional organization of crustacean nervous systems, and how those nervous systems produce behavior. It complements other volumes on related topics of feeding biology, reproductive biology, endocrine systems, and behavioral ecology. There is a rich history of the study of the neurobiology of crustaceans, going back over 150 years. This has included studies on how their nervous systems allow them to perform behaviors that are adapted to their particular environments, as well as studying them as model organisms to understand basic biomedical principles about neural function, such as sensory transduction and processing, synaptic transmission and integration, neuromodulation, and learning and memory. The volume has three sections that build progressively on each other. The first section is on the basic organizational features of the crustacean nervous system and the principles upon which it is built. The second section is on sensory ecology - the organization of each sensory system and how it is used in intra- and interspecific interactions, within an ecological context. The third section uses case studies of how crustacean nervous systems are organized to perform complex behaviors and interactions, such as walking, escape, social interactions, and memory and learning. Taken together, the 20 chapters synthesize our modern understanding of the neural control of behavior in crustaceans, based on the most recent technologies in physiological recording, molecular biology, and computational science. This volume will be useful to students and researchers as a concise summary of current knowledge of crustacean neuroscience.

Reviews

"A clearly written, beautifully illustrated, and entirely comprehensive review of the nervous systems of crustaceans, this volume is sure to be THE classic source for the field for many years -- likely decades -- to come. It will be required reading for all who work on crustacean behavior and sensory biology."
--Sönke Johnsen, Duke University

"This volume is a welcome compendium that provides the reader with important insights about the crustacean nervous system. It is satisfyingly rich in information and scholarship. It is exactly what one wants from a work of this kind and is a most welcome addition to the neuroscientist's bookshelf."
--Nicholas Strausfeld, University of Arizona

"In these days of fragmented information overload, it is rare to find such a useful compendium focused on a group of animals important in forming the basis for our current understanding of neuroscience. The volume presents contributions from knowledgeable experts in the field offering the reader timely reviews of subjects ranging from sensation to motor patterns and behavior."
--Thomas Finger, University of Colorado School of Medicine

About the authors

Charles Derby is a Regents Professor of Neuroscience and Biology at Georgia State University who studies how animals use sensory information in solving life's challenges, such as finding high-quality food, identifying mates, and avoiding predators. His focus has been the chemical senses of decapod crustaceans, especially spiny lobsters, clawed lobsters, and brachyuran crabs.

Martin Thiel is a marine biologist with strong interests in animal behavior and natural history. During the past 20 years, he has conducted studies on crustacean behavior ranging from evolution of parental care behaviors to mating interactions and anti-predator behaviors. He is also interested in dispersal ecology and biogeography, and in promoting the participation of citizen scientists in marine research.

BOOK REVIEW

Nervous Systems and Control of Behavior

Edited by Charles Derby and Martin Thiel

An exclusive review for TLN by Win Watson
University of New Hampshire
win@unh.edu

I have to admit. I didn't read the entire book. In fact, I can't remember the last nonfiction book I read from start to finish. But, I did read all the chapters that I felt competent to judge (8) and, I have to admit, I loved them all. I looked forward to returning from my lecture at noon, and reading a Chapter while having my lunch. One day it was Biological Rhythms the next day it was Sensory Biology. All were equally interesting, up-to-date, and complete.

I don't know about the rest of you, but these days it seems like I just can't keep up with the literature. Part of the problem, for me, is that I have spread myself too thin. But the other problem is that so much of the literature is accessible in an electronic format that we really have no excuse for not being aware of all the work that is being published, even if our local library does not subscribe to a given journal. We try, but we are overwhelmed, given all our other responsibilities. Therefore, books such as this one, provide an excellent opportunity to bring yourself up to speed in your area of expertise, or in a field that you realize you need to understand more thoroughly.

This is not textbook; it is a reference book that is a pleasure to read. If your own work overlaps with any of the subjects covered in the 20 chapters, you will find it useful to pick up a copy to expand your own horizons and to provide the people who work in your lab an opportunity to become more aware of the breadth and depth of work that has been carried out in your field. Importantly, while each of us is probably very aware of the literature relating to our own species of interest, which for me is the American lobster, we are likely less knowledgeable about the related studies that have been performed in other crustaceans. Thus, one very important achievement of this book is to expand our knowledge base beyond our own, species-o-centric world, and allow us to appreciate both the similarities and differences between the neural mechanisms underlying specific behaviors in our species of interest versus other crustaceans. For example, studies in various species of crayfish have provided a great deal of information, some controversial, about extraocular photoreceptors and the possible role of cryptochromes in this process. My own work suggests some of these same mechanisms are present in American lobsters, but they are slightly different from the processes taking place in crayfish. Similarly, it was very enlightening to read about the sensory capabilities of various crustaceans, ranging from vision to magnetoreception, and then learning about how these capabilities relate to the behavioral ecology of each species. These are not the kinds of topics one can learn about from reading the primary literature. They are only fully appreciated when someone who really knows the field, and the diversity of primary literature, pulls the information together and organizes it in a manner that makes sense; that makes it possible to appreciate the basic themes and principles.

So, in closing, if you work in this field, buy this book. If you have students working in your laboratory pick up this book so they can bring themselves up to speed in the field. It provides them with both the classic studies and the current perspective on the subject. If you need something to read while you eat lunch, get this book. If you are about to write a paper or a grant and you need help with the introduction or discussion, you need this book. And I hope, that by the end of the year it will be the first nonfiction book I have finished in quite some time.

Nervous Systems and Control of Behavior
Volume 3 of *The Natural History of the Crustacea,* 2014.
Edited by Charles Derby and Martin Thiel
Oxford University Press: New York.

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Still Life with Lobster and Fruit, early 1650s
Abraham van Beyeren (Dutch, 1620/21-1690)
www.metmuseum.org

RESEARCH NEWS

The Search for the first record of an early benthic juvenile stage of the Mediterranean slipper lobster

From Ehud Spanier & Kari Lavalli

While attending the 9th Colloquium Crustacea Decapoda Mediterranea (9CCDM), in Torino, Italy in 2008, the first author visited the crustacean collection of the zoological museum (Museo Regionale di Scienze Naturali) for measurements associated with a study of comparative morphology in slipper lobsters (Spanier et al., 2011).

This collection was, unfortunately, not in good shape, but Ehud told the apologetic emeritus curator, Dr. Lisa Levi, that nevertheless the collection could be useful and may contain some "secrets". And indeed it did -- in this old collection he found a tiny preserved specimen of what is likely to be that of the Mediterranean slipper lobster, *Scyllarides latus* (Latreille, 1802), collected at the beginning of the 20th century.

This finding was of great significance, since no postlarva (nisto) or juvenile of the commercial Mediterranean slipper lobster has been found to date despite continuous sampling efforts. Only adults and sub-adults of this overfished slipper lobster were reported (Lavalli & Spanier 2007; Spanier & Lavalli, 1998, 2006, 2013 and references there).

The knowledge of the biology of a given species of lobster is incomplete unless all life stages and their natural habitats are known. This is especially important for commercial species, such as *S. latus*, for the purpose of understanding population dynamics to allow for population estimates, predicting future fishing stocks, and possibly undertaking rearing experiments. These life stages include the essential post-larval (nisto or “pseudibacus”) and the first benthic stage (the first – instar juvenile). Limited information on postlarval and juvenile slipper lobster behavior, ecology, and ontogenetic changes is available only for some soft bottom scyllarids such as *Thenus* species that have been successfully reared in the laboratory (e.g., Lavalli & Spanier 2007, Spanier & Lavalli, 2013 and references there).

Up until this present finding, the smallest *S. latus* was caught off Israel (100 g, Spanier & Lavalli, 2006, 2013). Almog-Shtayer (1988) reported that the smallest specimens of this species collected off Israel were a 64 mm carapace length (CL) male (200g) and a 69 mm CL female (252g). Bianchini & Ragonese (2007) reported that the smallest animal recorded in Italian waters weighed no less than 100 g. The smallest exuvia found in the field reported from the coast of Israel measured 38 mm CL (at 15m depth) (Spanier & Lavalli 2006, 2013). Similarly Romeo et al. (2004) recorded a rare small male of 39 mm CL (81 mm Total Length (TL)) (21.33g) among 200 *S. latus* collected in the Straits of Messina at a depth between 15-60 m along a jagged coastline with steep bottom topography and a mixture of rocks, sand, and coralligenous biotic communities. The smallest specimen was caught by trammel net at a depth of 40 m in a horizontally oriented shelter.

Surveys of lobsters in various zoological museums revealed that, until 2009, the smallest preserved *S. latus* was a 34.3 mm CL male found in the collection of the Museum of Zoology of the University of Florence, "La Specola"(Spanier & Lavalli, 2006, 2013). Further inquiries disclosed that this specimen (catalogue number MZUF 3766) was collected in spring 1987 by Marco Borri, using 20 mm mesh scientific trawl net at depth of 450-700 m in front of Leghorn (Livorno) in a soft, muddy bottom at least 40 km offshore. This specimen measured 36 mm in CL, 84 mm in TL (TL excluding the telson was 72 mm), and 31 mm in Carapace Width (CW) (Gianna Innocenti, "La Specola", Florence, Italy, personal communication, October 2008).

The tiny preserved specimen, likely to be a recently settled *S. latus*, discovered in the zoological museum of Turin (Fig. 1) (catalogue number CR 1410 (Ex 1587), measured 11.7 mm CL, 15.8 mm for an anterior carapace width, 13 mm for a posterior carapace width, and 38.7 mm in TL, and was colored brown-yellow. It varied considerably from adults of this species with a carapace width greater than the carapace length, a proportion that is reversed from that of adults. It is more similar in morphology to the nistos known from a few other *Scyllarides* species. This juvenile was similar to the description of small juveniles of *S. nodifer* (Stimpson, 1866) by Lyons (1970), and also had granulation on its exoskeleton as in adults, although less noticeable. Gastric and cardiac bumps and the branchial ridges parallel to the cardiac region were also conspicuously evident as in small juveniles of *S. nodifer*. The fourth abdominal segment had a striking node which was very developed and much higher than in adults of this species; again this striking feature was similar to that described in small juveniles of *S. nodifer* by Lyons (1970). Unfortunately, the only details on the collection site of the subject specimen are that it was collected in Reggio Calabria (Italy) and was donated to the museum by Moschella in 1903.

Figure 1. Early benthic juvenile stage likely to be that of the Mediterranean slipper lobster, *Scyllarides latus* (Latreille, 1802) (Photo by J.J. Gottleib).

The finding of this first record of the apparently newly settled juvenile *S. latus* does not shed much direct light on the settling habitat of this species. Spanier & Lavalli (2006, 2013) pointed out that the juveniles were rare not just in studies of *S. latus* but in those of other commercial *Scyllarides* as well. The fact that the small juvenile *S. latus* from the Museum of Zoology of the University of Florence was collected at depth of 450-700 m may imply that nistos of *S. latus* settle offshore on soft bottoms at great depths, where they can develop into small juveniles under less predation threat. It is assumed that they later migrate onshore to recruit to adult habitat such as that described by Romeo et al. (2004) in the straits of Messina. One of the scenarios suggested by Sekiguchi et al. (2007) may explain how recruitment to existing scyllarids adult stocks eventually comes about: larvae drift large distances (and for a long time: possibly 11 months for *S. latus* as estimated by Martins, 1985) before settling as nistos in deeper water. They then return to the adult grounds as migrating juveniles; this scenario seems to fit *S. latus* in light of the limited information available at present. The proximity of the area where the likely *S. latus* early benthic juvenile was collected in the beginning of the 20th century (Reggio Calabria with off shore depths > 850m) and the adult habitat sampled by Romeo et al. (2004) in the straits of Messina (less than 20 km apart), together with the geomorphology of the region (its depth from south to north decreases rapidly from 2000 m opposite Capo d'Armi, Ionian Sea, to about 80 m on the sill rising between Punta Pezzo (Calabria) and Ganzirri (Sicily), supply additional support for this assumed recruitment scenario. We hypothesize, therefore, that *S. latus* larvae drift large distances for many months in the pelagic before settling as nistos in deeper water where they are possibly more protected against predators and, subsequently develop into small juveniles, returning to the shallower adult grounds as migrating larger juveniles or sub-adults.

It is interesting to note that Pagliarino et al. (2013) very recently reported beach stranded scyllarid phyllosomas and an exuvia from Cape Faro, straits of Messina, the same area described above. We hope that a DNA analysis of the subject specimen (e.g., Palero et al., 2009) will establish its identification as *S. latus.*

The authors wish to acknowledge the valuable help of Dr. Lisa Levi from Museo Regionale di Scienze Naturali, Torino, Italy and Dr. Gianna Innocenti, Museum of Zoology of the University of Florence, "La Specola", Florence, Italy.

Additional Readings

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Ehud Spanier
The Leon H. Charney School for Marine Sciences
University of Haifa
espanier@univ.haifa.ac.il

Kari Lavalli
College of General Studies
Boston University

Lobster-Tail Burgonet (Zischägge), ca. 1630-40
German
www.metmuseum.org

A field-based nursery for "head starting" lobsters to improve post-release survival for potential stock enhancement in Long Island Sound, Connecticut

From R. Mercaldo-Allen, R. Goldberg, C. Kuropat, P. Clark, R. Alix, W. Schreiner, J. Roy, & students from The Sound School

The American lobster, *Homarus americanus*, fishery in Long Island Sound (LIS) collapsed in the 1990s, following a significant die-off event. Commercial lobster landings declined from 3.8 million pounds in 1998 to 250,000 pounds by 2011 (LIS Assembly 2013). The fishery may benefit from stock enhancement designed to supplement natural recruitment. Introduction of hatchery-reared lobsters into the environment is a possible strategy for increasing abundance.

Lobster stock enhancement has been practiced since the 1800s on the east coast of North America in an attempt to maintain a continuous supply. For many decades lobster hatcheries in Maine, Massachusetts and Canada have released millions of postlarval fourth stage lobsters (Nicosia and Lavalli 1999). Despite sustained effort, scant evidence exists of survival of released lobsters or increased landings. More recent European efforts with *Homarus gammarus* have demonstrated that released hatchery-reared lobsters can survive and contribute to spawning populations. Even so, newly settled lobsters, by virtue of their small size and undifferentiated claws, are highly vulnerable to predation. These lobsters undergo stresses, such as finding suitable habitat and adapting from a hatchery diet to foraging for prey. Hatchery conditions are relatively constant compared with natural environmental conditions. All of these factors influence whether cultured lobsters might recruit successfully.

Release of lobsters at larger sizes may enhance survival of hatchery-reared animals in the environment (Wahle 1992; Benevente 2010). The concept of a field-based nursery to head-start lobsters was demonstrated in Ireland (Beal et al. 2002) and in Maine (Beal 2012; Beal and Protopopescu 2012). Holding lobsters in individual containers precluded cannibalism and the gear used was relatively low-cost and easily deployed. These efforts demonstrated that postlarval lobsters, held in perforated containers, survived and grew by consuming only naturally occurring foods, further minimizing cost. These studies have provided evidence

of the potential for field-nursery culture to produce larger juvenile lobsters for release.

In our study, early benthic stage lobsters, raised by students from The Sound School in New Haven, Connecticut, were used to test an experimental nursery system for field grow-out in LIS. We designed novel low-maintenance rearing containers that could be easily deployed. The goal of our pilot study was to determine if hatchery reared lobsters would survive and grow in our gear and reach a size where they might be tagged, prior to release. Our hypothesis was that these young lobsters would grow rapidly in the warmer estuarine waters of Connecticut, compared to more northern locations, where field nurseries had been tested previously.

Lobster larvae: Egg-bearing female lobsters were collected locally in March 2013. After hatching, students cultured lobsters to the early benthic stage. These lobsters were transported to the laboratory, photographed, numbered, and placed in porous rearing "habitats".

Grow-out Containers: Rearing "habitats", made from cylindrical, 1 x 3 mm mesh plastic tubes, (7.5 cm long x 6.3 cm wide) were sealed with plastic end caps, held by rubber bands (Fig. 1a). Each habitat nested inside a larger cylindrical "sleeve" (25 cm long x 9.8 cm wide) made from 3 x 4 mm mesh, with molded plastic mesh end caps secured with a PCV ring (Fig. 1b). Larger mesh openings in the outer sleeves ensured optimal water flow and inhibited excessive fouling to inner habitats. Twenty-four plastic sleeves, each containing one habitat with one hatchery-reared lobster, were placed onto one of two shelves of a 23 x 53 x 69 cm wire mesh cage (Fig. 1c). Three cages, suspended 1m off the bottom on individual lines, were deployed on June 3rd, 2013 on a leased clam bed, southwest of Charles Island, near Milford. Each line was anchored with a 250-pound cement block and surface buoys kept the lines vertical in 8m of water. Cages were pulled monthly to inspect fouling intensity, check for mortality, and photograph lobsters for later digital measurement. Each habitat was placed into a clean sleeve and returned to the bottom. While empty, cages, lines and buoys were power washed to remove excess fouling.

Fouling: Outer sleeves became colonized by newly settled mussels *Mytilus edulis*, bryozoans, colonial tunicates, egg masses and hydroids within 2 weeks of deployment in mid-July. Heaviest fouling occurred in mid-August with outer sleeves covered in mussels, barnacles, hydroids and bryozoans and inner habitats fouled in place. Clean replacement sleeves refouled with tunicates, *Crepidula*, mussels, stalked bryozoans and hydroids in mid-September. By late October, no further fouling occurred. That concluded monthly sampling for 2013 and cages and lobsters remained in the field to overwinter from November until May 2014.

Figure 1. Grow-out containers. (A) Inner habitat container for lobster grow-out; (B) outer sleeve protects habitat; (C) cage containing outer sleeves.

Survival and Growth: Lobsters retrieved two weeks after deployment on June 17th had low initial mortality. This suggests that lobsters began feeding almost immediately, by either capturing prey from the water column or consuming a biofilm which had formed. Fouling of the inner habitats and outer sleeves with encrusting organisms took several weeks. Cumulative survival at the end of 5-months was: 83% for cages 1 and 2 and 63 % for cage 3. Mean total survival rate for all lobsters was 76% (55/72). Lobsters had substantial increase in carapace length (CL) from June through October 2013 (Fig. 2). Lobsters grew throughout the summer and fall with the largest increase in CL occurring from July 23rd to August 14th when temperatures ranged from 23.9 to 22.0 ºC.

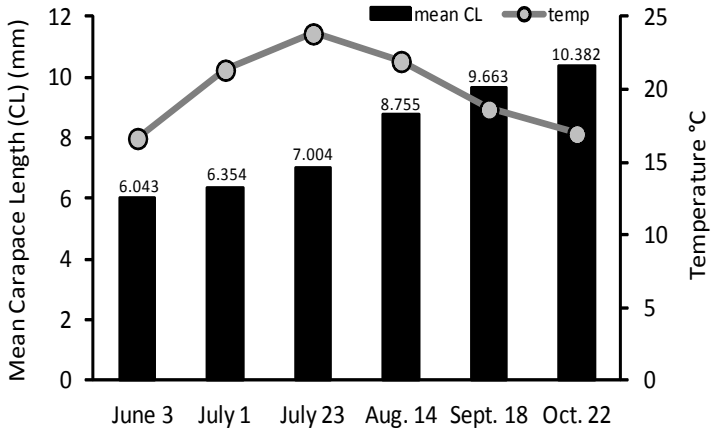

Figure 2. Field results: growth (mm CL) of early benthic stage lobsters from June to October, 2013.

General observations and conclusions: Early benthic stage lobsters grew and survived in grow-out habitats in Connecticut waters over a 5-month period during summer and fall of 2013. Outer mesh sleeves protected the inner rearing habitats and reduced fouling, thereby ensuring sufficient water flow to lobsters. The warmer water temperature in LIS provided a longer growing season for lobsters, compared to those in the Maine experiments. Maine lobsters increased 4.7 mm, growing from 4.2 mm to 8.9 mm CL in 14 months (Beal, 2012). During our 5-month experiment, lobsters grew from 6.0 to 10.4 mm CL, an increase of 4.4 mm (Fig. 3). Our work suggests that early benthic stage lobsters are tolerant of intermittent handling and can be successfully reared in mesh containers in LIS. This lays the groundwork for replicated experimental studies addressing variations in gear design, handling regime, and duration of grow-out. Lobsters reared to 12 mm CL or larger could be marked with coded wire tags and released on suitable habitat. This would allow monitoring of released animals to assess whether cultured lobsters recruit successfully to enhance natural populations.

Figure 3. Initial size (left, range 4-7 mm CL) and final size (right, range 8-12 mm CL) of experimental lobsters.

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R. Mercaldo-Allen, R. Goldberg, C. Kuropat, P. Clark, B. Alix, & W. Schreiner
Milford Laboratory, Northeast Fisheries Science Center
NOAA Fisheries
212 Rogers Ave. Milford, CT 06460 USA

The Sound School
60 South Water St. North Haven, CT 06519 USA

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Data Collection Tools for a Modern Lobster Industry

From Gavin Scandlyn

Quoting directly from its website, "The New Zealand Rock Lobster Industry Council manages an extensive rock lobster stock monitoring programme. This includes intensive catch sampling, vessel logbooks, and lobster tag, release and recapture projects. Information collected is delivered to the Ministry for Primary Industries research database for use in stock assessments, annual Total Allowable Catch and sustainability decisions" (www.nzrocklobster.co.nz).

The Fugitive

On board the 40-foot lobster boat *The Fugitive,* Skipper Graham Taylor and his crew Rob Anderson deploy over 100 pots along the coast from Port Underwood, Marlborough, New Zealand.

Graham (left) and Rob readying a Cray pot; note the yellow Wet-Tag

They enter catch data into their Zebra-Tech deck logger, simply and easily recording the information required to satisfy the voluntary catch log book requirements of the lobster industry. The tough deck logger is plugged into the boats power supply but can also operate on its internal rechargeable battery. When Graham and Roy head back to shore with their catch, they have less paperwork to do.

"The deck logger has been great," notes Graham. "In the past on a [windy] day like today, the old paper logs would have been blowing around everywhere."

The Cray Boat Logger, designed for fisheries data collection

Graham's Crayfish region "CRAMAC5" is very progressive and works collaboratively with Zebra-Tech, a New Zealand based underwater instrumentation manufacturer to develop tools for their industry.

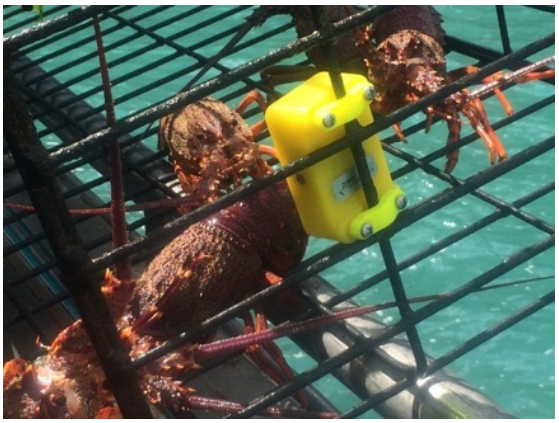
Deck Logger and Wet-Tag, low cost and easy to use technology for fishermen

Their newest development, the Wet-Tag, looks set to be hugely beneficial. The Wet-Tag is permanently attached onto each pot. It activates as it hits the sea water.

Underwater, the Wet-Tag measures the water temperature. When the pot is lifted, the soak time and water temperature data are automatically and securely transmitted wirelessly to the vessels deck logger.

Rugged, low cost, with a 5+ year battery lift. The Wet-Tag gathers and sends data to the deck unit

The deck unit logs the Wet-Tag data, together with the position, time and date *The Fugitives'* crew measure the lobster in the pot and quickly enter the data into the deck logger. The deck logger stores the information securely for offload, using USB in this case. The option to offload using Iridium Satellite communication is also being looked at, a great option if the fishery requires VMS tracking as well.



The Wet-Tag securely transmits data from the pot

Low cost systems such as these are fully customisable to suit a range of fisheries. There are huge advantages to tracking pot use, not only for log book purposes, but also to ensure pots have not been tampered with by someone other than the owner. Peace of mind for the fishermen.

Zebra-Tech gratefully acknowledges the assistance and support of the Fugitive *crew and CRAMAC5.*

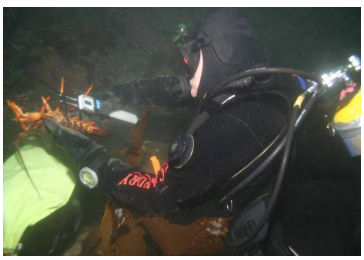
Gavin Scandlyn
175 Cross Quay, Nelson, New Zealand
gavin@zebra-tech.co.nz
www.zebra-tech.co.nz

New data collection tool for the Lobster industry: The Wet-Tag™ www.zebra-tech.co.nz

The **Wet-Tag™ -** A Lobster pot tag that wirelessly transmits data to the Zebra-Tech Deck Logger. Securely and automatically record **pot ID**, **GPS position**, **water temperature**, **soak time**... on every pot. Combines with the Zebra-Tech Deck Logger allowing **manual entry of other catch data** through a simple user interface. It's time to move beyond paper based log books and reporting!

Better data management for fisheries. Zebra-Tech LTD.

LobsterDeck Loggers



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The Lobster NEWSLETTER

Editors:

Nick Caputi
Western Australian Fisheries and Marine Research Laboratories
PO Box 20
North Beach WA 6920 Australia
nick.caputi@wa.gov.au

Richard A. Wahle
School of Marine Sciences
University of Maine
Darling Marine Center
Walpole, Maine 04573 USA
richard.wahle@maine.edu

Assistant Editor – This Issue:
Noah G. Oppenheim
School of Marine Sciences
University of Maine
Darling Marine Center
Walpole, Maine 04573 USA
noah.oppenheim@maine.edu

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Contact Nick Caputi (southern hemisphere) or Rick Wahle (northern hemisphere) about article submissions and inquiries or corrections to the Lobster Newsletter mailing list.