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The Lobster NEWSLETTER

ANNOUNCEMENTS

From: Mark Butler

It has been a pleasure to serve as an editor for *The Lobster Newsletter* for the past 11 years. I think its time for some new blood and I am pleased that Rick Wahle has agreed to take my place as co-editor along with Roy Melville-Smith. They are a capable duo with many years of experience in lobster science, management, and publishing. It is also advantageous to have editors from opposite ends of the globe, and those with expertise in both spiny and clawed lobsters. Adds a nice balance in coverage and perspective to *The Lobster Newsletter*, don't you think?

Mark Butler, departing editor of *The Lobster Newsletter*

Having Rick succeed me as editor reminds me of the day that Professor Stan Cobb, one of the fathers of *The Lobster Newsletter* (along with John Pringle), asked me to take over for him back in 1996. Stan and John started the newsletter based on a suggestion by Jim Stewart at the 1985 Lobster Workshop in St. Andrews, Canada and the first issue appeared in 1988. The editorship tasks were somewhat different back then, as I described in a newsletter article when I accepted the editorship:

> *"Its easy to forget that the newsletter's life-blood (haemolymph?) are its editors. Sitting here late at night in Stan Cobb's home amidst a pile of half-edited articles while listening to Stan recount the details of preparing, printing, and distributing the Newsletter, adds a new perspective and appreciation for the time that Stan and John have put into the past eighteen issues." (The Lobster Newsletter, 1997, Vol. 10(1)).*

Not only were paper copies of *The Lobster Newsletter* printed and mailed around the world back then, but someone had to pay for all that because subscriptions were free. It was the editors who found those funds and kept the newsletter going. With the advent of the internet, along with rising costs of printing and mailing, it was obvious that we had to take the newsletter electronic. I am pleased to have shepherded that transition to the current electronic newsletter and to have created *The Lobster Newsletter* website, where all of the past issues are archived. Still, I cherish my old printed issues of the newsletter and thank goodness I had them, as it was from those dusty pages that the pdf files available on the website were copied page by page.

By far the best part of serving as an editor for *The Lobster Newsletter* was interacting with you – the lobster biology and management community – and reading all of your fascinating stories, new research accomplishments, and provocative opinion pieces. I encourage you to contribute regularly to the newsletter so that it continues to be an effective means of communication among lobster biologists, managers, and fishers around the world. It may not be *Science* or *Nature*, but *The Lobster Newsletter* is ours. An enduring tribute to those who began the newsletter three decades ago, and an expression of the community of "lobster folks" who read and contribute to it today.

Good luck to our new editors, Roy and Rick. I'll send you an article soon … I promise.

The Lobster Newsletter Wecomes New Editor

From: Rick Wahle

Rick Wahle, new co-editor of *The Lobster Newsletter*

I am pleased and honored to join Roy Melville-Smith as co-editor of *The Lobster Newsletter*. For the past decade, our recent co-editors, Mark Butler, John Booth, and Peter Lawton have done an outstanding job of ushering *The Lobster Newsletter* into the Internet age. Thanks to them, twice a year, *The Lobster Newsletter* has continued its tradition of networking students of lobsters of all stripes around the globe.

The obvious advantage of a newsletter is that new developments and opinions can be aired in advance of, and in a more streamlined manner than, the peer reviewed scientific literature. And all that comes for free! Our intent is for *The Lobster Newsletter* to continue to play its primary role in facilitating communication and collaboration among lobster scientists, managers and industry members around the world. And for graduate students, it is an outlet to gain early visibility and recognition for their work.

Lobster science and management finds itself in a time both disturbing and exciting. Human and environmental pressures on the commercially important lobster species continue to mount. Adding to long-standing concerns about fishing impacts are recent episodes of disease and mass mortality; and the implications of climate change, ocean acidification, and habitat destruction for the future of these fisheries are still disconcertingly unclear. We therefore anticipate topics relating to fisheries, aquaculture and interactions with the ocean environment to continue to dominate newsletter contributions. For other researchers lobsters represent a convenient model system with which to study fundamental questions in physiology, behavior and ecology. Either way, as sources of research support are increasingly stretched, it will likely be ever more important for the scientific community to partner with the private sector to meet today's challenges.

The Lobster Newsletter's ability to maintain these lines of communication depends on our collective efforts to share information. So, let this be my first appeal for submissions to the first issue of 2009 and beyond. Send us your contributions, whether on research, management, education, or the commercial aspects of lobsters. Even if you're inspired to share an item of lobster-related art, humor, or song (Pete Lawton?), we look forward to hearing from you!

India invites lobster scientists to International lobster meet in January 2010

From Dr. R. Kirubagaran

India, a country of amazing diversity, always warm and inviting, is a place of infinite variety - one that favors you with a different facet of its fascination every time you come on a visit. Its not humans alone, even the lobsters are diverse, with many species of spiny and slipper lobsters living together along the Indian coast offering fascinating opportunities to explore their interaction in a particular niche. To fulfill the aspirations of lobster scientists across the world, the National Institute of Ocean Technology (NIOT), Chennai, Ministry of Earth Science, Government of India, in collaboration with other participating institutions in India, announces an International lobster meet on "**Recent Advances in Lobster Biology, Aquaculture and Management"** at NIOT premises in Chennai during 5-8 January, 2010. The theme of the conference is a review of lobster research across the world and focus on lobster research in India to generate international cooperation in formulating projects on lobster management, biology and aquaculture. It offers great opportunity for lobster scientists to have a mid term review of research before the ninth International Lobster Conference in Norway in June 2011.

Chennai, the largest city in southern India is located on the Coromandel Coast of the Bay of Bengal. A bustling metropolis, Chennai is a convenient base to peep into the varied aspects of traditional south Indian culture and life styles which inter- mingle with the modern city complete with its plush hotels and restaurants - offering a range of continental and typical, south Indian cuisine.

Modern shopping centres in Chennai offer traditional handicrafts, textiles and much more peculiar to this part of India. Bounded by the majestic Himalayan ranges in the north and edged by a spectacular coastline surrounded by three seas, India is a vivid kaleidoscope of landscapes, magnificent historical sites and royal cities, golden beaches, misty mountain retreats, colorful people, rich cultures and festivities.

Note the dates and plan your trip. Do not miss this great opportunity to attend the lobster meet and to visit India. January is the best month to visit India. Formal announcement of the conference will follow. For details, please contact Dr. R. Kirubagaran, Group Head, Ocean Science and technology for Islands (OSTI), NIOT, Pallikaranai, Chennai – 600100, INDIA, E-mail: ralbam@niot.res.in

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

From: Gro I. van der Meeren

In the interests of keeping you all posted about progress in organizing the 9th Lobster Conference, I can now tell you that the venue will be in the very centre of Bergen, Norway from 19-24 June 2011 at the Raddisson SAS Hotel (see http://www.radissonsas.com/servlet/ContentServer?pagename=RadissonSAS/integration/hotelInfo&hotelCode=bgoza for information on the hotel). We plan for this to be a great conference, so start saving now.

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RESEARCH NEWS

Life Under a Lobster Carapace – A Newly Discovered Organism?

From: Samuel Tarsitano, Kari Lavalli and Ehud Spanier

While dissecting the gill chambers of the Mediterranean slipper lobster, *Scyllarides latus*, living off the coast of Israel, we discovered tubular structures adhering to the ventral surface of the carapace (Figure 1). The tubes have a bifurcating pattern and are composed of calcium carbonate. There are no indications of pockets for zooids of bryozoans, corals, or graptolites. A few small openings were found on the tubular walls, but it is unknown if these represent any openings for zooids, hydranths, or tube worms. In addition, there is no regular patterning for these openings and they appear to be too small to house any creature that could have made the tubes.

The internal view of these tubes could be seen due to breaks in the walls. The internal structure of these tubes is complex, having a honeycomb pattern of partitions (Figure 2) unlike that seen in other tubular structures secreted by marine worms. The partitioning appears to run the length of the tubes.

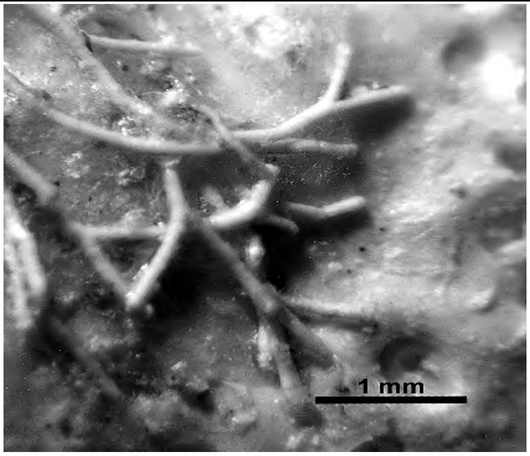

Figure 1. External view of the mysterious organism.

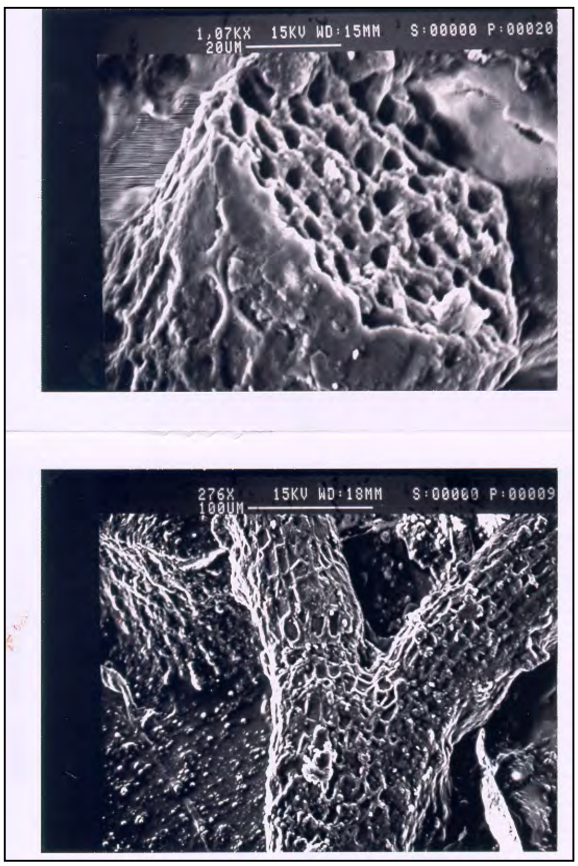

Figure 2. The internal structure of the tubes.

At intervals along the tubes there are circumferential indentations (Figure 3) that might represent either joints or segments of the creature making these tubes. When viewed with transmitted light, the external tube surface has an architecture of minute ridges. Thus far the tubes were found in three specimens of the Mediterranean slipper lobster from Israel and measure about 1 mm wide and vary in length between 1-2 cm. Although scientists at various institutions have examined these specimens, they remain unidentified. The morphology resembles, to a certain extent, that of some coralline algae, specifically Amphiroa rigida, but the structures on the gill chamber carapace are an order of magnitude smaller. One also wonders how would photosynthetic algae survive in the gill chambers of lobsters where light does not penetrate. Until living forms can be collected, this organism is represented only by its apparent skeletal tubular structures. Any suggestion regarding the nature of this structure/organism will be welcome.

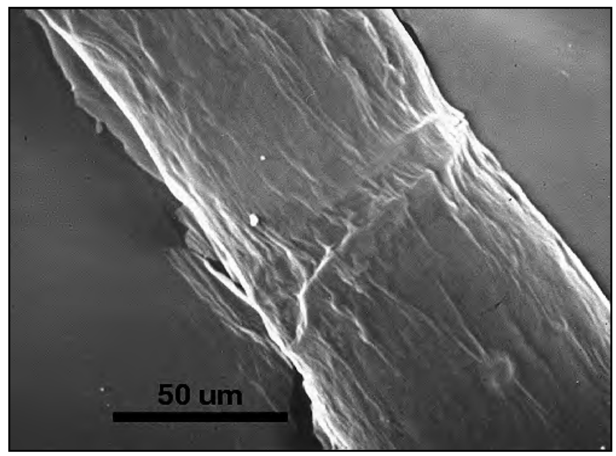

Figure 3. A circumferential indentation seen along the tubes.

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Carbon Management in Lobster Fisheries

From: Gary Morgan

Lobster has long been known as a luxury food, although prior to the late nineteenth century it was often so plentiful and cheap that, in North America and Europe, it was used to feed prisoners and indentured servants in place of valuable cod and mackerel. One group of servants in Massachusetts became so fed up with their diet of lobster that they took their owners to court and won a judgment that it not be served to them more than three times a week[1].

Times, of course, have changed. Nowadays lobster is viewed as an expensive, high-status delicacy with producers targeting the very top end of consumers and markets. Lobster has, generally, moved beyond the status of a mere food commodity and now has more of the characteristics of a luxury good[2].

This position of lobster in the global marketplace has its advantages and disadvantages, particularly at a time of concern about climate change and high oil prices.

On the positive side, while the United States economy, overall, approaches a recession, the demand for luxury goods generally has been remarkably resilient as the wealthier sectors of the economy continue to prosper. These luxury goods include expensive, high status food items such as lobster.

Secondly, the rising wealth of China, already a major market for lobster, means that the demand for lobster and other luxury goods will continue to grow strongly. In 2005, China was the third-biggest consumer of luxury goods, accounting for 12 percent of sales worldwide, up from 1 percent in 2000 (Goldman Sachs, 2005). It is expected that China will surpass Japan to become the world's second-largest purchaser of luxury goods by 2015, when it could account for 29 percent of the world's luxury sales.

However, there are emerging disadvantages for global lobster fisheries that are positioned in this segment of the market. Among these are the combined pressures of increasing production costs as a result of high oil prices and the weakness of the American dollar, which make the price of imported lobsters into the United States, and other markets, high in comparison with the local product.

However, perhaps the greatest emerging issue is that of climate change and consumers response to it.

While climate change is an issue that needs, and is slowly getting, a global response in reducing greenhouse gases, the consumer response to issues surrounding climate change has tended to be more rapid, particularly in the luxury segment of the market where expenditure on luxury food items is discretionary and demand is generally inelastic to price. This response has been reflected in initiatives such as the development of the (now generally discredited) concept of 'food miles' and the increasing importance of

[1] Reported in *The Economist*, July 1, 2004
[2] Some industries, such as the Southern Rock Lobster industry in Australia have developed marketing strategies that explicitly promote their product as a luxury item and consciously work to maintain a 'point of difference' between their product and other seafood commodities.

environmental issues such as sustainability and carbon footprint issues in purchasing decisions. The growth of 'eco-friendly' retail food outlets in the United States (such as Whole Foods) and Europe (such as UK supermarkets) cater to the consumers for whom these issues are important in their purchasing and consumption decisions.

Luxury food consumers, at least in western countries, are therefore increasingly basing their decisions whether to purchase or not on moral and environmental factors as well as status, rarity and price (Business Trends, 2008)[3].

This is quite different to the mainstream of seafood consumers who are purchasing 'staple' items where a number of studies have shown that the purchasing decision is most influenced by price and quality, rather than environmental or moral issues (e.g. Ruello & Associates, 2005).

Within this environment, many global lobster fisheries may not be well placed to defend their market position in the face of the 'moral consumer'.

Carbon Management, Greenhouse Gases, Climate Change and Marketing of Lobsters

A greenhouse gas is any gas with an infrared (IR) absorbance, which surprisingly means, that almost every gas known is a greenhouse gas (with the exception of a few including some diatomics and the noble gases). "Carbon emissions" are in fact scientific shorthand for a whole aggregate of greenhouse gases. As carbon dioxide is by far the most common greenhouse gas, all greenhouse gases are multiplied (or divided) by their relative effect compared carbon dioxide, in order to create a standard measure.

For example, methane, which is a farming by-product and is produced by rotting organic material, is 25 times more powerful than carbon dioxide as a greenhouse gas. So 40kg of methane is counted at "one tonne of carbon emissions". Another example is nitrous oxide, which is 296 times more powerful than carbon dioxide, which means 3.4kg of nitrous oxide is "one tonne of carbon emissions". This essentially means that one tonne of "carbon emissions" could be as little as 3.4kg of gas. The burning of coal is particularly problematic because such burning produces numerous highly active greenhouse gases such as oxides of nitrogen and sulphur (which, in themselves, can also produce environmental impacts such as acid rain) in addition to carbon dioxide.

Carbon emissions in production of lobster arise principally from the diesel that is used in the catching vessels although energy inputs in bait, electricity etc also contribute. Typically, direct fuel inputs typically account for between 75 and 90 per cent of the total industrial energy inputs to fishing (European Parliament *et al*, 2004).

In the catching sector, most lobster fisheries rely on small catch rates and high prices to achieve economic returns. In lobster trap fisheries, average catch rates are often around 1kg/trap pull. Although few studies have been undertaken on the carbon emissions emanating from catching lobsters, recent studies in South Australia (Econsearch, 2008)[4] have shown that, in 2006/07, the fishers there used 7.098 million litres of fuel to take 2,386t of lobsters. Using a conversion of 2.7kg of greenhouse gas emissions per litre of diesel fuel used (Australian Greenhouse Office, 2008), this results in 19.16 million kg of carbon emissions being produced at an average of 8.03kg of carbon emissions for each kg of lobster caught.

[3] Business Trends, 2008. Their research indicates that consumer spending on luxury environmentally friendly products will rise to half a trillion dollars in 2008. They attribute this rise to luxury consumers being eager to be part of the movement to 'save the planet', and want to express their loyalty to those ideals through their brands of choice.

[4] Based on financial information for the 2006/07 season, Econsearch, 2008.

Although this only reflects one, albeit large, aspect of carbon emissions (and does not include emissions from other production activities such as electricity generation, trap manufacture, bait supply etc or, importantly, from distribution and marketing of the product), it is extremely high and is a reflection of (a) the energy-intense nature of lobster fishing and (b) high prices that makes fishing viable at low catch rates.

In comparison with other primary production, these carbon emissions from lobster fishing are also extremely high. For example, emissions from dairy production in New Zealand are 1.4kg of carbon emissions/kg of product (taking into account all emissions, not only fuel use which accounted for just 0.38kg/kg product) and for apple production 0.19kg/kg production (Sanders *et al*, 2006).

Table 1 provides some estimates of carbon emissions from select lobster fisheries, as well as other fisheries and other industries as a comparison.

The generally high carbon emissions per kg of product produced for lobster fisheries will almost certainly become an issue of examination in many countries as consumers increasingly demand more information on the carbon footprint of the luxury goods they are buying and consuming.

Table 1. Estimated Carbon emissions (kg) per kg of product produced for a range of primary products. Note the high estimated emissions from lobster fishing.

Industry	**Carbon Emissions (kg) from fuel use per kg of product produced[5]**	**Total Carbon Emissions (kg) per kg of product produced**
European lobster		20.20[6]
South Australian rock lobster (northern zone – input managed)[7]	16.10	20.11[8]
South Australian rock lobster (southern zone – quota managed)[9]	5.94	7.43[10]
South Australian Spencer Gulf shrimp fishery[11]	3.75	4.69[12]
Scottish demersal trawl		4.14[13]
European cod fishery		1.20[14]
British Columbia salmon, gillnet fishery		3.14[15]
NZ dairy industry	0.38	1.44
NZ apple industry	0.03	0.19
NZ lamb industry	0.26	0.69

[5] Direct fuel inputs typically account for between 75 and 90 per cent of the total industrial energy inputs to fishing, See European Parliament *et al* (2004).
[6] This includes carbon emissions ex-harbour. From LCA Food Database. Available at www.lcafood.dk
[7] Based on financial information for the 2006/07 season, Econsearch, 2008.
[8] Estimate based on fuel accounting for 80% of total energy inputs
[9] Based on financial information for the 2006/07 season, Econsearch, 2008.
[10] Estimate based on fuel accounting for 80% of total energy inputs
[11] Data from Econsearch (2007)
[12] Estimate based on fuel accounting for 80% of total energy inputs, 2005/06 season
[13] European Parliament *et al* (2004). Figures given in Gj/ton, converted at 0.0364GJ/litre for diesel and 2.7kg of carbon emissions/litre
[14] This includes carbon emissions ex harbour. From LCA Food Database. Available at www.lcafood.dk

As a result, it is highly likely that, in lobster fisheries, it will be the consumer that drives initiatives to measure and subsequently reduce the carbon footprint from lobster fisheries, rather than regulatory bodies and Governments that are acting on environmental grounds.

Carbon Management and Sustainability Management

Many, if not most, of the major lobster fisheries worldwide are now under some sort of management arrangements, with that management usually being based on the concept of resource sustainability. However, the issue of carbon management throws a new and interesting twist into the management mix, particularly in relation to the interaction of carbon management objectives and sustainability management objectives. Carbon management, at its most basic level, will involve addressing the issue of economic efficiency and particularly that of fuel use in capturing lobsters because fuel probably constitutes the major energy use in most lobster fisheries.

In almost all adjustments to fuel use that might be contemplated, there will however be impacts on stocks since there are many potential ways of reducing fuel use in lobster fisheries. These range from structural adjustments (such as smaller vessels, smaller and/or more fuel efficient engines) to operational adjustments such as shorter fishing trips, longer soak times for traps, fishing more traps per vessel etc. Operational adjustments are usually more easily and quickly made than structural adjustments but all will involve a trade-off between reduced fuel use and catches.

Some of the possible impacts on stocks and fisheries might be:

- A concentration of fishing effort on inshore lobster stocks leading to local depletion of stocks
- As a result of this concentration on inshore stocks, possible greater potential conflict with recreational lobster fishers where they exist
- Greater catch of smaller lobsters since, in most lobster fisheries, smaller lobsters tend to be concentrated in inshore areas
- A possible seasonal concentration of fishing at times when weather is good
- Increased labour costs if more traps are fished per vessel
- Increased deaths of both lobster and fish in traps as a result of possible longer soak times

However, from a management point of view, it will be the type of management arrangements that are put in place to achieve defined management objectives (including those related to carbon emissions) that will be crucial.

In particular, the issue of whether input or output management techniques are adopted has the potential to be vitally important since output management tends to lead to greater economic efficiency in taking the catch, including efficiency in energy use.

For example, Table 1 reports data from a unique situation in South Australia where two zones of an otherwise similar rock lobster fishery are managed in different ways – the 'northern zone' by input controls and the 'southern zone' by Individual Transferable Quota (ITQ) management. A comparison of the carbon emissions from these zones is instructive in that the quota-managed fishery uses about half the fuel to take their catch than the input-managed fishery.

This is generally consistent with the theoretical basis of ITQ management where economic efficiencies can be pursued in taking the quota but, in this case, by providing the management environment where increased economic

[15] European Parliament *et al* (2004). Figures given in Gj/ton, converted at 0.0364GJ/litre for diesel and 2.7kg of carbon emissions/litre

efficiency can be pursued, the management arrangements have also resulted in reduced carbon emissions per kg of product taken[16]. The method of management used to achieve sustainable fisheries therefore, in this case, seems to have had a profound impact on carbon emissions.

Whatever form it takes, most lobster fisheries will need to address the issue of carbon management in coming years. In addressing this issue, lobster fisheries do not generally seem to be well placed currently and reducing carbon emissions from lobster fisheries may require a combination of structural and operational changes as well as changes to the way in which fisheries are managed.

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[16] There are some differences in stock density between the zones but these are not significant

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There's no place like home

From: Shane Kelly

Adult *Jasus edwardsii*, like a number of other spiny lobsters, maintain a strong association with relatively small areas of reef for long periods of time. For instance, individual *J. edwardsii* in the Leigh Marine Reserve, in north-east New Zealand, have been resighted in the same area eight years after being tagged (Kelly and MacDiarmid 2003). This does not mean that adult *J. edwardsii* limit their movements to these small areas of reef. On the contrary, acoustic tracking of lobsters in the marine reserve and in Tawharanui Marine Park has shown that they undertake seasonal, predominantly offshore, migrations to feed on the surrounding sand-flats, and to release their larvae (Kelly *et al*. 1999; Kelly 2001).

Figure 1. Rock lobsters gathered at their primary "home" site

Acoustically-tagged lobsters moved up to 3 km away from their primary "home" site and remained away for up to 3 ½ months (Kelly and MacDiarmid submitted). The relatively long period that lobsters spent away from their primary home sites demonstrated that they possess impressive long-term, spatial memory. In fact, a quick literature search suggests that lobsters may have the longest memory retention reported for any invertebrate. Interestingly, some *J. edwardsii* had two home sites and made repeated, rapid movements between these two areas, which were 250 m to 1.3 km apart.

Particular areas of reef seemed to be important staging posts during "large-scale" movements, where lobsters from distant sites gathered prior to offshore movement (Figure 1). Multiple aggregations of 2 to ca. 200 lobsters gathered at a number of locations in the Leigh Marine Reserve and Tawharanui Marine Park. These areas typically consisted of patch reefs on the deep, seaward margin of the reef proper.

Over longer distances, return movements typically involved route reversal, which suggested that *J. edwardsii* may use dead reckoning to navigate between remote areas. However, other methods of orientation may be also used at different scales and within familiar reef areas. The relatively long life span and high site fidelity of *J. edwardsii* increases their potential to build up a detailed spatial memory of their home site. This could permit more complex methods of orientation in familiar territory. This hypothesis was supported by the results of a displacement experiment, where six lobsters were indirectly moved several hundred meters from their original den. Three lobsters found their way back to their initial sites within two days, even though they were prevented from accumulating spatial information on the outward journey.

During longer offshore movements lobsters had to travel through extensive areas of reef that were obviously suitable lobster habitat, because other lobsters were abundant in these areas and some acoustically-tagged lobsters were resident there. The question therefore arises: why do lobsters home to particular sites when they have to pass similar areas to do so, and what ecological advantage does homing provide?

In some crustaceans an energetic investment in the construction or maintenance of nests or burrows may motivate individuals to remain close to and defend their homes. However, this is not the case with *J. edwardsii*, as they are gregarious, and utilise a number of naturally occurring shelters within their home site. While males defend shelters during the 2-3 month mating season, individuals appear to co-habitat harmoniously with conspecifics at other times of the year. Furthermore, some lobsters left their home sites for up to 103 days, leaving ample time for others to move in and take over the occupancy of dens. The only other arthropod group known to home over relatively large distances are social insects such as bees and ants, in which homing has evolved as a means of supplying the resources needed by the nest or hive. This behaviour differs from that of lobsters, which do not co-operate in the maintenance of "superorganisms". Nonetheless, returning to a familiar area may enhance the fitness of individual lobsters if they can remember the spatial distribution of essential resources, such as food and shelter. Homing may also reduce intraspecific competition by maintaining a more dispersed lobster population on inshore reefs.

The tracking of *J. edwardsii* movements has demonstrated that this species displays complex patterns of homing behavior, but the mechanisms used for spatial orientation and the functional role of homing are yet to be determined. These aspects of *J. edwardsii* ecology should provide some exciting opportunities for future research.

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Control of shell colour changes during the White phase of the western rock lobster, *Panulirus cygnus.*

From: Nicholas M. Wade, Roy Melville-Smith, Bernard M. Degnan and Mike R. Hall.

The transition from juvenile to adult in the Australian western rock lobster, *Panulirus cygnus* (George), is preceded by a mass migration from inshore nursery reefs to offshore breeding grounds (George, 1958). Unlike any other lobster species, this migration coincides with a characteristic colour change from deep red to pale pink, known in the industry as the White phase (Figure 1). Comprising up to approximately 25% of the annual catch, the marketing of White lobsters results in a significant annual loss of revenue to the fishery due to the lower price paid by buyers for white compared to red lobsters. In this project we wanted to specifically investigate the primary triggers for this White phase colour transition and, by understanding this, the possibility of rapidly returning Whites to their natural colouration once captured by the fishery.

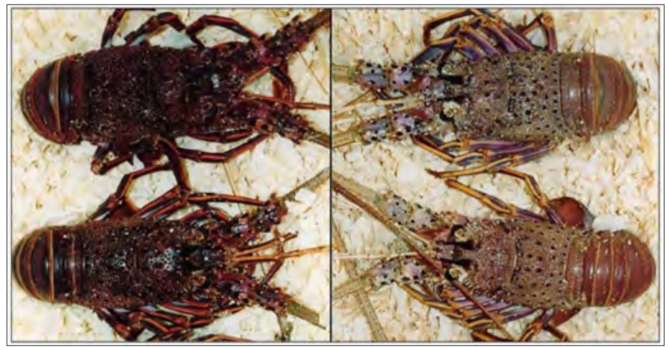

Figure 1. Colour differences observed in wild caught *Panulirus cygnus* Reds and Whites

Animals were kept under various conditions over two successive years (Figure 2) and were fed approximately 30 g of an artificial diet per animal per day prepared either with or without an astaxanthin and incorporating gelatine to maximise the carotenoid intake. Individuals were very successfully tracked across moults using Hallprint T-bar anchor tags inserted in the mid-ventral abdomen and a separate moult indicator was glued to the lateral carapace. The colour change of individual lobsters was tracked on the L*a*b* three dimensional colour scale by measurement with a MiniXE Colorimeter (HunterLab) standardised under illumination that most accurately replicates natural sunlight.

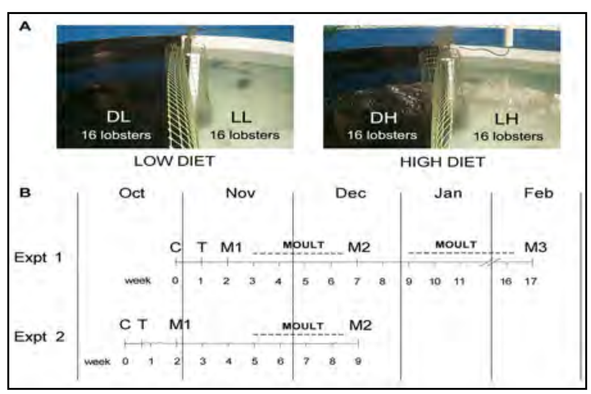

Figure 2: Two experiments were run over successive years, one encompassing the entire Prewhite - White - Red transition and the second acclimated Prewhite lobsters for a longer period of time before their Prewhite to White moult. Symbols: C - Capture date; T - Tagging date; M1 - Measurement 1; M2 - Measurement 2; M3 - Measurement 3.

Table 1. Multiple regression analysis of the change in lobster shell color

	M1 to M2		M2 to M3	
2002 Experiment	beta	P values	beta	P values
high diet	-2.00	0.28	-1.72	0.33
dark background	-0.89	0.63	-8.60	1.89×10^{-5}
interaction	-0.36	0.89	-0.80	0.73
intercept – "other factors"	+4.25	1.5×10^{-3}	+5.76	2.8×10^{-5}
2003 Experiment				
high diet	-2.03	0.14	-	-
dark background	-7.16	2.66×10^{-6}	-	-
interaction	+4.26	0.0295	-	-
intercept – "other factors"	+11.33	8.23×10^{-17}	-	-

Our primary focus was to investigate which factors drive the change in colour over time (not just colour itself), therefore we modelled the difference between individuals between M1 and M2 (and also M2 and M3 for the 2002 experiment). Without the desire to overwhelm the reader with statistical jargon, we used a simple linear regression model. Individual colour changes were set as dependent variables, while high diet, dark background colour and the interaction between diet and background were the explanatory variables. The regression coefficients beta (strength indicators) and p values (statistical significance) describing the association with the measured colour change are shown in Table 1. The intercept of the regression, we will now refer to as "other factors", can be interpreted as a combination of all other factors, unrelated to diet or background colour, that are assumed to affect every individual uniformly.

In both years we observed that the strongest and most significant effector of shell colour change of each individual across the White phase moult (from M1 to M2) was "other factors". This effect was positive thereby indicating that, on average for each individual, there was a significant lightening of shell colour across this moult and hence the animals appeared lighter in colour. In the 2003 experiment, background colour exerted a slightly stronger influence on shell colour change than in the previous year, something likely due to the extended period of acclimation (from 3 weeks in 2002 to 5 weeks in 2003). Exposure to a dark background alone or in conjunction with a high carotenoid diet was expected to promote a strong darkening of shell colour (Melville-Smith *et al*., 2003). However, in this experiment, some animals under this treatment became markedly lighter in colour (DH-W), replicating the natural Prewhite to White transition. As could be expected, a significant relationship developed with background colour after a further 4 months of treatment conditions (M2 to M3), one that during this time rivalled that of "other factors", although these two effects could be distinguished in our analysis.

Overall, there was no mass colour change induced between M1 and M2 in response to dietary carotenoid intake or background colour, making it unlikely these environmental factors are solely responsible for the onset of the White phase. Yet within each treatment, we observed individuals whose shell colour showed a striking similarity to wild caught Whites (Figure 3), regardless of the treatment and over successive years. Although not every individual underwent this colour change, it could not be determined how many animals would enter their White phase during this experiment. This colour change may well be an effective protective mechanism during the migration across open stretches of sand, however, our data suggest that Prewhite individuals would need to aggregate on pale coloured sandy substrates for at least one to two months prior to moulting, something that is not observed in the wild.

Given that another mechanism is likely to be responsible for this rapid shell colour transition, we propose that this sharp individual colour change is induced by a presently unidentified molecular change rather than as a direct physiological response to environmental change, possibly requiring the down-regulation of genes involved in shell colouration before the moult from Prewhite to White. The "other factors" identified here may be a combination of genetics and other unknown environmental factors. Whether the primary trigger for this colour change is internally linked to the onset of sexual maturity, or is initially triggered by other unknown environmental cues, requires further study.

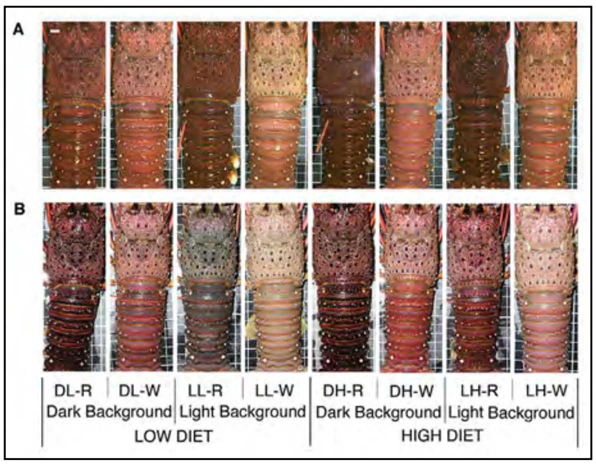

Figure 3. Shell colour changes at M2. Lobsters selected from each treatment tank demonstrated that some animals underwent a colour change that rivalled the Red to White transition, both visually and using colorimeter measurements, regardless of the treatment. A 1cm scale bar is shown at the top left of the figure and is applicable to all images.

Other mechanisms clearly exist that are able to cause large changes in crustacean shell colour, and these are likely to be the key to the White phase colour change and the ability to reverse it. It could also be unexpected that this mechanism is shared among all crustaceans and hence effective for rapidly darkening the shell colour of any commercially relevant species, especially within an aquaculture framework.

This article has been modified from the original publication (Wade *et al*., 2008) with permission of the Company of Biologists. Nick Wade received his PhD from the University of Queensland in August of 2006. He is currently working in medical research in Switzerland, however, he is continuing to write articles from his thesis work and hopes to return to lobster research in the future.

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Morphological Features of Slipper Lobsters: A Clue to their Habits and Swimming Abilities?

From: Ehud Spanier, Kari Lavalli, Dani Weihs

Slipper lobsters, family Scyllaridae, belong to a highly diverse family of lobsters distributed in a variety of geographical regions and oceanic basins, habitats, and depth ranges. The family includes four subfamilies, 20 genera, and at least 88 living species recognized to date compared to about 48 species of clawed lobsters, and 45 species of spiny lobsters. Slipper lobsters live in sand, mud, coral reefs, and rocky or complex structure benthic environments; some species appear to engage in offshore-inshore migrations, while others remain in a localized habitat for life. They are found in temperate, subtropical, and tropical seas, from lagoons to deep-sea ridges and seamounts (Sekiguchi *et al*. 2007). As diverse as their adult habitats may be, their larval life history are also diverse. Some species have long larval durations, and others have shorter larval durations; as a result, some species have larvae that settle close to adult habitats, while others have larvae that disperse further from adult grounds (Sekiguchi *et al*. 2007).

Adults are also diverse in morphological features, size ranges, and locomotory behaviors. They range in size from 50 mm total length (TL) to ~0.5 m TL. They can be vaulted with a cylindrical shape, similar to that of clawed and spiny lobsters, or be dorsoventrally flattened to a slight or extreme degree. The few studies done on the locomotory behavior of these lobsters indicate that some species within the genus have strong tail-flip swimming abilities (Jacklyn & Ritz 1986; Jones 1988; Spanier *et al*. 1991; Spanier & Weihs 1992, 2004; Faulkes 2004). Since both vaulted, cylindrically shaped and flattened lobsters swim, we were interested in determining if body morphology may indicate which species are likely to have superiorly developed swimming abilities and whether such abilities might be correlated to the habitats in which these lobsters live.

Morphological features of representative species of slipper lobsters were examined and these features were correlated to the different habitats in which they are found, as well as to their locomotory behavior and lifestyle. Preserved specimens representing all four subfamilies of slipper lobsters (26 species in 8 genera) were examined at Leiden's National Museum of Natural History-Naturalis,the Netherlands, Harvard University's Museum of Comparative Zoology, USA and the Invertebrate Museum at Tel-Aviv University in Israel. Morphological features measured included the flattened second antennae (mistakenly called "shovels") that play an important hydrodynamic role in controlling swimming movement by serving as stabilizers and rudders and the tail fan that acts as a propulsor, but also may serve as a control surface. The circumferences of each of these structures were drawn and their areas were calculated using ImageJ. Other features noted include the center of gravity, shape of the carapace (rectangle, triangle), thickness of the carapace, carapace length (CL), carapace width (CW in anterior and posterior positions), cross-section of the carapace (flat or thick), CW/thickness, abdominal length, and maximum (stretched) and minimum (folded) size of the tail fan and the flattened antennae surfaces (Figure 1). Since there are great differences in sizes between species, these features were normalized, for the purpose of comparison, by dividing the areas or measurements with the square of the Total Length (TL). The size, position of, and distance between the eyes were also compared. Additional measurements were taken on a few species of clawed and spiny lobsters.

Figure 1. Measuring CW and determining the center of mass of a museum specimen.

The current analysis refers only to genera to obtain a broader view of the morphological features because some of the older preserved specimens (collected some 150 years ago!) have had their genus revised. In all genera thus far examined, linear relationships were found between the anterior, as well as posterior, and TL and also between of the area of the flattened antennae and the tail with TL (Figures 2 & 3), indicative of isometric growth. However species of the genera Scyllarides and Evibacus have relatively larger flattened antennae that provide better maneuvering ability during swimming (Figure 3). Members of the former genera have also relatively larger tail, which provides better propulsion for swimming.

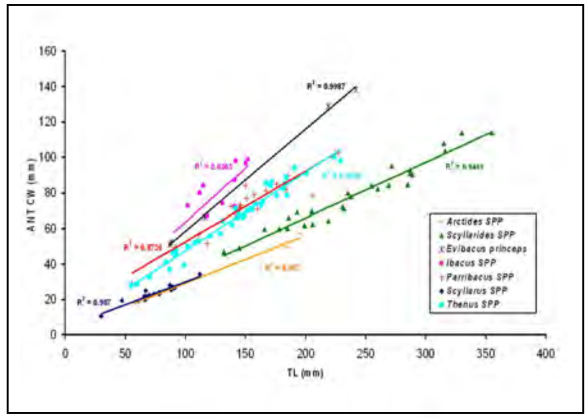

Figure 2. Linear relationship between anterior CW (ANT CW) and TL; only in Ibacus is the R^2 value for the relationship less than 0.8, suggesting more allometric growth in width for species in this genera.

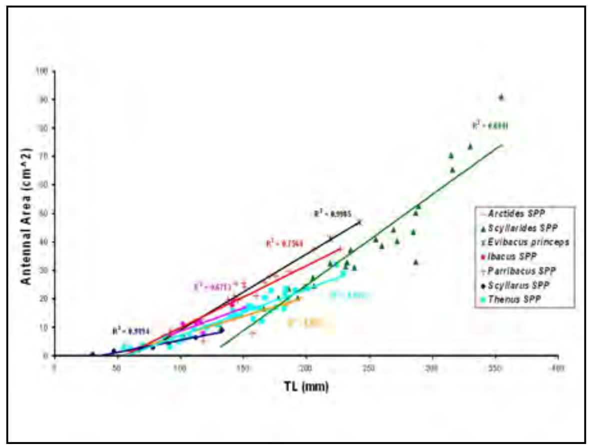

Figure 3. Linear relationship between antennal area and total length. Certain genera have a steeper slope, suggesting a larger antennal area and, thus, a better ability to use the antennae as rudders during swimming.

When comparing width (CW Anterior) and thickness (T), slipper lobsters are broader and more dorsoventrally flattened (CW / T: >1.3) than either spiny (CW / T: <1.0) or clawed lobsters (CW / T: <0.85). This flattened morphology of slipper lobsters adds to lift and makes them better swimmers as they can invest less energy in getting up in the water, and more into a faster and longer swim.

Comparison of Width /Thickness (CW/T) among slipper lobster genera (Figure 4) pointed to two groups: a) those with narrower and thicker bodies – inhabiting mainly complex substrates such as rocky coral reefs, rubble, seaweeds and b) those that are flatter and thinner inhabiting mainly plain substrates such as sand and mud. Body shapes also split into 2 groups: a) those with triangular shape (CW Anterior / CW Posterior >1.2) representing species in the genera Thenus, Ibacus, and Evibacus and b) those with rectangular shape (CW Anterior / CW Posterior <1.2) such as in the genera Arctides, Scyllarides, Scyllarus. We assume that the more triangular shape is an adaptation for non-complex habitats (soft bottoms) and for maximal lift and better swimming speed when exposed. The cylindrical shape is probably adaptive for living in complex hard substrates (e.g., rocks, coral reefs) and sheltering in crevices during the day (that have back doors for escape from an intruding predator).

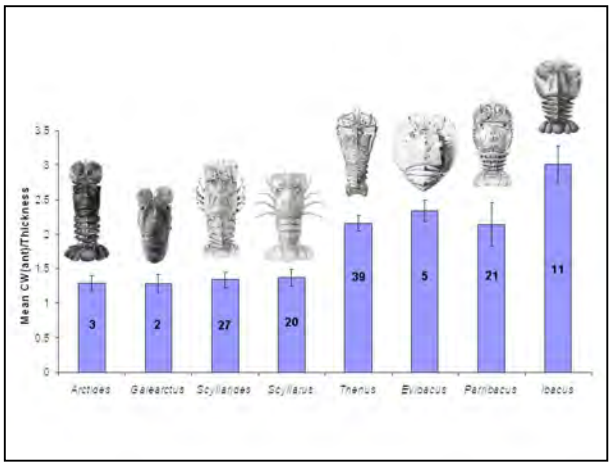

Figure 4. Relationship between mean CW (anterior) and thickness of the lobster, showing two basic body shapes: (left four) more tubular or cylindrically shaped genera and (right four) more flattened.

The relationship of the distance between the eyes and the anterior CW was linear except in *Ibacus*, where an increase in width did not cause an increase in distance between the eyes—in other words, their eyes became more closely spaced as the lobster grew in size (Figure 5). Widely spaced eyes (near the edges of carapace), as in the genus *Thenus*, are assumed to enable better binocular distance estimation (to detect prey/predators) and a larger visual field around the animal (lessened if eyes are small). Closely-spaced eyes (medially located), such as those found in the genera *Ibacus* and *Parribacus*, are assumed to be an anti-predator adaptation since they are harder to attack than those located on the peripheral edges. Also the size of the eyes varies among taxa: they are large in *Parribacus* species, intermediate in *Scyllarides* species, and very small in *Thenus* species. Smaller eyes may represent shallow water species or those that are less nocturnal (more exposure to light) and may also represent animals that burrow. Such small eyes would then be an adaptation to minimize damage to a photoreceptor (the function of which would be limited to detect changes in brightness/day and night).

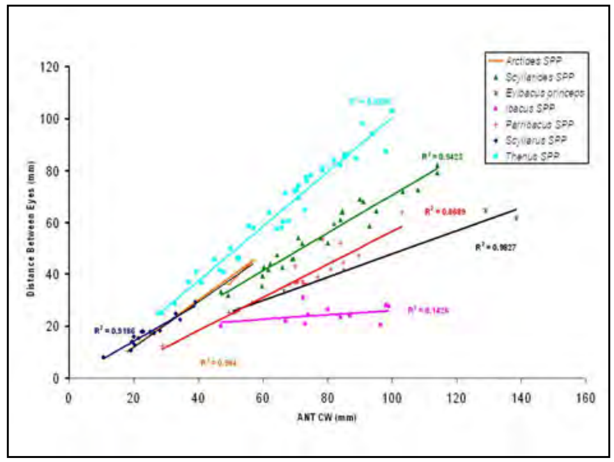

Figure 5. Relationship between eye distance and anterior carapace width of slipper lobsters. All have a linear relationship, except Ibacus that shows a constant distance between the eyes irrespective of increasing size.

We continue to measure specimens in various museums and have plans to visit the Smithsonian Institution for their large collection of scyllarids. We thank the curators of the museums we have already visited (Professor Goren, Dr. Fransen, Ardis Johnston, Van Wallach, and Adam Baldinger). We also are in the process of building models based on our morphological measurements. If anyone has access to live specimens of *Evibacus*, *Ibacus*, and *Thenus*, we would appreciate receiving an email from you.

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FISHERIES & AQUACULTURE UPDATE

Growout of tropical rock lobster in shrimp pond conditions in Australia

From: Clive Jones and Scott Shanks

Although the growout of marine spiny lobsters (*Panulirus ornatus*) in Vietnam has been successfully developed using sea-cages exclusively (Williams, 2004; Jones and Williams, 2007), the development of a lobster growout industry in Australia will necessitate that other growout systems are assessed. Preliminary economic analysis has suggested that in Australia use of sea-cages may be significantly more expensive than land-based systems such as ponds, raceways or tanks. Furthermore, the establishment of sea-cages along the Queensland east coast may be more problematic than land-based systems because of restrictions within the Great Barrier Reef Marine Park.

Although neither a hatchery produced nor wild caught supply of juveniles is currently available, preliminary assessment of growout systems is prudent in advance of confirmation of that supply, to expedite industry development. The Australian *P. ornatus* fishery catches lobsters from 600g upwards, although maximum value (>$A60 kg^{-1}) is reached for lobsters over 1kg. Growout trials of lobsters in the 600g to 1000g range provides an opportunity to determine the suitability of shrimp pond water for growout.

A commercial shrimp farm north of Cairns in northern Queensland Australia provided access to their seawater intake channels. Although separated from the shrimp populations in the ponds, the seawater was of equivalent quality.

The trial did not involve experimental treatments, but applied best management practice to a number of replicated groups. The objective was to establish baseline growth and survival data for *P. ornatus* under shrimp pond conditions.

The trial system consisted of four rectangular cages, 1.8m x 1.8m x 0.9m deep, suspended from the surface using a floating frame. The cage mesh was made from knotless netting of 15mm mesh size. Each cage was covered with a lid made from 90% shadecloth.

Cages were each stocked with 20 lobsters (6.17 m^{-2}) of mean size 750.2 ±6.0g. A control group of 13 lobsters (mean size 717.8 ±9.4g) was stocked to a fibreglass tank at NFC and managed equivalently.

A manufactured, 7mm pellet food was provided twice daily. It was made locally at the Northern Fisheries Centre in Cairns to a specification developed by CSIRO, and consisted primarily of a commercial shrimp diet (50%), fresh fish flesh, mussel flesh, binder and pigment. Initially the ration was 3% of biomass per day (dry weight equivalent), and this was adjusted on the basis of visual observation. A feeding tray was positioned on the cage floor for the placement of the feed.

Aeration was provided by a paddlewheel aerator located within the channel 10m upstream from the cages.

Cages were removed from the water at monthly intervals for cleaning. Lobsters were removed from each cage, counted and weighed, and then returned to the same cage once cleaning was completed.

Growth data were calculated as daily growth coefficient (DGC) ($100 \times (Wt_t^{1/3} - Wt_0^{1/3})/t$), specific growth rate (SGR) ($100 \times (\mathrm{Ln}\ Wt_t - \mathrm{Ln}\ Wt_0)/t$) and grams per day.

Weight and growth data are presented in Table 1. Mean survival in the cages was 77.5% and 100% in the tank.

The condition of the lobsters at the time of stocking was relatively poor, due to prior protracted holding at low temperature (<20°C) in a live holding facility in Cairns. The poor condition at stocking was worsened by the cages being too deep, such that the cage bases and therefore the lobsters, were positioned on the sediment of the channel for extended periods at low water. Consequently, at the first cage cleaning lobsters appeared lethargic and in poor condition, and tail fan necrosis was evident. Lobsters were not weighed at this time.

Subsequently, the depth of cages was reduced to lift them from the sediment and condition and growth of the lobsters improved significantly. Growth over the entire trial period was good (Figure 1) and comparable with the best previously achieved in tanks (Jones *et al.*, 2001) in Australia and with that in sea-cages in Vietnam (Williams, 2004).

Due to the loss of some pellet food through the cage floor, the use of a standard FCR statistic does not accurately reflect the consumption nor efficiency of the diet. Nevertheless, as a guide to the relative effectiveness of the diet, FCR's were calculated and compared between the cages and the control tank. FCR across all cages averaged 15.4:1, while that of the tank population was 9.5:1. Although the diet appeared attractive, well bound and was actively sought by the lobsters, these FCR's would need to be significantly reduced for commercial acceptance. A smaller mesh size on the floor of the cage is an obvious first step to minimise losses.

There appeared to be no moulting and no individual growth during the first month. Subsequently, moulting appeared to be synchronised to the extent that distinct peaks in moulting occurred across all cages, with intervening periods of little or no moulting.

Table 1. Mean weight of lobsters at stocking and harvest, and growth during the trial period.

Cage	Starting Weight g	Final Weight g	DGC % day^{-1}	SGR % day^{-1}	Growth g day^{-1}
1	762.5	858.5	0.29	0.09	0.76
2	743.5	878.3	0.41	0.13	1.07
3	773.3	969.3	0.57	0.18	1.55
4	721.5	865.2	0.44	0.14	1.13
NFC tank	717.7	884.0	0.50	0.16	1.32

The cage moult frequency was also synchronised to the tank population. Subsequent to periods of increased moulting, food consumption increased significantly, dropping shortly before the next moulting event. Tail fan necrosis disappeared entirely by the end of the trial.

Water quality remained acceptable throughout the trial, although dissolved oxygen levels were variable and ranged from 4.2 to 7.5 ppm. Salinity ranged from 28 to 35 ppt.

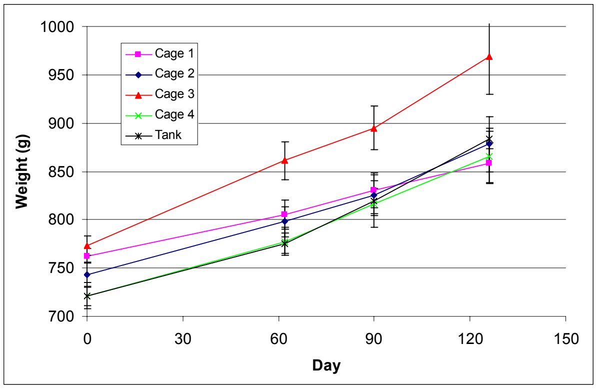

Figure 1. Mean weight (±SE) of lobsters grown in cages within a shrimp pond intake channel over 126 days.

Sub-adult tropical rock lobster (*P. ornatus*) were successfully cultured under estuarine shrimp farm conditions. Although salinity remained relatively close to normal marine levels due to the absence of significant rainfall during the trial period, previous research suggests that significantly lower salinities will be tolerated by this species (Jones, 2008). Water quality conditions were otherwise typical of a shrimp farm environment in northern Australia, with fluctuating dissolved oxygen, high turbidity and slightly alkaline water. Although this differs substantially from typical *P. ornatus* preferred reefal habitat, growth and survival were good, and lobsters harvested after 126 days of culture were vibrant in colour, vigorous and very clean. Subsequent marketing indicated they attracted the equivalent price of wild caught lobsters in the local market place.

Figure 2. Lobster cages in the intake channel adjacent to shrimp pond.

Personal observation of farmed lobsters (*P. ornatus*) from Vietnam in the wholesale fish markets of Hong Kong in 2008 indicated that the product is clearly distinguished from fishery product from Australia, Indonesia and Philippines, due to its dull coloration and poor vigor. If farming of tropical lobster in Australia is to be successful, economics will necessitate that the product is as good or better than the fishery product to ensure premium market price. The early indications from this trial are encouraging, that production of tropical lobsters on a formulated diet, in shrimp farm ponds may be possible.

Figure 3. Lobsters, *P. ornatus*, grown in cages in shrimp pond intake water at harvest.

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Looking forwards from 10 years of quota management in Tasmania

From: Caleb Gardner

The latest stock assessment for the Tasmanian lobster fishery included an interesting statistic – the estimate of legal-sized biomass for the State is now almost exactly double (199.9%) of that in 1994 when stocks were at their lowest. This article takes a look back at how we reached this significant milestone and at the other changes that have occurred over 10 years of quota. How do patterns of the last decade provide guidance for current management?

In the late 1980's and early 1990's catch rates were trending downwards year after year and change in management was clearly needed. A series of seasonal closures from 1995 to 1997 arrested the decline in stocks and led to the start of stock rebuilding which was strengthened in 1998 when quota was introduced.

Here's a summary of some of the main indicators of the fishery over the last decade as reported in the latest fishery assessment by TAFI (2007):

- total allowable commercial catch (TACC) has been held effectively constant
- egg production has increased moderately, around 17% Statewide
- legal-sized biomass has grown each year on a Statewide basis
- in areas that had very depleted egg production (eg. the NW), recovery has been better on a percentage basis, but remains low
- commercial effort has shifted inshore and into winter
- recruitment has been low in the north since 2000/01 and commercial effort has shifted southwards

- commercial catch rates have grown on a statewide basis by around 40%
- recreational catch doubled in the first five years of quota management but has since stabilised. Recreational licenses have doubled.
- the commercial fleet has contracted by 32%
- commercial fishing days have dropped by 50%
- commercial potlifts have reduced by 32%
- commercial revenue or gross value of product (GVP) has grown from $45.6 million to $50.6 million. Corrected for inflation using CPI (Hobart) relative to 1998, the current GVP is $40.2 million, which represents a decline of 12% in adjusted revenue.
- Costs for monitoring and enforcement of quota management have been stable at around 1.3% of GVP per annum (~$270K monitoring; $390K for enforcement).
- the market capitalisation of quota units (total value of all units) has trebled to reach $440 million, an increase in wealth for quota owners of $300 million (based on transfer prices).
- total quota unit-holder return has averaged over 20% per annum for the decade (combining capital gain of quota units and income estimated by lease price).

An evaluation of the past 10 years under quota management provides several interesting considerations for the future of the fishery:

1. The increase in recreational catch following the introduction of a commercial quota shows that quota systems need to incorporate all sectors (commercial, recreational and non-extractive users) if benefits relating to property rights are to be most effective.

Quota units are quasi-property rights – they provide ownership of a share of the commercial harvest but not the stock. In 1998, the Tasmanian rock lobster quota only capped commercial harvest. As a result, stock rebuilding was partially eroded by an increase in recreational catch. My impression from port meetings is that this undermined support for a more conservative quota from the commercial sector. Effectively it raises their discount rate – they place less value on leaving lobsters in the water for next year if there is increased risk of the lobsters being taken by another sector.

The recreational catch has now been included within a combined TAC, but proposals to expand the number of MPAs around the State are now creating a similar problem, but with a different sector – the non-extractive users. Here the risk of loosing future catch again raises the discount rate of commercial fishers, which would be expected to translate into less support for stock rebuilding.

2. The historical decline in price seen over the last decade shows that improving price remains an unmet challenge for the industry.

In 1998 there was hope that several of the management strategies would deliver higher average price. These included the restricted supply under quota and also the expectation that fishers would change their operations to maximise the price of catch. For example, it was thought that average beach price would be raised by greater discarding (release) of lobsters missing limbs and through a shift of effort to winter when prices were higher. While there has been modest shift of effort into winter months to obtain higher prices, costs are also higher at that time, mainly because females are berried and can't be harvested. Overall, gains in revenue from increased winter fishing have been outstripped by inflation. Prices have also been eroded by a less favorable exchange rate and reduced seasonal price volatility.

3. Management that reduces costs can deliver larger than expected gains to industry

The most significant change in the fishery over the last decade has been the gain in capitalisation of the quota units, an estimated increase of $300 million in wealth across the fishery. This gain in value is a measure of the scarcity of the resource, which exists because the resource is finite and can't be eroded by competition. People often see the limits on production in the lobster fishery as a downside for business, but resource scarcity and limitation is something that delivers wealth and should be valued.

It's remarkable in this sense that fishing businesses have gained $300 million from not catching lobsters! The gain has occurred through three processes. The first is that by allowing lobsters to grow larger (especially in fast growth areas) biomass has increased, and fishing costs have been lowered (this is known as the "marginal stock effect" – by allowing small fish to grow a little larger before they're harvested, biomass and catch rates increase).

Secondly, and more importantly, the cap on harvests of all competing fishers has improved catch rates, which has allowed fishing effort to decline (this is known as the "stock externality" – the harvest of one fisher affects the catch rates of the rest of the fleet because all fishers access the same stock). The same catch is now taken with around 100 fewer boats than 10 years ago, which means the same stock of lobsters is now having to support much less maintenance and vessel depreciation. These savings feed into profits and thus quota prices through higher catch per unit effort. The final benefit from not catching lobsters has been reduced volatility in business earnings from year to year, which is more favourable for investment.

4. Investment in research pays dividends

The gain in value of quota units has resulted from the setting of appropriate TACCs over the period under quota. There is a clear difference in the history of the market capitalisation in the Tasmanian rock lobster fishery compared to quota fisheries where the TACC has had to change frequently. We've been able to have a stable TACC because we got it right early on, which is a function of good assessment information.

5. Good fisheries management means good environmental management

With more lobsters in the water the fishery and the ecosystem on which it depends is more "resilient". What I mean by this is that the fishery is less exposed to the ups and downs in juvenile recruitment that occur naturally. Rebuilding the stock also has major benefits for the ecosystem, which is better able deal with perturbations including impact of unwanted pests, such as the long spined sea urchin, and other effects of climate change. The history of increasing biomass in the Tasmanian lobster fishery is a real win-win for the fishery and the environment, but is not well understood or appreciated by those that think all fishing is unsustainable and more of our coast should be locked up in reserves. Good sustainable fisheries management, that has outcomes of high biomass and catch rates, holds a greater prospect for healthy marine ecosystems compared to a network of no take MPAs surrounded by areas that are overfished.

So the (multi) million-dollar question is: Can we keep growing?

Interestingly, growth in economic value was never a major objective of policy in 1998; the gains have been a byproduct of other objectives. Only one of the 28 strategies in the 1997 policy document related to economic benefits (Strategy 6.3). Fishery assessments have never provided direction on management to improve economic benefits. The lack of effort in this area suggests that there's almost certainly room for improvement even with the existing management tools.

There's also scope for greater gains with more novel management and I see three main opportunities to improve. The first is adjusting management to regional differences in the biology of lobsters (eg. translocation, regional size limits, deep water quota). The second is changing management to better meet market needs (eg. more harvest around Chinese festivals). Lastly, our management system retains a lot of input controls that make fishing inefficient; most of these could be better structured in the future to increase profitability.

Downside risk for the future comes from both above and below the water. Recruitment has been very low for several years in some regions – it's unclear when recruitment will pick up (if ever). Climate change has the potential to affect long-term supply of recruits and Tasmania is especially at risk because it is expected to be a hot-spot for change in water temperature. Above the water, foreign exchange rates and oil prices are significant issues. All of these put pressure for a lower TAC to maintain or raise profit and the capitalisation of quota units.

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New Zealand Rock Lobster Fisheries – Research Activities

From: Daryl Sykes

The NZ Rock Lobster Industry Council Ltd is the principal contractor to the Ministry of Fisheries (MFish) for the provision of rock lobster fisheries stock monitoring and stock assessment research services. The company shareholders comprise the regional commercial stakeholder organisations (CSOs) for each of the nine rock lobster fishery management areas operating within the New Zealand Quota Management System (QMS). In addition to the principal contract, the NZ RLIC Ltd coordinates and facilitates the delivery of a range of industry-generated and industry-funded research services in support of CSO initiatives.

The NZ RLIC Ltd has an extensive array of contractual relationships with skilled service providers in New Zealand and overseas which enable delivery of the research services provided under contract to MFish. These include NIWA, Trophia Resources, StarrFish, Haist Consultancy, Lat37 Ltd, and seven other sub-contractors doing fieldwork.

The main objectives of the principal contract are determined annually by a research planning process overseen by MFish. The core objectives are consistent with a medium term research plan for lobster fisheries developed by the National Rock Lobster Management Group (NRLMG), a multi-sector cooperative user group providing rock lobster fisheries advice to the Minister of Fisheries.

In addition to the services contracted from the NZ RLIC Ltd, MFish also contracts a separate lobster settlement-monitoring project from NIWA, which represents the longest time series of biological data for any New Zealand fisheries.

The current stock monitoring work programme for the NZ RLIC Ltd and contracted providers comprises

a) observer catch sampling in four management areas and vessel Logbook programmes in three management areas to collect length frequency and other biological data; and
b) a tag release and recapture programme to measure the growth of lobsters for use in a length-based population model.

Observers completed 116 samples days in 2007/08 and measured 55, 700 lobsters, recording details of size, sex, maturity, location, depth and condition. The vessel Logbook programme has over 70 participant commercial fishermen delivering similar information from 3,900 fishing events, 14,000 potlifts, and 67,000 lobsters. 3,000 lobsters were tagged and released in 2007 and recaptures reported from all management areas covered by the tagging programme.

The NZ RLIC and Trophia Research have implemented a web-based tag and release "track and trace" system that enables more timely reporting of tag recapture data by commercial and non-commercial extractive users. The system can be accessed at <http://www.tagtracker.trophia.co.nz/>
The stock assessment science team is principally engaged in –

a) updating the standardised CPUE analysis from all management areas and report on the operation of current decision rules;
b) estimating biomass and sustainable yields for nominated rock lobster stocks; and
c) evaluating new management procedures for rock lobster fisheries.

The assessment team members are also science advisors to the NRLMG.

Two new management procedures developed in 2007/08 informed the TAC/TACC decisions for the Otago and Southland rock lobster fisheries implemented in April 2008. Two other management procedures incorporating harvest control rules to adjust commercial catch limits were reviewed and updated. One of those informed a CSO decision to voluntarily reduce catches for the 2008/09 season.

In addition to the research services delivered to MFish under contract, the NZ RLIC Ltd has oversight of a number of elective research programmes initiated by CSOs. In 2007/08 these included supplementary puerulus collection and fine scale spatial mapping of fishing grounds in two management areas. The NZ RLIC Ltd has a business relationship with the NZ Seafood Industry Council (SeaFIC) in support of GIS programmes for the lobster industry.

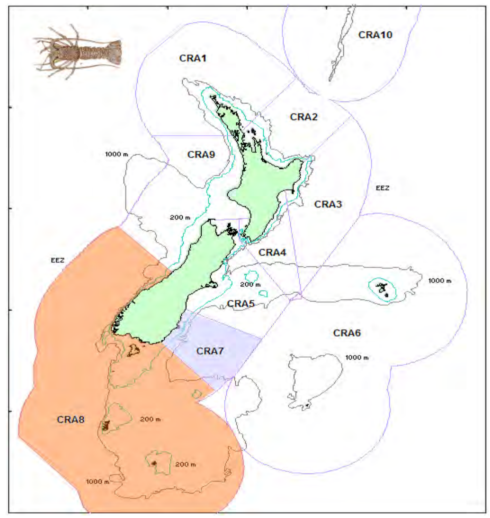

Figure 1. Rock lobster fishery management areas, New Zealand

The NZ RLIC Ltd has invested in updating and improving the TagTracker web site and has commissioned a preliminary analysis of vessel Logbook data collected but not used in assessments. Pot type and discard data could inform future industry harvest initiatives.

The NZ RLIC Ltd continues to invest in the development of electronic data collection technology. The ERNIE electronic data system developed by the NZ RLIC Ltd in partnership with Lat 37 Ltd and R White Woods is now routinely used for most observer catch sampling and all tag and release work. On behalf of a number of constituent CSOs the NZ RLIC is exploring options for the deployment of electronic logbooks that will enable fishermen to record and report fine scale catch and effort data in real time.

The New Zealand rock lobster industry research programme reflects the industry intention to properly fulfil the roles and responsibilities of commercial rights holders anticipated by the implementation of the

Quota Management System for rock lobster fisheries implemented in April 1990. The programme also incorporates the concepts of regional autonomy and self-determination embodied in the rock lobster industry organisational design.

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The post-larval culture of juvenile eastern rock lobster, *Jasus (Sagmariasus) verreauxi*

From: Arthur Ritar

There is great interest in the farming of rock lobsters to help meet the world demand for live and processed product. In south-eastern temperate Australia (and similar latitudes in New Zealand), *Jasus* spp. predominate in the wild. In these regions, the southern *J. edwardsii* is found in relatively high abundance compared to the eastern (or packhorse) *J. verreauxi*, with the latter mainly inhabiting the warmer regions. It seems that *J. verreauxi* is undergoing a name change to *Sagmariasus verreauxi* (Booth and Webber, 2001) but *J. verreauxi* will be used here.

J. verreauxi shows greater promise for aquaculture than *J. edwardsii* in that the larval phase during hatchery rearing is relatively short with high survival. Kittaka *et al*. (1997) considered it to be one of the most suitable temperate species of rock lobster so far examined for larval culture through to metamorphosis. By comparison, *J. edwardsii* has a considerably longer larval duration and lower survival in culture (Kittaka *et al*., 1988). *J. verreauxi* juveniles also appear to have a faster growth rate. Indeed, a preliminary investigation by Crear (2000) found that wild-caught pueruli grow rapidly throughout the juvenile phase when held at a constant 23°C.

In this study, we examined the growth at different temperatures of *J. verreauxi* pueruli and juveniles that had been produced from the hatchery rearing of larvae from egg through to metamorphosis at the Tasmanian Aquaculture and Fisheries Institute of the University of Tasmania. In January 2006, newly hatched phyllosoma larvae were obtained from broodstock that had been captured as pueruli and small juveniles on the east coast of Tasmania in 2000. The broodstock had reached sexual maturity at a weight of at least 1.4 kg and carapace length of 140-145 mm. Larvae were hatched and reared to metamorphosis in 7-10 months at 21-23°C according to the procedure outlined by Ritar *et al*. (2006). The resultant pueruli (0.46 ± 0.02 g; mean ± sem; n = 52) were randomly assigned to duplicate 50 L tanks (Nally bins) at 15, 18 or 21°C and individually tagged (Figure 1).

Figure 1. *Jasus verreauxi* pueruli and juveniles after hatchery rearing. Note the large differences in colouration of animals ranging from red-brown to blue-green.

After nine months, animals were moved to 300 L tanks (RELN). Tanks were supplied with partially recirculated seawater and contained shelters constructed from black oyster mesh on a frame of polyurethane pipe. Animals were fed daily a mixed diet of freshly opened blue mussels and Kuruma prawn pellets (Higashi Maru).

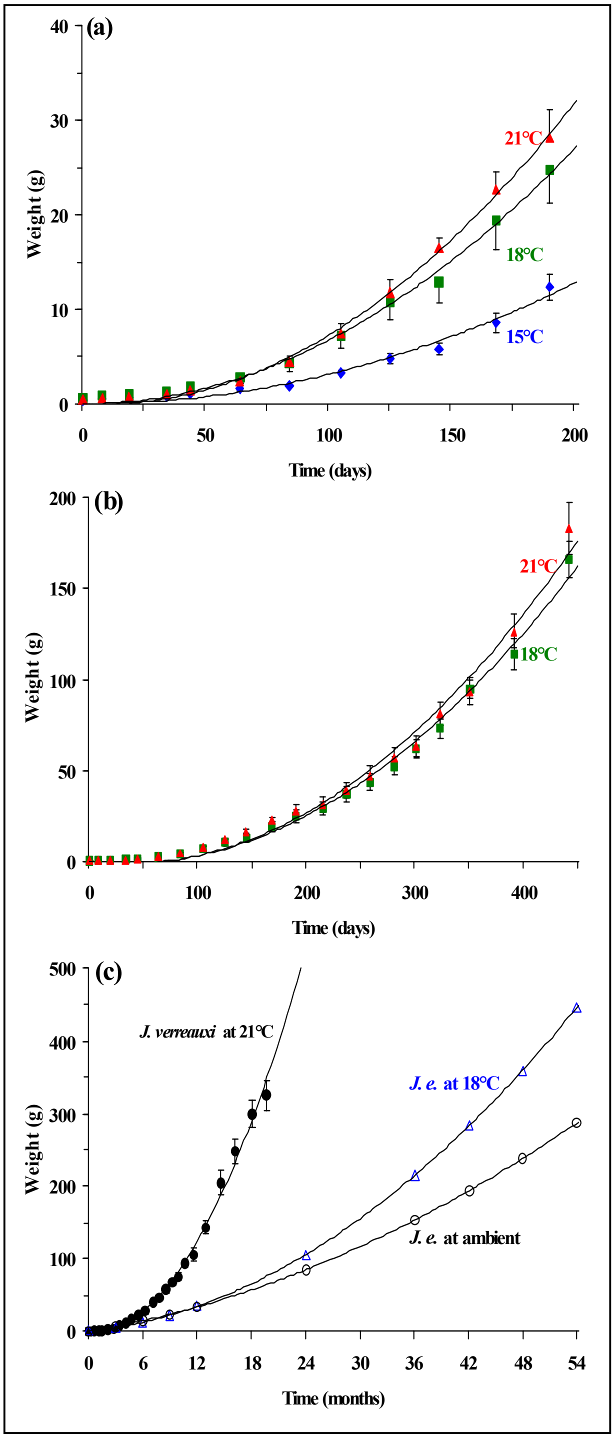

Figure 2. Mean weight of *Jasus verreauxi* juveniles (a) from puerulus at 15, 18 or 21°C until Day 190 (when 15°C animals were divided between 18 and 21°C), (b) at 18 and 21°C until Day 464 (when 18°C animals were placed on 21°C), and (c) at 21°C until 595 days, and compared with data from Jeffs and Hooker (2000) for *J. edwardsii* juveniles at 18°C and ambient temperature.

The growth of animals to 6 months was significantly greater at 18 and 21°C (24.8 ± 3.6 and 28.2 ± 2.9 g) than at 15°C (12.4 ± 1.4 g) (Figure 2a). Animals were then held at 18 or 21°C and the weights at 15 months were similar at 166 ± 10 and 183 ± 14 g (Figure 2b). Subsequently, all animals were held at 21°C and their weight at 20 months was 325 ± 19 g (Figure 2c, 3).

When the juvenile growth rates were compared to published data for *J. edwardsii*, (see Jeffs and Hooker, 2000), it was clear that *J. verreauxi* grew considerably faster, reaching 300 g in 18 months from pueruli compared with *J. edwardsii* which were estimated to take 42 months at 18°C and 54 months at ambient temperature. However, the comparatively rapid growth rate of *J. verreauxi* juveniles was less than predicted by Crear (2000) at 23°C, possibly because animals in this study were held at 21°C. Nevertheless, growth was markedly faster than the 100 g at 12 months estimated by Lie (1969) for *J. verreauxi* juveniles in the wild.

The growth increment at the moult during early development was highest between Juvenile 2 to 3 where there was a 91% increase in weight. Moult increment declined steadily thereafter, so that between Juvenile 11 to 12, the increase was 40%, and this is reflected in the changes in weights (Figure 4). There was no significant difference between the sexes in growth rates and liveweights.

These results indicate that *J. verreauxi* juveniles are a good prospect for farming in that they are robust and grow rapidly at or above 18°C, although the upper limit has not yet been examined. They also tolerate lower temperatures at which they still grow quicker than *J. edwardsii*. In house taste testing of cooked *J. verreauxi* indicated that they were similar if not better than *J. edwardsii*. Future research for juvenile *J. verreauxi* aquaculture should focus on the development of a complete formulated diet, as well as husbandry factors to optimise the economics of farming, such as shelters and refuges, lighting (intensity and photoperiod) and tolerance to reduced water quality in recirculation systems.

Figure 3. *Jasus verreauxi* juveniles at at 18 months old and about 300 g.

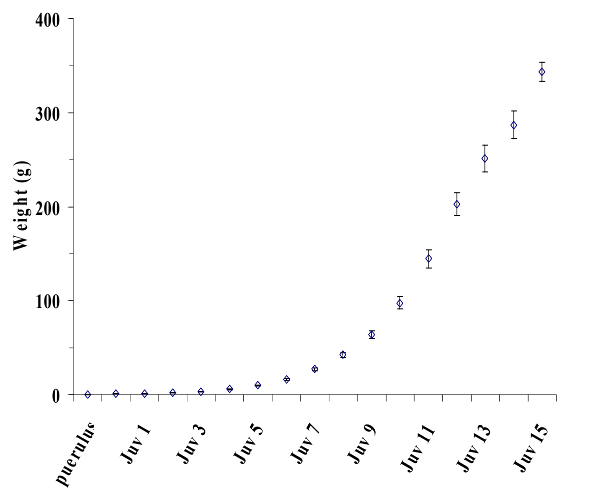

Figure 4. Change in weight of *Jasus verreauxi* at each successive moult after metamorphosis (data complete to Juvenile 15, ~Day 595).

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REQUEST FOR INFORMATION

Information Needed: Special Methods for Collecting or Preserving Lobsters?

From: Mark Butler

Cambridge University Press is producing a new book titled "Crustacean Field Methods" edited by Samuel DeGrave and Joel Martin. I have been asked to write a short chapter on special methods for collecting and preserving lobsters. I am reasonably familiar with the various nets used to obtain phyllosoma, artificial collectors deployed to catch postlarvae, and fishing traps and diver-based search methods (cpue, transects, quadrats, etc.) commonly used to collect adult lobsters. No doubt, however, there are other methods that some of you utilize that are not commonplace or well-known. I would very much like to hear about those unique methods for lobster (spiny, clawed, or slipper) collection and preservation, and request your help in disseminating that information.

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Obituaries: Dr. Lipke Bijdeley Holthius

Dr. Lipke Bijdeley Holthuis, the world's leading lobster taxonomist, and Emeritus Curator of the National Museum of Natural History (now the Naturalis) in Leiden, The Netherlands, died in Leiden, on March 7, 2008 at the age of 86.

Dr. Holthuis was possibly one of the most productive decapod taxonomists of the 20th century. He was appointed as an honorary assistant curator for the Naturalis in 1941 and completed his Ph.D. on "The Stenopodidae, Nephropsidae, Scyllaridae, and Palinuridae" at the University of Leiden in 1946; he was then appointed curator of crustaceans in 1947. As the curator of Crustacea at the museum, he built the decapod collection, including many lobsters, into one of the best in the world.

His work not only spanned from 1941 to 1986, the year of his official retirement, but also from 1986 to a few weeks before his death – 67 years of continuous service to science! During his 22 years of "retirement" he continued to develop new research areas, but in the 1990's he decided that he would focus work on only things he had left unfinished, such as a revision of scyllarid lobsters and a study of New Guinean crayfish. He finished the former in 2002, but did not succeed in completing the latter task.

During his long and distinguished career he published over 600 scientific publications that described hundreds of new taxa, many of those on lobsters. For lobster biologists his outstanding monograph "*Marine Lobsters of the World*. FAO Species Catalogue, FAO Fisheries Synopsis No. 125, Vol. 13," continues to be extremely useful for species identification and distributional information. He was known for resolving nomenclature nightmares where species named long ago were given multiple names in many different languages and styles. Because of his love for these historical conundrums and the zoological code, he served as Commissioner of the Zoological Commission for 43 years and was the commission's Vice-President for 13 years, its Acting President for 7 years, and its Secretary General for 4 years. He also selflessly helped hundreds of colleagues worldwide both in identifying specimens and in helping those from developing countries finish and publish their manuscripts. He has been described by his colleagues as a true gentleman scholar.

In addition to scientific literature, he published a history of the Leiden museum from 1820 to 1958 that included biographies and portraits of all of the staff members of the museum and he kept records on the lives and research activities of past carcinologists.

When we completed our recent book *The Biology and Fisheries of the Slipper Lobster* (Crustacean Issues 17. CRC Press ,Taylor & Francis Group) published in early 2007, we decided to dedicate it to Lipke Holthuis "who has worked tirelessly on the taxonomy of slipper lobsters for more than fifty years and who, perhaps single handed, has done more than anyone to further our knowledge of the existence of these fascinating creatures". One of us (Ehud) was fortunate to visit the Naturalis in May 2007 to measure slipper lobsters in the collection established by Dr. Holthuis and met him in person. In a modest ceremony, a copy of the book was given to this outstanding and humble scientist (Figure 1).

Figure 1. The slipper lobster book dedicated to Dr. Holthuis (right) given to him by Ehud Spanier (Museum Naturalis, Leiden, May 2007).

Dr. Holthuis never married, instead devoting his life to science without any regrets. Dr. Charles Fransen, the present curator of Crustacea at the Museum Naturalis, expressed the devotion of Dr. Holthuis to science in a simple sentence: "He was married to Crustacea".

Dr. Holthuis' influence will live on with us and hopefully his professionalism, work ethic, and colleagiality will serve as an example for the rest of us.

Ehud Spanier & Kari Lavalli

The Lobster NEWSLETTER

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The Lobster NEWSLETTER