VOLUME TWENTY THREE APRIL 2010 NUMBER ONE

The Lobster NEWSLETTER

ANNOUNCEMENTS

The 9th International Conference and Workshop on Lobster Biology and Management

Bergen, Norway 19-24 June 2011

First announcement

The largest international conference for lobster research and management.
More than 300 participants.
Network with the world's leading experts on lobsters.

Venue: Radisson Blu, Hotel Norge, Bergen

Hosts: Norway's Institute of Marine Research in collaboration with other institutions and agencies working with lobster research, fisheries and export in Norway and Europe.

Conference web-site: www.imr.no/icwl_bergen

Deadline for abstract submission: 1 October 2010

See Bergen at its best! Short summer nights, long days and traditional summer celebrations.

See page 2 for details →

Tentative theme sessions (other suggestions welcome):

- **Conservation and management:** lobster management practice, lobsters in ecosystem-based management; marine protected areas, stock enhancement, habitat studies, invasive species
- **Ecosystem and climate variability**: foodwebs, intra- and interspecific interactions, distribution, population dynamics, genetic studies
- **Resource Development:** fisheries, aquaculture, post-harvest practices, marketing
- **Animal Welfare:** nutrition, physiology, reproduction, health, diseases, parasites
- **Ecology and Behaviour:** all life stages, from larvae to adults, introduced species
- **Bioengineering:** technological innovations; pharmacological studies, human nutrition, biochemistry

Workshops on special topics:

- Large marine protected areas
- Marine diseases and parasites
- Sea-ranching and aquaculture
- Population connectivity
- Live export and species invasions

Topics will be selected by the scientific committee based on responses we receive.

Please submit suggestions for theme sessions and special topics. Seeking volunteers for session and workshop chairs.

Final program available spring 2011. Information on abstract submission, travel, accommodation, costs will be available on the website

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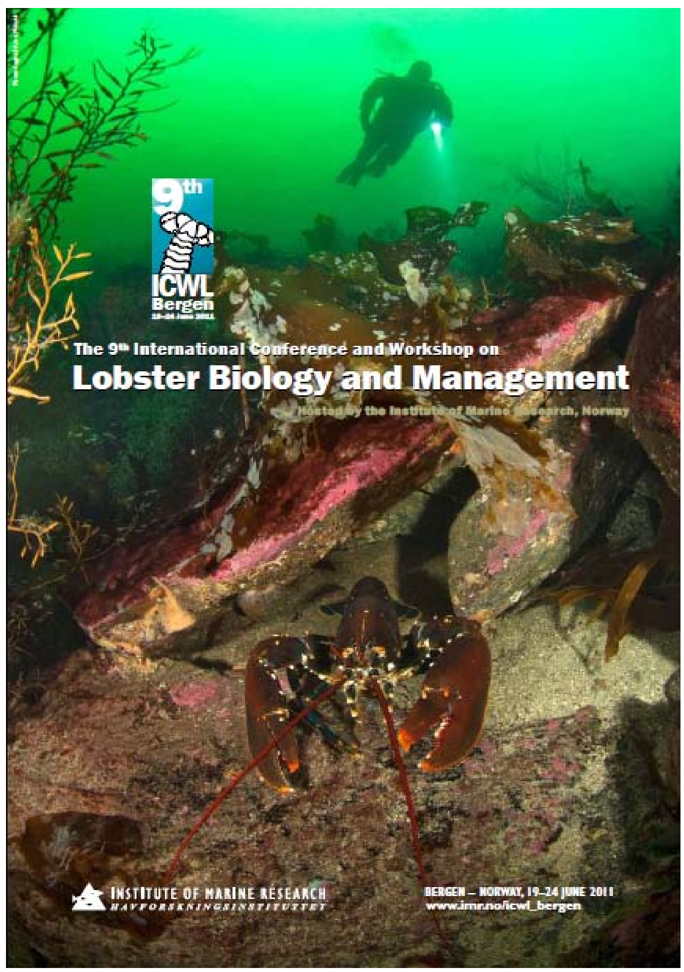
Venue: Radisson Blu, Hotel Norge, Bergen, Norway



WORKSHOP UPDATES

Conference Synthesis: Recent Advances in Lobster Biology, Aquaculture and Management (RALBAM 2010), Chennai, India, January 2010

From: M. Vijaykumaran

The International Conference on *"Recent Advances in Lobster Biology, Aquaculture and Management (RALBAM 2010)"* was organized by the Ocean Science and Technology for Islands (OSTI), National Institute of Ocean Technology (NIOT) at its Conference Centre "Sagar Sangamam" in Chennai during 5-8 January 2010. The conference objective was a review of lobster research around the world mid-way between the 2007 and 2011 *International Conference and Workshop on Lobsters*. The particular focus of this conference was on lobster research in India to generate international cooperation in formulating projects on lobster conservation, management and biology with special reference to habitat studies and aquaculture.

The conference was attended by lobster experts from many countries such as Australia, New Zealand, USA, Canada, Spain, Norway, Israel, Japan, Taiwan, Vietnam and India. Wide ranging discussions were held on the state of lobster research, lobster fishery, management and aquaculture in India and around the world, and possible collaborative projects to be undertaken in future. Seventy-nine Indian delegates and 26 delegates from other countries participated in the conference. All the important institutions involved in lobster studies in India such as the National Institute of Ocean Technology, Chennai; Central Marine Fisheries Research Institute, Kochi; Central Institute of Fisheries Technology, Kochi; Fishery Survey of India, Mumbai; Marine Products Export Development Authority, Kochi, were represented at the conference. Department of Fisheries of few maritime states, staff and students from universities, private entrepreneurs involved in aquaculture and lobster export, lobster fishers trained by NIOT for lobster fattening and financial institutions also participated. Forty-one oral presentations including a key note address, seven plenary talks and 21 poster presentations were made during the four days of deliberations at the conference.

Dr. E. G. Silas, former Vice-chancellor of Kerala Agricultural University inaugurated the conference and the inaugural function was presided over by Dr. P. Krishnaiah, Chief Executive of the National Fisheries Development Board. Dr. M. Vijayakumaran, the organizing Secretary of RALBAM 2010, described the genesis and importance of the conference. A review on lobster research in India was given during the inauguration, which was followed by a key note address on *"Are the spiny lobster fisheries in Australia sustainable?"* by Prof. Bruce Phillips. The Poster session was inaugurated by Dr. Stewart Frusher in the evening on the opening day and was open till the conclusion of the conference. The conference was divided into seven oral sessions: Fisheries; Larval distributions and settlement; Physiology; Nutrition and pathology; Climate change impacts; Aquaculture; and Conservation, management and ecosystem interactions. A poster session augmented the breadth of presentations. Social events during the conference included a pre-conference meet and greet dinner, a cultural show depicting classical and folk dances of India, and local tour to the historically important port town of Mahabalipuram. Post-conference tours to Pondichery and Gulf of Mannar Biosphere Reserve were also offered.

The sessions on conservation and ecosystem issues spanned a broad range of topics, from deep sea lobster, *Puerulus sewelli* and participatory approaches in conserving the lobster fishery in southeast India, to the role of artificial habitats in preventing predation, and modeling regional differences in growth of the American lobster using size-frequency and tagging-based approaches.

The session on larval distributions included presentations on the importance of ocean currents in spiny lobster larval distribution in Japan, to a review of the 20-year larval settlement index of American lobster, and the importance of vertical movements of phyllosoma larvae in its horizontal distribution attracted attention in session on larval distribution.

The sessions on physiology, nutrition and pathology considered the role of physical and chemical cues influencing lobster growth in communal rearing, the energy requirements of puerulii in culture, endocrine mechanisms controlling molting and egg maturation, paralytic shellfish poisoning in Canada and gaffkemia infection in Indian spiny.

The session on climate change highlighted the impact of warming sea temperatures on Tasmania's fisheries. Discussion during that session addressed the need to create a database to understand the vulnerability of global lobster fisheries to climate change.

The final session on aquaculture reviewed lobster aquaculture across the world, from the present status of lobster farming and puerulus collection in Vietnam and indoor and sea cage culture experiments in India, to the new venture on commercial production of slipper lobsters in Australia.

Prof. Bruce Phillips presided over the concluding awards session. The best student oral presentation award was given to Ms. Charlene E. Bergeron, graduate student at the University of Maine, U.S.A. for her paper, *"Modeling growth without age-markers in a variable environment: integrating size-frequency and tag-based methods in the American lobster."* The best poster presentation award was given to M. Anbarasu, R. Kirubagaran and N. V. Vinithkumar of the NIOT, Chennai for the poster entitled, *"Diet and eyestalk ablation induced changes in lipid and fatty acid composition of Panulirus homarus."* The best exhibit award went to the booth displayed by the Ministry of Earth Sciences, Government of India.

The organizers are very satisfied with the enthusiastic participation by lobster scientists and feel that the objectives of the conference were fulfilled to a great extent. It is hoped that the interaction between scientists and institutions from India and abroad will result in many inter-institutional ventures on lobster research in India.

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RALBAM 2010 Attendees (Photo credit: NIOT)

Assessing the Status of All the World's Lobster Species. IUCN Redlist Workshop, Taiwan, November 2009

From: Nadia Dewhurst

In 2002, 188 Nations committed to significantly reduce the current rate of biodiversity loss, under the Convention on Biological Diversity 2010 target. The International Union for Conservation of Nature (IUCN) Red List Index (RLI) has been adopted by the Convention as one of the global biodiversity indicators by which to measure progress towards the target. It has also been selected by the United Nations as a measure for its Millennium Development Goals. By tracking the fate of species and carrying out repeated Red List assessments over time, a trend in extinction risk can be calculated by monitoring the movement of species between the categories of conservation status. However, RLIs can currently only be calculated for a few fully assessed vertebrate groups, and therefore does not truly represent global biodiversity.

In a coordinated attempt to broaden the coverage of the RLI, the Zoological Society of London has led the development of a sampled approach to the Red List Index, making it more indicative of overall trends in biodiversity. The sampled approach selects species from a broad range of taxonomic groups, from vertebrates and invertebrates, to plants and fungi, for inclusion into this indicator, rather than just using data on the more well studied species such as birds. This will enable the identification of those taxonomic groups, biogeographic realms, and habitats in which species are deteriorating most rapidly, and identify why species are threatened, and what conservation actions are needed.

There are some 250 species of marine lobster, many of which have some commercial value to humans either as a food source or for bait. Lobsters vary greatly in their vulnerability to fishing pressure, owing to variation in their life history characteristics. While the commercial species are well studied, there is still a significant gap in knowledge, particularly for tropical species. Throughout the course of the 20th century, there have been a number of reports indicating growth and recruitment overfishing in commercial species. At present none of the lobster species have been assessed against the IUCN Categories and Criteria, so a comprehensive assessment was urgently required to determine the status of this commercially important group. The assessments and index will provide a much needed source of information for policy makers, resource managers, scientists, educators, and conservation practitioners, as well as the general public.

Since July 2009, a small team of researchers at the Zoological Society of London have been collating data on the world's 250 species of lobster. On the 30th of November 2009 a group of world experts (**Mark Butler** of Old Dominion University, USA; **Tin Yam Chan** of the National Taiwan Ocean University; **Andrew Cockcroft** of the Department of Environmental Affairs and Tourism, South Africa; **Sammy De Grave** of University of Oxford, UK; **Peter Ng Kee Lin** of National University of Singapore; **Suzanne Livingstone** of the Global Marine Species Assessment Program, USA ; **Alison MacDiarmid** of the National Institute of Water and Atmospheric Sciences, New Zealand, and **Richard Wahle** of the University of Maine, USA) met at the West Pacific Marine Red List Assessment Workshop in Taiwan to assess the status of the worlds lobster species by applying the IUCN Categories and Criteria. Preliminary results from the workshop indicate that a low proportion of the world's lobster species are threatened with extinction. However, over 40% of species have been preliminarily placed in the Data Deficient category, of which 80% are known from the Indo-Pacific region particularly around Japan, Taiwan, China, the Philippines, and Indonesia. Landings in these areas are often reported as multi-species catches making it difficult to observe individual population changes. The results do however highlight that lobster fisheries are in fact some of the best managed marine fisheries: all of the major commercial species such as *Homarus americanus, Jasus edwardsii, Jasus tristani, Jasus lalandii, Panulirus spp., and Palinurus spp.* were assessed as Least Concern (although some species are still pending further comments). In addition to stringent fisheries measures and a good understanding of species biology, a large number of these species have extensive ranges, spanning the Indian and Atlantic Oceans affording them protection from localised harvest. The species of current concern are *Jasus frontalis*, *Panulirus argus, Homarinus capensis* and *Jasus paulensis* which are exhibiting poor levels of recruitment and significant declines in population numbers. Population declines are thought to be a result of poor fisheries management, and small range size in some cases. In the case of *Homarinus capensis*, it would appear to be a naturally rare species; the last specimen having been found in 1992.

Figure 1. Three of the Red List delegates, from left, Andrew Cockcroft, Mark Butler and Alison MacDiarmid at a fish market in Taiwan. (Photo credit: Rick Wahle)

The final results of the workshop will be published later this year both on the IUCN Red List of Threatened Species website (http://www.iucnredlist.org/), and in a peer-reviewed journal article. If you have any questions regarding this project, please contact Nadia Dewhurst (nadia.dewhurst@ioz.ac.uk). See www.zsl.org/indicators. A huge thank you to the following for additional comments on various species reports: C. Gardner, A. Linnane, H. Sekiguchi, C. Grobler, D. Sykes, M.L.E. Yee, P. Ziegler, J. Stewart, and R. Goñi.

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First International Spiny Lobster Culture Workshop Paraiba, Brazil, September 2009

From: Phil James, Jason Goldstein, and Andrew Jeffs

In September of 2009 the State University of Paraiba (Universidade Estadual da Paraiba) hosted the first Brazilian International Spiny Lobster Culture workshop. The conference was organized by Dr. Marco Antonio Igarashi from the Brazilian Ministry of Fisheries, in conjunction with the University and local businessman Mr. Diogo Lima. International researchers present at the workshop included Jason Goldstein, University of New Hampshire (USA), Dr. Andrew Jeffs, Auckland University (New Zealand), and Dr. Phil James, National institute of Water and Atmospheric Research (New Zealand). The workshop included a general introduction to the Brazilian lobster fishery by Dr. Igarashi as well as talks on advances in phyllosoma culture of *Panulirus* *argus* by Jason Goldstein, puerulus settlement trends and the Vietnamese experience by Andrew Jeffs and a description of the New Zealand experience in culturing *Sagmariasus verreauxi* larvae and on-growing wild caught puerulus by Phil James and Andrew Jeffs. Highlights of the day included passionate speeches from both Mr. Lima and a local lobster fisherman (Reginaldo 'Reggie' José da Silva) describing their initial efforts to raise *P. argus* phyllosoma at a home built facility in the fishing village of Bahia da Traçao. A visit to his house the following day revealed the incredible ingenuity of Reggie's holding and hatching facility.

Figure 1. Participants at the inaugural international workshop in spiny lobster larval culture held in Joao Pessoa, Paraiba state, Brazil, September, 2009. Clockwise from left to right: Dr. Andrew Jeffs, Mr. Diogo Lima, Reginaldo José da Silva, Jason Goldstein, Dr. Phil James, and Dr. Marco Antonio Igarashi. (Photo credit: J. Goldstein)

The outcome of the workshop was a series of recommendations regarding future spiny lobster culture in the State of Paraiba in northeast Brazil. These included the construction and deployment of puerulus collectors to monitor long-term settlement of pueruli on the nearby coastline which shows great settlement potential, developing a broodstock program for the three species of lobsters commonly found in this area (*Panulirus argus*, *P. laevicauda* and *P. echinatus*), and the renovation of a local land-based shrimp farm for possible future phyllosoma culture.

The workshop followed the initial investigations that have already been made in Paraiba on spiny lobster culture, and the organizers hope it is a step in the direction of commercially culturing spiny lobsters in Brazil. Their aim is to continue international collaboration with other like-minded groups.

The international researchers that attended the workshop express their gratitude to Dr Igarashi and Mr. Diogo Lima for organizing the event, and particularly Mr. Lima for his generous hospitality during our stay in Paraiba State.

Figure 2. (Left): Mr. Reginaldo José da Silva, lobsterman from Bahia da Traçao, in his wet lab with large female Panulirus argus. Mating studies will be designed and carried out to produce large numbers of phyllosomas for experimental growout. (Right): a prototype culture tank for the growout of phyllosoma. This tank was conceived and designed by 'Reggie' and has already been used for 2 other species of spiny lobster in Brazil. (Photo credit: J. Goldstein)

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American Lobster Settlement Index at 20 Years: Looking Back – Looking Ahead Workshop, Maine, USA, June 18-21, 2009

From: Rick Wahle

This workshop celebrated the 20th anniversary of the American Lobster Settlement Index. Hosted by Bigelow Laboratory for Ocean Sciences and Maine Department of Marine Resources, with additional sponsorship by Maine Sea Grant, the meeting convened some 40 scientists, fishery managers and industry members from New England and Atlantic Canada who have been involved in the monitoring and research over the years.

The workshop's two-part aim was to give a retrospective on the scientific contributions of the Settlement Index to date, including a preview of work in progress, and to look ahead to the challenges and priorities still to be met in monitoring, research, data management, and outreach. The meeting was divided between two half-day sessions, starting with oral and poster presentations on past and current research and ending with a discussion prioritizing future directions. The island retreat also provided a relaxed atmosphere featuring a Friday evening lobster bake and a Saturday afternoon hike at nearby Damariscove Island, a location that figured prominently in the beginnings of the Index. Workshop organizers, Rick Wahle, then still at Bigelow Laboratory, and Carl Wilson of Maine's Department of Marine Resources were grateful to have much help from students and staff.

Figure 1. American Lobster Settlement Index Workshop attendees outside the Burnt Island education center, Maine, USA. (Photo credit: E. Cobb)

The Settlement Index was initiated in 1989 soon after diver-based suction sampling proved an effective way of sampling newly settled lobsters in shallow, cobble-boulder nursery habitats. The survey has expanded from a few sites in coastal Maine, USA, to encompass other lobster-producing regions of the Northeast United States and Atlantic Canada. Supported by state and provincial marine resource agencies, monitoring is conducted annually at the end of the late summer-early autumn postlarval settlement season. The index is currently used in stock assessment as one indicator of the health of the lobster resource. It has also been the springboard for numerous research projects, contributing to some 24 peer reviewed publications and technical reports to date. Inspired by Western Australia's success in forecasting western rock lobster, *Panulirus cygnus*, landings, there has been much interest in evaluating the predictive power of the time series for subsequent fishery trends of *Homarus americanus*. Research has therefore focused on developing an understanding of the pre- and post-settlement processes influencing lobster population dynamics. Presentations by the participants the first day synthesized previous work and featured new findings. Discussion on the second day began to prioritize issues surrounding three areas: survey methodology, ecological processes, and resource assessment. For more information on the American Lobster Settlement Index and a more detailed summary of the workshop go to http://www.umaine.edu/marine/people/sites/rwahle/LobsterSettlementIndex.htm

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RESEARCH NEWS

First Postlarval Records of Robinson Crusoe Island Lobster Interrupted by Tragic Tsunami

From: Alvaro Palma and Carlos Gaymer

The first records of newly settled postlarvae of the Robinson Crusoe Island spiny lobster, *Jasus frontalis*, were beginning just as a tsunami devastated the island on 27 February 2010. After almost two field seasons of research on the early ecology of this spiny lobster endemic to these southeast Pacific islands, our Chilean expedition has successfully sampled newly settled postlarvae (pueruli) on artificial settlement collectors. This article briefly summarizes our initial findings obtained just before the project was catastrophically interrupted by the tsunami that was triggered by the magnitude 7.8 earthquake on the Chilean coast 600 km away. Twenty lives were lost as the lower section of the island's only town was swept away in a matter of minutes (Figure 1). We mourn the death of our friend, student and co-worker, Paula Ayerdi, age 28. As we recover from this tragedy, we are seeking to replace some $US80,000 of equipment and supplies to continue our research and evaluate the impact of this natural disaster.

This collaborative project started in the austral spring of 2008 with funds from Fondecyt (the Chilean Fund for Science and Technology). Among the main goals of this research is to unveil relevant aspects of the early ecology of this commercially valuable species, specifically, distribution and abundance of planktonic larvae and newly settled postlarvae near the island after a journey of almost two years spent in the water column. An understanding of early life stages of this species is crucial for its management and conservation.

Figure 1. View of the Robinson Crusoe Island village waterfront before (left) and after (right) the 27 February 2010 tsunami. Yellow line marks the inshore extent of the wave damage. Arrows indicate the Chilean team's dive locker/field lab and their residence a few blocks inland (Before-photo from Google Earth; after-photo taken by a member of the scientific team).

We devised a strategy to detect newly settled *J. frontalis* in collaboration with Dr. Rick Wahle (University of Maine) who was a visiting investigator on the project during our first season, in 2008. Collector design and depth of deployment were modeled after previous designs successfully used for other spiny lobsters around the world (Witham et al. 1968, Booth 1994, Phillips et al. 2001, 2005). At first we deployed a variety of synthetic fiber substrates which were fastened to mooring systems at depths less than 10 m (see TLN April 2009). These attempts were unsuccessful, but during the 2009-2010 season our luck changed. We followed up observations by local fishermen that pueruli occasionally attach to traps and ropes deployed at 80-100m. We expanded collector deployments to as much as 80m at sites around the island. Collectors were surveyed every 8-14 d depending on the weather. Using SCUBA to 20m, collector units were exchanged with new ones *in situ* and brought to the boat to be checked (Figure 2).

Although not abundant, most of the *J. frontalis* pueruli were found in collectors at the 80 m stratum (Table 1), suggesting a tendency to settle deep, just as fishermen had said, but at depths greater than those reported for other species of *Jasus*. These low numbers suggest the availability of recruits is naturally low, at least at this time of year, and that we need to expand our sampling effort in order to have more quantitative data. We were fortunate to have heeded local knowledge, underscoring the value of cooperative efforts between scientists and the fishing industry.

Our science and the Robinson Crusoe Island fishing industry have suffered from the February tsunami. Although we have two more years of Fondecyt support, in the coming months, we need to recover not only our capacity to undertake the original research plan, but to seize an unparalleled opportunity to evaluate the impact of the tsunami on the lobsters and other denizens of Robinson Crusoe Island's benthic community.

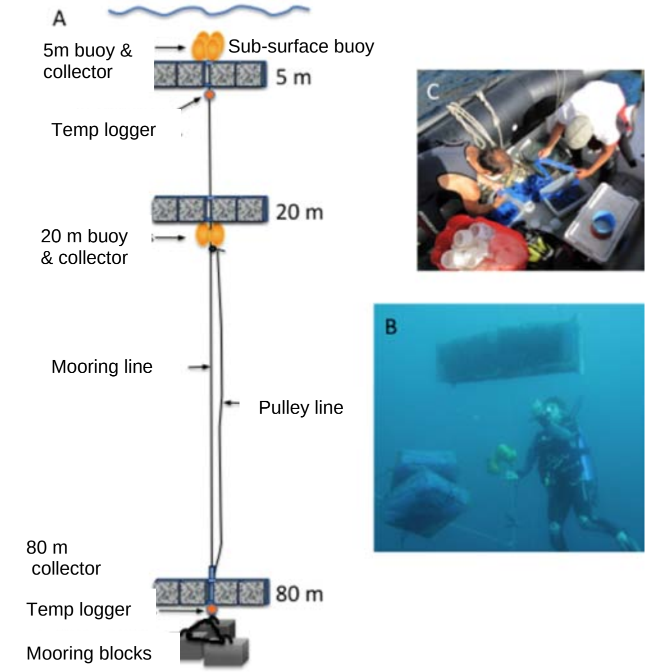

Figure 2. **A.** Mooring set-up with collector units placed at different depths. The 80m collectors are retrieved and replaced by divers using a pulley system at 20m. Temperature loggers fastened at 5 and 80 m depth. **B.** Diver retrieving and replacing collectors., **C.** Collectors being checked on board the boat. The collecting material (scrubbing plastic mesh) is extracted from 10 mm plastic mesh (Vexar™) and carefully sorted using 500 µm sieves. (Photo credit: Alvaro Palma).

Table 1. Occurrence of newly settled *Jasus frontalis* pueruli found in artificial collectors deployed at 5, 20 and 80m at four sites around Robinson Crusoe Island on the five sampling occasions before the tsunami strike on 27 Feb 2010.

	Punta Loberia					El Ingles					Tres Puntas					Tiera Blanca				
Depth (m)	7-Jan	12-Jan	2-Feb	8-Feb	12-Feb	7-Jan	12-Jan	2-Feb	8-Feb	12-Feb	7-Jan	12-Jan	2-Feb	8-Feb	12-Feb	7-Jan	12-Jan	2-Feb	8-Feb	12-Feb
5															x					
25																				
80	x		x			x		x											x	

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Influence of the General Circulation on Settlement of European Spiny Lobster Populations (*Palinurus elephas*) in the Balearic Islands

From: David Díaz, Raquel Goñi, Ben Stobart, Olga Reñones, Elisa Roldán, and Salud Deudero

Ocean currents can transport larvae of marine organisms over large distances. Populations are therefore demographically ''open'' and connected by larval dispersal (Planes et al. 2009). The rates, scale and spatial structure of larval exchange among local populations drive population replenishment, and therefore, have important implications for population dynamics and spatial management (e.g., marine protected areas; Cowen et al. 2006).

Recruitment of marine fish and invertebrate larvae is often highly variable, and identification of patterns is usually based on long-term settlement data which may provide insights into the biotic and abiotic variables influencing transport and survival (Acosta et al. 1997). However, it is impossible to empirically capture the full range of spatial and temporal variability resulting from oceanographic conditions and larval behavior. Thus, identifying the scale of marine larval dispersal remains one of the fundamental challenges of marine ecology and oceanography (Cowen et al. 2006).

Palinurid spiny lobsters have a complex life history, with a lengthy larval phase which can last from a few months to two years, and therefore is subject to widespread dispersal. Prevailing currents strongly affect larval transport and distribution in spiny lobster (Inoue & Sekiguchi, 2009). The puerulus postlarvae of many species settle in shallow nearshore nursery habitats, and the nearshore supply of postlarvae for certain palinurid species has been linked to large-scale oceanic processes (Acosta et al. 1997).

As part of a study of recruitment patterns of the spiny lobster *Palinurus elephas* in the Western Mediterranean, we have investigated spatial correlations between settlement indices and fishery production in various localities across the Northwestern Mediterranean region (Díaz, 2010). Preliminary results suggest that *P. elephas* has a metapopulation structure with a common larval pool (Díaz, 2010).

The dispersive larvae of *P. elephas* lasts only about five months (Goñi & Latrouite, 2005), but observations of *P.elephas* phyllosoma in the Western Mediterranean are very scarce

(Hunter, 1999) and none appeared in the series of planktonic surveys carried out around the Balearic Islands during 2002-2005 (Mallol et al. 2008). As a result, very little is known about *P. elephas* larval distribution, behavior and dispersal. As a way to overcome this, we assessed postlarval settlement in benthic habitats, which is a relative estimate of immigration rate and may be converted to an absolute estimate through measurements of flux across the water column (Lipcius et al. 1997).

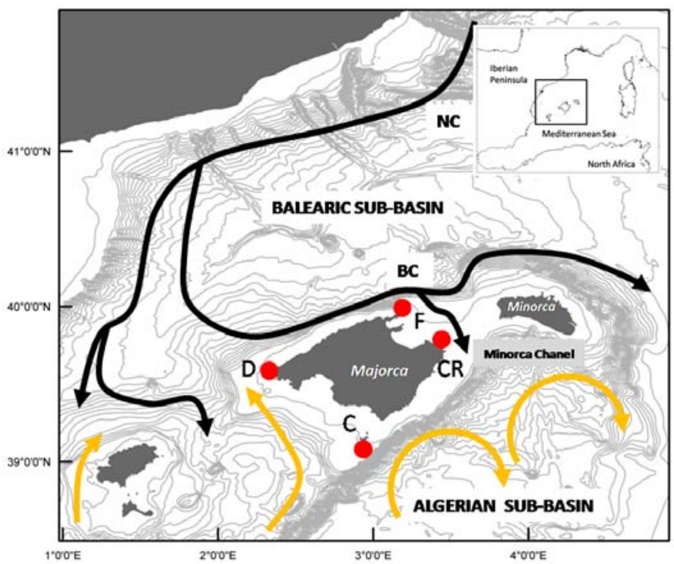

Figure 1. Map of the Balearic archipelago showing bathymetry (grey lines) and predominant currents. The Northern (NC) and Balearic Currents (BC) in black, and the branches of the Algerian Current in orange (Redrawn from Millot, 1999). Red dots mark the settlement sampling locations: northwest (Formentor, F), northeast (Cala Ratjada, CR), southwest (Dragonera, D) and southeast (Cabrera, C).

The Balearic Islands lobster fisheries are among the few still viable and productive in Western Mediterranean (Quetglas et al. 2004), with particularly rich fishing grounds located in the northern shores of Majorca Island and in the Minorca Channel (Figure 1). In contrast, along the southern shores of Majorca *P. elephas* occurs only sporadically and no targeted fisheries exist. Optimal *P. elephas* habitats for both settlers (empty date mussel *Lithophaga lithophaga* holes bored into limestone, Díaz et al. 2001) and adults (coralligenous substrates at 50-100 m depth, Goñi & Latrouite, 2005) abound throughout the Balearic islands. Thus, without habitat limitation for either settlement or adults as an explanation for the absence of spiny lobsters populations in the south of Majorca Island, we hypothesized that hydrodynamic patterns in the archipelago lead to differences in larval supply causing the observed spatial patterns of exploitable lobster abundance. To test this hypothesis we first ruled out the possibility that local populations were self-recruiting.

In previous studies of spiny lobsters self-recruitment was evaluated by analyzing the correlation between adult and post-settlement abundances (Lipcius et al. 1997). Here we examined correlations between adult populations (estimated throughout landings of nearby harbors) and settlement indices (with 1-year lag) among four locations around Majorca Island: northwest (Formentor), northeast (Cala Ratjada), southwest (Dragonera) and southeast (Cabrera) (Figure 1) and found no indication of self-recruitment (Table 1).

Table 1. Pearson's correlations coefficient (significance level $p < 0.05$) between settlement index and landing of spiny lobsters in the nearest fishing harbours from 2005- 2008 (1-year lag).

Locations	Coef Corr.	p-level
FORMENTOR	0.48	0.517
CALA RATJADA	0.72	0.715
DRAGONERA	0.46	0.542
CABRERA	0.45	0.553

To test the hypothesis that external larval supply from outside the area is one factor likely determining the distribution of adult lobsters around Majorca Island, we analyzed four years of settlement surveys carried out by scuba diving from 2005 to 2008 in the same four locations. We sampled four sites separated by < 500 meters in order to integrate spatial variability at each location. Inter-annual variation of settlement index (no. individuals / minute) was significantly different between the northern and southern locations ($F_{(3, 1196)} = 25.168$, $p < 0.001$). On average settlement densities were greater in the northern locations of Majorca Island while the southernmost location, Cabrera, had the lowest settlement counts (Figure 2). This pattern is consistent with the pattern of prevailing currents in the Balearic Islands (Figure 1). The southern side of Majorca Island is under the influence of the Algerian current that brings Atlantic water through the Strait of Gibraltar (Figure 1), while the Northern current, and its branch the Balearic current, bathe the northern shores of the Island. Thus the two sides of the island are influenced by currents of different origins, with the northern current presumably connecting the Balearic lobster populations with other traditionally productive grounds to the north and east of the Mediterranean basin.

Therefore we propose that in the Balearic Islands ocean circulation is a key factor determining spatial differences in larval supply and, as a consequence, of adult abundance. Hence, the presence of optimal settlement and adult habitats alone do not secure the presence of exploitable densities of *P. elephas*, although they are necessary for the existence of well establish populations. The influence of general circulation should be tested on a larger spatial scale. Expanding the settlement surveys to the south and east of the Western Mediterranean basin will be part of a future project.

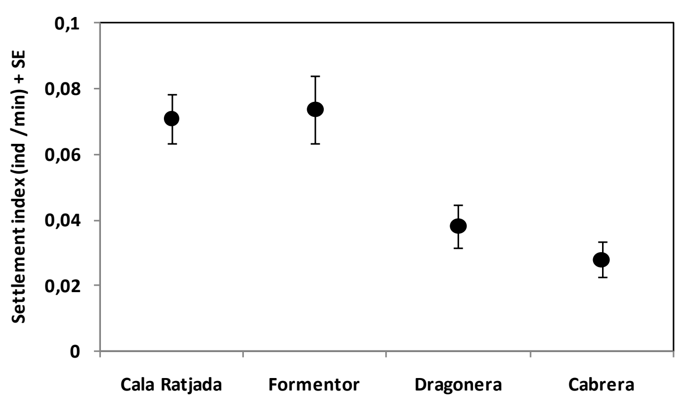

Figure 2. Mean *Palinurus elephas* settlement index (individuals/min) ± S.E. at four main sites on the Majorca Island. Data from the 2005 to 2008 surveys combined.

Acknowledgements

All the people who helped me in numerous surveys, and Pep Coll for the speed in which he provided data on spiny lobster landings from Balearic Ports. The Secretaría General del Mar, promoted and co-funded this work with a grant awarded to the Instituto Español de Oceanografía for the ERICOL Project (2005-2008).

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Lobsters on the Move

From: Diane F. Cowan

For more than a century, fishermen and scientists have been devising clever ways to follow movements of the American lobster, *Homarus americanus* (Herrick 1895). Several years ago I realized acoustic tags could be used to investigate whether lobsters stayed in one place. While mark-recapture studies that depend on lobster traps to capture lobsters require that lobsters be motivated to crawl into traps, acoustic telemetry works even if lobsters do not move. Together, a group of scientists and local fishermen created the Lobster Sonar Tracking Project to investigate the relationships between temperature, movements and body size of ovigerous lobsters (Cowan 2003; Cowan et al. 2005, 2007; Holden & Blackburn, 2006).

Trying to study long-term movements by attaching external tags to lobsters poses a problem because external tags are cast off along with the exuviae. Tag loss during the harvesting process is another problem. We maximized our tracking time to the 12-month life of the transmitters by taking advantage of the nine to 13 month brooding period during which lobsters generally do not molt and are protected from harvest.

We outfitted 191 lobsters with an acoustic transmitter attached to the carapace, a streamer tag surgically anchored into the muscle tissue between body and abdomen, and temperature data logger attached to the claw (Figure 1, Cowan et al. 2007). The gear did not seem to interfere substantially with behavior based on tests in *The Lobster Conservancy's* mesocosm and comparisons of distance and direction of movements with previous studies using lobsters not equipped with so much gear (Campbell & Stasko 1986 and references therein).

Figure 1. Ovigerous lobster tagged with acoustic transmitter adhered to carapace using super glue and drab olive green duct tape, ribbon tag with identification number and *The Lobster Conservancy's* phone number, and HOBO TidbiT temperature data logger attached to right cheliped. (Photo credit: Dianne Cowan).

Lobsters with freshly extruded eggs captured in shallow waters on the fishing grounds of Friendship, Maine, USA, were tagged and immediately released. Originally, we planned to tag 300 egg-bearing females: 150 at or above and 150 below the size at 50% maturity (Cowan et al. 2007). The traps captured an order of magnitude more of the smaller size class, and although we sampled more than 3,000 lobsters, too few females below the size at 50% maturity were brooding because they were not yet mature (Cowan et al. 2007). We only found 79 "small" ovigerous lobsters to tag and stopped tagging the large size class when we reached 112 to avoid further discrepancies in sample size.

We used three methods to relocate tagged lobsters: (1) detection of transmitters via handheld hydrophone deployed from lobster boats, (2) traditional recaptures in lobster traps, and (3) diver recaptures using a hand-held receiver.

We detected a total of 156 out of 191 (82%) of all tagged lobsters at least once after release. Forty-six percent (88 lobsters) were recaptured at least once. The 27% that were both detected and recaptured yielded the most detailed location data. Only 35 (5 small and 30 large) individuals were never detected after initial release.

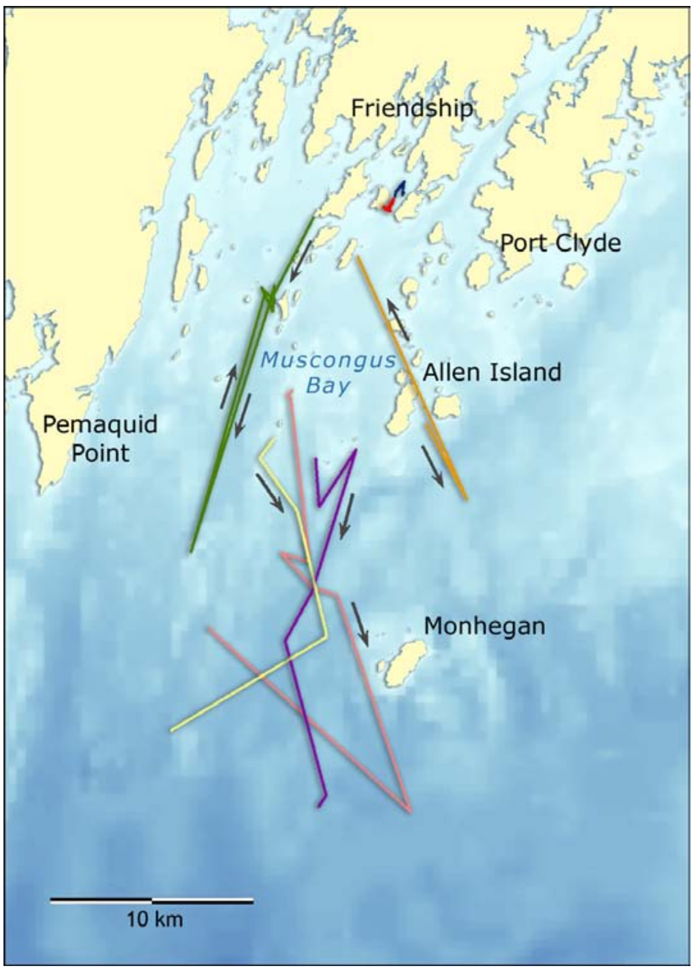

Figure 2. Locations of seven ovigerous lobsters tracked repeatedly in and around Muscongus Bay, Maine, USA, from Sep 2002 – July 2003. Note that each lobster is indicated by a different color and the location of #54 is in red. (Map courtesy of C. Brehme).

Combining traditional recapture with modern sonar tracking techniques yielded detailed movement data on individuals that remained within our listening area. Figure 2 shows the location data for seven transmitters. Part of the beauty of the acoustic transmitter was that it made it possible for us to know if the lobsters did not move. We called the lobsters that stayed within 10 km of the original position "non-movers." For example, lobster # 54 was a small female tagged and released on location in Morse's channel on 18 September 2002 (Figure 2). She was "heard" every subsequent month except March and May, 2003. The channel froze over in February. When the ice went out, we dove but ended up at a boulder we could not get under. One summer day a lobsterman handed me #54's temperature data logger and told me she was fine, still brooding her embryos, and still hanging out in Morse's channel!

Once the lobsters moved outside of our "listening" range we had to rely on recaptures. A total of 19 individuals were recaptured at a maximum displacement of >20 km. Of these, 13 or 12% of large body size and 6 or 8 % of small ovigerous lobsters were "long distance" travelers (Figure 3).

For the first publication arising from this work, we used movement and temperature data from 30 eggers that were recaptured after at least 9 months at large. Most small ovigerous lobsters stayed within 10 km of where they were tagged, and therefore were designated "non-movers." In contrast, the longest straight-line displacement for a large ovigerous lobster was 210 km (Cowan et al. 2007). This large egger was last heard in Friendship in November 2002 then recaptured off Cape Cod, Massachusetts, in June 2003.

At the outset, in September 2002, daily mean temperatures experienced by the 30 lobsters were between 10 and 17°C. All lobsters were at about 12°C when the thermocline mixed during the autumn. Then, the surface and shallow waters started to cool and some lobsters (e.g., #54) got really cold, while others stayed relatively warm. For example, during the winter lobster #54 near Friendship Harbor was experiencing water colder than -1°C on the same days other lobsters in deeper offshore water were experiencing temperatures as warm as 8°C. In spring lobsters were once again experiencing similar temperatures until surface and shallow waters warmed up so that some lobsters (e.g., #54) were subject to warmer temperatures than the others. In June lobster #54 was bathed in temperatures of 14°C while another lobster not far away was still in the deep chill of <4°C (Cowan et al. 2007).

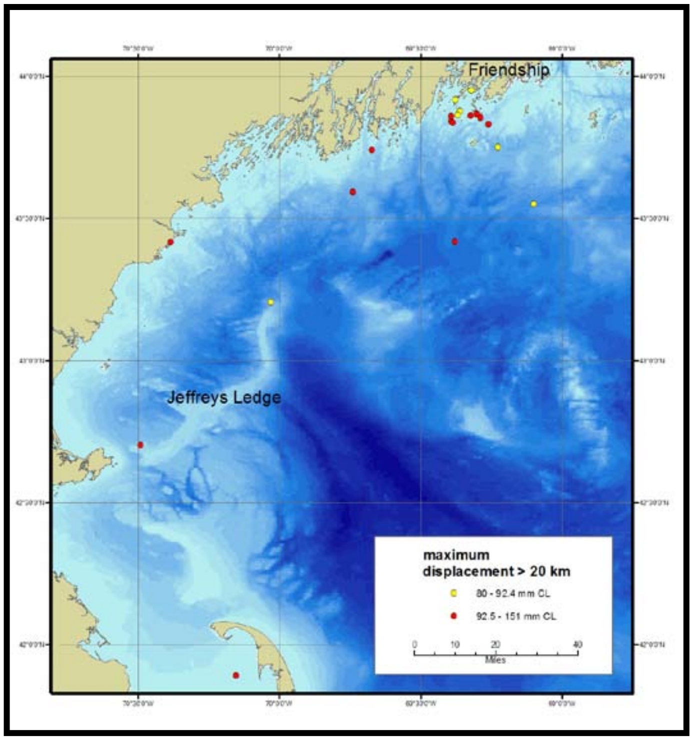

Figure 3. Point of furthest displacement from origin (all tagged and released in Friendship) where "long distance" travelers were detected either via acoustic telemetry or recaptured in lobster traps. Red dots indicate "large" ovigerous lobsters, *Homarus americanus,* measuring $\geq$93 mm CL and yellow dots, "small" ovigerous lobsters.

In short, our results indicate that smaller ovigerous lobsters were subject to colder temperatures in the winter and greater extremes during the rest of the year than large ovigerous lobsters (Cowan et al. 2007). Apparently, ovigerous lobsters do not need to move to relatively warm waters. The lobsters in this study gained sufficient degree-days for embryonic development in the same time frame whether or not they moved (Cowan et al. 2007).

In light of our results, it seems the larger "long-distance" travelers are more likely to seed distant locations while the smaller "non-movers" reseed local areas. For more on gene flow and mixing, see Kenchington et al. (2009) for an interesting account of genetic structure across the range of the American lobster.

The two most important things to come from *The Lobster Conservancy's* Lobster Sonar Tracking Project were the temperature results and the evidence that many ovigerous lobsters hardly move at all. Never before had temperature loggers been affixed to lobsters for nine to 13 months. We simply did not know how variable individual temperature profiles could be. This study uncovers tantalizing fisheries management, behavioral, ecological and physiological questions for further research on lobster movements and temperature.

Acknowledgements
Special thanks to co-PI's Win Watson and Andy Solow; *The Lobster Conservancy* staff members, Sara Ellis and Linda Archambault; Island Institute fellows Dan O'Grady and Andrew Mountcastle; 75 lobstermen, including key participants Tim Thompson, Mark Havener, Philip Bramhall, Steve Lash, Jim Bolen and Richard Barter from Friendship, Maine. Major funding for this project was provided by Northeast Consortium, National Fish and Wildlife Foundation and Darden Restaurants Foundation.

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Classic Slipper Lobster Thesis Goes Digital

From: Jason Goldstein and Kari Lavalli

Despite their ecological significance and increasing commercial importance, both as a targeted fishery and as by-catch, slipper lobster research still lags far behind compared to the biological data that we have amassed for clawed and spiny lobster over the past few decades. As with most lobsters, however, early-life history stages (eggs through postlarvae) of many scyllarid genera have been identified from field samples, and more and more researchers are making headway with recent advances in larval culturing systems and nutritional requirements. Considered by most researchers as the definitive work on the larval history and development of Western North Atlantic slipper lobsters, Phillip B. Robertson's 1968 dissertation, ***"The larval development of some Western Atlantic lobsters of the Family Scyllaridae"***, contains a wealth of information including detailed collection data, thorough larval descriptions, and beautiful drawings of slipper lobster phyllosomas and postlarvae (nistos). Recently, we were able to obtain a hardcopy of this 500+ page work, and with the help of the Boston Library Consortium and University of New Hampshire, were able to digitize the entire manuscript. Although Robertson did publish a few manuscripts from his work, a disproportionate amount of information remains in the original document. Hence, much useful information may be difficult for many to locate and use in their own research programs.

Highlights from Robertson's work include:

- Descriptions of postlarval stages of three species of *Scyllarus*,
- Provisional key to the scyllarid phyllosomas of the Western Atlantic,
- Identification key for the generic determination of the phyllosoma stages of both spiny lobster and slipper lobster families (world-wide),
- Molting, growth, and larval duration for phyllosomas of four species of *Scyllarus* and one species of *Scyllarides* cultured in the lab.

The primary impetus for completing this project was to: (1) more fully discern slipper lobster phyllosoma identification from field samples when these are often confused with identifications of spiny lobster phyllosoma stages; (2) relate developmental sequences of various phyllosoma stages to their oceanic distributions on temporal and spatial scales; and (3) describe and observe the rearing and maintenance of phyllosomas in the lab for various lengths of time.

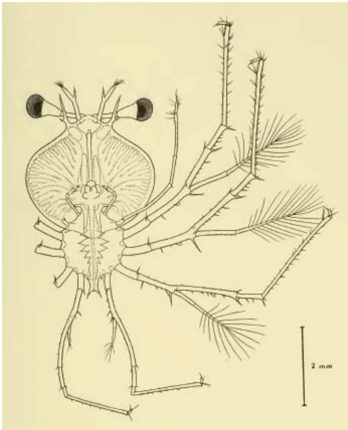

Figure 1. A cultured *Scyllarus nearctus* Stage V phyllosoma. From Robertson (1968), figure 28.

Figure 2. A cultured *Scyllarus americanus* nisto. From Robertson (1968), Figure 14.

This dissertation is now available in full as a PDF file at the following website: *http://www.archive.org/details/larvaldevelopmen00robe*.

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Neurosecretory Cells and Egg Production in the Female Spiny Lobster *Panulirus homarus*

From: Rachel Fernandez and E.V.Radhakrishnan

Crustaceans have neurons modified to perform the endocrine function by the production and secretion of neurohormones and neuroregulators that control various physiological activities including reproduction.

Studies on the factors regulating reproduction in crustaceans date back to the early part of the twentieth century when neurosecretory cells (NSCs) and sinus glands were observed in several crustaceans by Hanstrom (1931 and 1933). These studies gained momentum with the Panouse's eyestalk ablation experiment on *Palaemon serratus* in 1943. Thereafter, intensive studies were carried out to find out the factors involved in crustacean reproduction.

For the successful captive breeding of lobsters, precise knowledge of the source, nature and mode of action of neuroendocrine factors in relation to vitellogenesis is imperative. The neuro-secretory cells (NSC) distributed in the optic, supraoesophageal and thoracic ganglia play a major role in vitellogenesis. Studies reveal that the NSCs in the eyestalk synthesize a neurohormone which inhibits vitellogenesis. It is also suggested that a gonad stimulatory substance secreted by the NSCs in the supraoesophageal and thoracic ganglia stimulates vitellogenesis.

Keeping in mind the necessity of developing a viable hatchery technology for *P. homarus*, an investigation was carried out to study the general morphology of the central nervous system; and the structure, morphology, distribution and secretory activity of the NSCs in the optic, supraoesophageal and thoracic ganglia of *P. homarus*. The secretory status of the NSCs was correlated at various stages of vitellogenesis at the cellular and ultra cellular level. The NSCs were identified, classified and mapped by staining the histological sections of neuroendocrine tissues using Gomori's paraldehyde fuchsin method (Cameron and Steles 1959) and Mallory's triple staining method (Mallory,1944). The ultra structural studies were carried out using transmission electron microscopy (Beams and Kessel, 1963, Spurr 1969).

The central nervous system of *P. homarus* follows the general arthropod pattern which consists of a ganglionated nerve cord extending from the cephalic region to the end of the abdomen. NSCs are characterized by the presence of a large nucleus, abundant cytoplasm, conspicuous granules, vacuoles and cell organelles, including golgi complex, endoplasmic reticulum, ribosome, mitochondria etc. in their perikarya. NSCs differ significantly in their size, shape and cytological characteristics. Based on these factors, the NSCs were classified into different cell types. In *P. homarus* the NSCs in various ganglia are significantly different. Therefore separate classification was given to the NSCs in the optic, supraoesophageal and the thoracic ganglia. The optic ganglia have six types of neurosecretory cells whereas the supraoesophageal ganglion and the thoracic ganglia have eight neurosecretory cell types.

Cyclic changes were observed in the perikarya of neurosecretory cells in relation to the synthesis of neurosecretory material. These changes follow a basic pattern and this was divided into four phases, viz. synthetic phase, vacuolar phase, secretory phase and quiescent phase. The cyclic secretory activity of neurosecretory cells at various ovarian developmental stages indicates that three neurosecretory cell types present in the optic ganglia may have a prominent role in the production of vitellogenesis inhibiting hormone. Similarly, a particular neurosecretory cell type in the supraoesophageal ganglion and two neurosecretory cell types in the thoracic ganglia are likely to be the probable sites of synthesis of neuroendocrine factors or hormones, which accelerate the process of vitellogenesis. This demands further clarifications at the molecular level, and these clarifications could pave the way for a major breakthrough in the captive breeding of lobsters and other crustaceans by the production of analogues of neurohormones or neuroregulators which can control the reproductive processes.

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Sustainability of Lobster (*Panulirus argus*) Fisheries in Southern Mexico Marine Protected Areas

From: Kim Ley-Cooper

A new PhD study has commenced in the Mexican Caribbean, where the spiny lobster, *Panulirus argus,* constitutes the most highly valued single-species fishery. Within the Marine Protected Areas of Sian Ka'an and Banco Chinchorro, this fishery is cooperative-based and accounts for more than 50% of the total catch for the State of Quintana Roo. The seasonal catch over the last few decades has proven to be relatively stable, which suggests a certain level of sustainability, and the reason why the fisheries have a local eco-labelling scheme in place, and are currently being evaluated for Marine Stewardship Council (MSC) certification. An integral stock assessment is yet to be completed, and is one of the main motivations for studying these sites on a detailed scale.

Sustainability has environmental, ecological, economic and social dimensions. An analysis of lobster population dynamics is fundamental to addressing sustainability in these fisheries. Biological aspects of this species are being examined for stock assessment, by using survey techniques like tagging (Figure 1), and modelling methodologies that will enable us to understand sustainability criteria and principles. Measuring puerulus recruitment is being conducted with GUSI-Collectors (Figure 2; named after the inventors, Gutierrez-Carbonell et al. 1992). Socio-economic analysis of the fishers will also be conducted to compare their current economic status to potential impacts of MSC certification and eco-labelling.

Figure 1. Tagging lobsters in Banco Chinchorro. (Photo credit: K. Ley-Cooper)

Figure 2. GuSi puerulus collector. (Photo credit: K. Ley-Cooper)

The research will also include an analysis of new live-capture techniques such as loops in reefs, casitas in seagrass areas, as well as the establishment of live lobster holding tanks where the establishment of a protocol for transport and handling arrangements is needed. An outcome of the project will be an evaluation of economic and social stewardship, as well as an analysis of how stakeholders and markets interact and relate to eco-labelling schemes as a new strategy of value-added commercialisation. It is expected that the knowledge obtained during this study will provide a better understanding of the long-term sustainability of the spiny lobster fisheries in the Caribbean, and improve the livelihoods of the fishers. I would be interested in hearing from other researchers studying spiny lobsters fished by artisanal fishers and social and economic studies of the fisheries.

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A Technique and Apparatus for Delicately and Quickly Sampling Early Stage Spiny Lobster Phyllosoma from Large Experimental Culture Vessels

From: N. G. Sachlikidis & B.P. Guy

Complete culture of the phyllosoma life stages has now been successfully achieved for many spiny lobster species (see reviews: Kittaka, 1997; 2000; Phillips and Melville-Smith, 2006; Jones, 2009), and although achieving success at commercial scale has so far proved elusive, there have been significant advancements towards commercial scale spiny lobster culture. More recently, this has been reflected by an increase in the scale of larval cultures and, although small (<10L) experimental vessels are still a practical means of replicating treatments, larger vessels are increasingly being employed as hatchery production and experimentation moves towards commercialization.

Ultimately, improvements in phyllosoma culture techniques are measured by increases in survival rates. Regular enumeration of phyllosoma cultures is therefore an important tool used to assess treatments applied in experimentation and hatchery culture success and health.

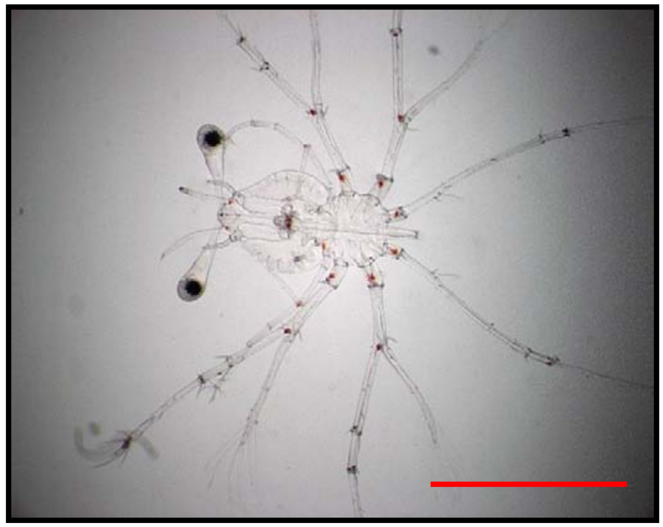

Figure 1. An early stage *Panulirus ornatus* phyllosoma. Limbs and eyestalks are especially delicate and are prone to physical damage if handled improperly. Red bar denotes 1.5mm. (Photo credit: L. Linton)

Estimating culture tank density, and therefore survival, of early stage phyllosoma (I-V) is more difficult and time consuming than for late stage phyllosoma (VI-XI). Early stage phyllosomas are generally cultured in higher density, are transparent and physically small (<4 mm carapace length; Figure 1). Survival estimation is especially difficult within large culture vessels, which carry many thousands of phyllosoma at a time. Currently, samples are taken from culture tanks, poured from jugs into counting trays and then returned to each vessel after counting, frequently resulting in damage to larvae. The delicate long, thin limbs and eyestalks of the phyllosoma are easily damaged by rough handling practices (Figure 1). Physical damage to phyllosoma including limb loss can result in reduced survival (Matsuda and Takenouchi, 2005), this may create a discrepancy between experimental survival results and best practice especially when repeated frequently for experimental purposes.

An alternate sampling technique for enumerating the early stage *Panulirus ornatus* phyllosoma from large vessels is compared here in terms of speed and accuracy to the current methodology. A sampling apparatus that both saves time and reduces the risk of significant injury to early stage lobster phyllosoma, whist accurately estimating phyllosoma density is introduced.

Figure 2: The counting of phyllosoma larvae after removal from culture vessels. The 3L bowl allows for dilution of the 1L sample amount which is especially important at high culture densities where greater numbers of phyllosoma must be counted. (Photo credit: N. Sachlikidis)

Sampling methods and apparatus

Sampling method 1: Pouring and counting method

This method represents the current sampling methodology. In this trial, a 1 L graduated jug was used to remove a 1L sample of culture water for each sample replicate. The sample was then poured into a 3 L plastic container where individual phyllosoma were counted under an incandescent lamp before being returned to the culture vessel (Figure 2).

Sampling method 2: Sampling wand method

The sampling wand is a purpose-built phyllosoma sampler. It consists of a clear, polycarbonate sampling tube, a top mounted gate valve, a bottom end stopper and a green, AA battery powered, 20,000 Mcd superbright LED light source (Figure 3). To sample, the top gate valve is first opened and the clear body of the device is lowered into the culture vessel. The top gate valve is then closed, the end stopper is placed over the bottom of the tube. The device is raised above the water level and the LED light is then turned on (Figure 3). The green light illuminates the transparent phyllosoma, making them more obvious and easy to count. After counting, the device is lowered back into the culture vessel, the end stopper removed, the top gate valve opened and the phyllosoma released gently back into the culture vessel. For the purposes of this trial, and for ease of comparison, the sampling wand was calibrated to a 1L sample volume.

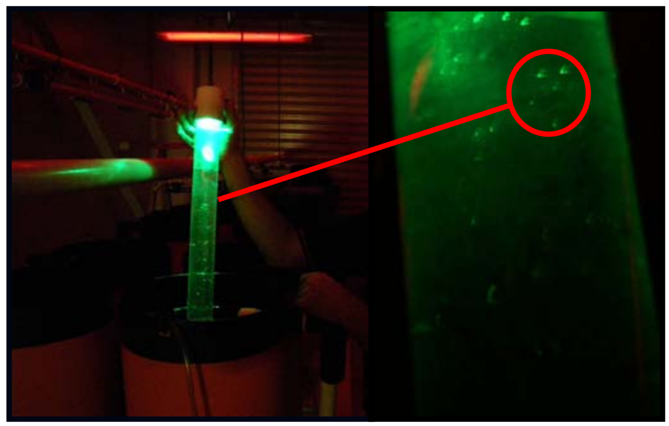

Figure 3: The sampling wand device ready for counting of phyllosoma. Larvae are lifted clear of the culture tank for easy counting, and then gently returned reducing the risk of physical injury during the enumeration process. The body of the wand is made from polycarbonate tubing allows for good optical clarity through the sample water, whilst the 20,000 green Mcd LED bulb illuminates the sampled phyllosoma to make counting quicker and easier. (Photo credit: B. Guy)

It is an assumption of both sampling methods that phyllosoma larvae are evenly distributed within the culture vessel. Prior to all sampling, water flow was turned off to each culture vessel and light aeration was applied to ensure mixing and even distribution of larvae throughout the tank.

Phyllosoma density estimates were not statistically different from the true density for both methods at all stages with the exception of the counting and pouring method at stage I (Figure 4). This sampling method significantly over estimated densities, recording an average of 42.55 phyllosomas/L after 20 samples, when the true density was 40 phyllosomas/L ($p<0.05$). Mean density estimates made with the sampling wand were closer to the true mean density across all stages at the densities tested and 95% confidence limits (CL) were within a maximum 8.5% of the true density at the stages and densities tested. This compared favorably to the pouring and counting method where 95% CL fell outside 10.4% minimum when added to sample means across all treatments.

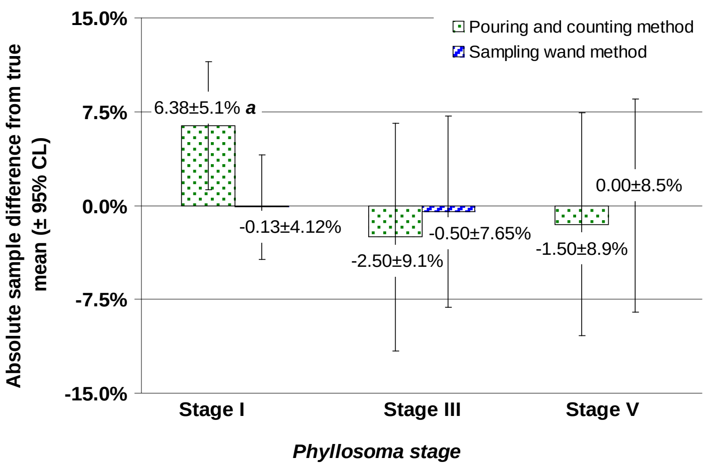

Figure 4: Early stage phyllosoma density sample results for two sampling methods against a known standard density ± 95% CL. Phyllosoma densities were 40/L at stage I and 20/L for stages III and V. The sampling wand method was more accurate than the pouring and counting method for stage I larvae at 40 phyllosoma/L. Both methods estimated average densities close to the true average for stages III and V. Letter denotes a significant difference between the estimated mean and true density.

The time taken to collect and count each sample with the sampling wand was less than half that taken if estimates were made by sampling and pouring, regardless of phyllosoma stage. Sampling times did not differ significantly between densities for the sampling wand method, but were significantly longer for the pouring and counting method at the higher density treatment (40 phyllosoma/L). Individual sampling times did not include between sample preparation times however the time taken to achieve 20 consecutive samples was 40 and 16 minutes for the pouring and counting and the sampling wand method, respectively.

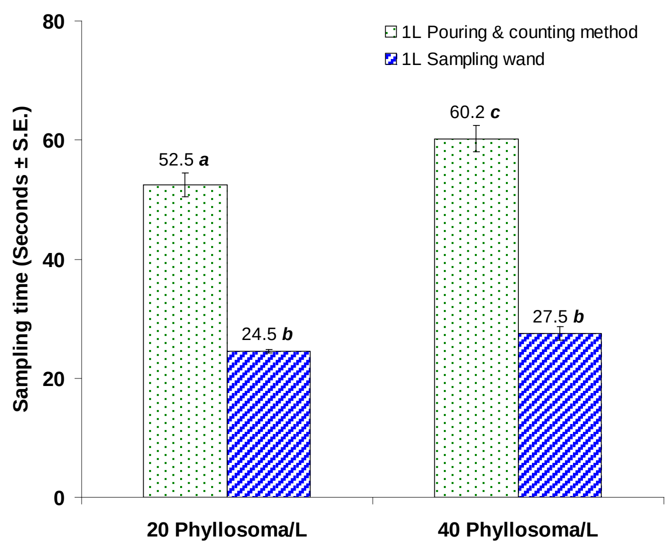

Figure 5: The time taken to collect and count each sample with the sampling wand was less than half that of the more traditional pouring and counting method. Measurements at the 20 phyllosoma/L density were stages III and V and stage I for the 40 phyllosoma/L treatments. Measurements did not include preparation times between samples and other preparation. Letters denote statistical significance ($\alpha=0.05$).

The sampling wand is a quick, gentle and accurate apparatus that is helpful in enumeration of phyllosoma cultures of the spiny lobster *P. ornatus*. It is likely that it will be effective for the larvae other cultures species including other lobster species. Limitations of this device include tank depth and larval agility and it may not be suitable for shallow tanks or for agile larvae such as fish. It is hoped that by reducing the impact of sampling, experimental work can be more regularly sampled whilst still achieving high survivals to better represent best practice larval rearing in larger scale experimentation where total counts are not possible.

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