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The Lobster NEWSLETTER

ANNOUNCEMENTS

Counting down the days before the biggest international & scientific lobster party ever held in Canada!

If you haven't registered for the upcoming 8th International Conference & Workshop on Lobster Biology & Management being held at the Delta Prince Edward in Charlottetown, Prince Edward Island Canada on September 23-28, 2007, don't worry; you still have time!

Come spend a week with us on Canada's beautiful island province, Prince Edward Island. The ICWL promises to be a unique opportunity for fishery managers and scientists from all over the world to learn about the latest advances in "lobster science" while networking with their international peers and establish research and other project collaborations. Come experience some great Prince Edward Island down home hospitality! Prince Edward Island is world-renowned for the distinctive flavour and high quality of its seafood including lobster, clams or the Malpeque oysters and PEI blue mussels that are indigenous to the Island and synonymous with the highest quality.

To register or get more information, visit the ICWL website:

www.lobsterscience.ca/conference

With over 230 abstracts accepted, a special day dedicated to industry, and the keynote address featuring one of Canada's most esteemed lobster scientists, Dr. Peter Lawton, the ICWL technical program will leave you wanting more. A special Symposium on Lobster Behavior will occur Monday morning, September 24th, to honor and recognize the contributions of Professor William Herrnkind to the scientific community. Subsequently, there will be two contributed paper sessions on lobster behavior on Monday afternoon.

You will not want to miss the ICWL closing dinner as it will be showcasing some of the best PEI artists in a kitchen party atmosphere along with a special appearance from Trevor Corson, author of The Secret Life of Lobsters. A social program that features excursion such as "Tails & Trails," the "Lobster Supreme Cruise" or a round of golf at the "Links at Crowbush Cove" -one of Canada's best courses with best scenery and best condition- are all additional reasons to attend what will definitely be a memorable world-class event.

We hope you will join us as we shed new light on the sea's deepest secrets. Don't miss the boat.

Lobster Behavior Symposium Honoring Professor Herrnkind at the 8th International Lobster Conference and Workshop

From: Mark Butler

A special symposium on Lobster Behavior honoring the illustrious career of Professor William Herrnkind, who retired in May 2007, will be convened as part of the 8th International Lobster Conference and Workshop, to be held September 23 - 28, 2007 on Prince Edward Island, CANADA (see http://www.lobsterscience.ca/conference/ for details). The one-day symposium begins with a morning session of invited presentations followed by contributed presentations on lobster behavior in the afternoon. Professor J. Stanley Cobb begins the morning session with a presentation highlighting Professor Herrnkind's scientific accomplishments, most notably in spiny lobster behavior and ecology. The session continues with a series of talks by Professors Win Watson, Jella Atema, Mark Butler, and Dr. Michael Childress who will both review and provide new evidence for the importance of behavior in directing lobster navigation, physiology, ecology, and evolution. The morning session will conclude with Professor Herrnkind's presentation: "To Lobsters and Beyond: Life-forms as Complex and Sophisticated as Those of Fur, Feather, and Scale".

RESEARCH NEWS

Aspects of antipredation in *Panulirus argus* and *P. guttatus*: behavior, morphology, and ontogeny

From:: Peter Bouwman and William Herrnkind

Spiny lobsters have conquered tropical, subtropical, and temperate coastal waters around the globe despite strong predation pressure. The mechanisms and function of antipredation strategies for most species in this highly successful taxon, encompassing behavior, morphology, and life history characteristics, are poorly understood, particularly against natural predators. We investigated mechanisms of antipredation in spiny lobster *Panulirus argus* in the open during the day, at night, and while sheltering diurnally in natural dens. We also examined the function of putatively defensive acoustic signals produced by *P. argus* during diurnal attacks by piscine predators and while escaping octopuses at night. We also compared and contrasted the mechanism and survival value of antipredator behavior and morphology between sympatric *Panulirus argus* and *Panulirus guttatus*. Finally, we investigated ontogenetic changes in defensive behavior by diurnally sheltered *P. argus* to chemically-mediated predator cues.

Nearly 40 species of spiny lobsters produce a characteristic sound (termed stridulation), speculated to deter predation. The occurrence and efficacy of stridulation has not been documented quantitatively during encounters with natural predators. We examined sound production in the sympatric spiny lobsters *P. argus* and *P. guttatus* during attacks by their common predator, gray triggerfish Balistes capriscus, to determine if lobsters produce sound during defense, how stridulation integrates with behavioral and morphological defenses, and how interspecific differences in sound production relate to efficacy in repelling predators. Both lobster species stridulated coincident with specific defensive actions during triggerfish attack. In *P. argus*, stridulation occurred both during antennal lunging and during escape attempts (rapid retreat by tailflips). *Panulirus guttatus* stridulated only coincident with tailflips and did not lunge. Same-sized individuals of *P. guttatus* were subdued ~3 times more quickly on average than *P. argus*. The two species differed also in the relative size of the primary defensive weapons, the spinose 2nd antennae, which were far more robust in *P. argus*, particularly at larger body sizes. These results suggest that stridulation is an integral component of aggressive defense and escape behavior in spiny lobsters.

The timing of sound production during aggressive, retaliatory defensive behavior (lunging) by *P. argus* suggests an aposematic role for stridulation against triggerfish. Using staged encounters of *P. argus* with *B. capriscus*, we examined whether stridulation, coincident with thrusting spines during aggressive defense, functions aposematically or simply renders a defending lobster more difficult to subdue without playing an aposematic role. We demonstrated, by disabling the stridulating organ in some lobsters (muting), that sound plays a vital role in defense against inexperienced (naïve) triggerfish, resulting in fewer successful attacks in subsequent encounters. Choice experiments with triggerfish, which previously bypassed defenses and consumed lobsters, show that experienced attackers do not choose muted lobsters over stridulating individuals. We propose that stridulation by *P. argus* against triggerfish is aposematic, as part of a multi-modal display, advertising the lobster's spiny defenses to predators.

It is widely documented that sound production in *P. argus* and other spiny lobsters accompanies grasping of the carapace or other disturbance by human captors. Additionally, stridulation accompanies tailflip escape attempts during attacks by triggerfish. Although sound production during daytime attacks doesn't appear to increase survival against triggerfish, stridulating during escape may be more effective against grasping predators like octopus. We investigated *P. argus* defensive behavior during nighttime encounters with Caribbean reef octopus *Octopus briareus* to determine whether *P. argus* stridulate during octopus attacks, how stridulation is used along with other defensive behavior (e.g. tailflips), and whether sound production improves survival in stridulating individuals. Lobsters stridulate both during grasping attacks by octopus and during escape attempts after being captured. Stridulating lobsters are also more likely to escape from attacking octopuses and remain uncaptured longer during encounters. We suggest that improving the efficacy of tailflip escapes against octopus may have been the function for which the stridulating organ initially evolved in the Stridentes clade of the Palinuridae.

Benthic stages of *P. argus* reside in shelters during the day as a primary means of antipredation. However, when an active predator approaches and/or successfully attacks a nearby conspecific, these individuals must decide whether to emigrate quickly from the area or remain in shelter (dens or macroalgae) and rely on crypticity, defensive behavior, or the presence conspecifics to avoid attack, injury, or death. In the final portion of this research, we examined how the three benthic juvenile phases of Caribbean spiny lobster *P. argus* respond to exposure to fresh conspecific body fluid and how antipredator behavior, particularly the decision to stay or leave the area, changes during ontogeny. Additionally, I examined how the presence of conspecifics affects the decision to stay or leave in gregarious juvenile stages of *P. argus*. Although all size classes of *P. argus* respond to alarm odor, the decision to stay or leave dens changes unexpectedly with increasing body size and in the presence of conspecifics. Once shelters were abandoned, body size was a strong indicator of distance traveled in response to alarm odor. This indicates that *P. argus* undergo an ontogenetic shift in defensive behavior, more frequently leaving dens in response to alarm odor and traveling across open substrate during the day, but only after reaching a body size at which they can effectively defend against predators.

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Testing a new tagging method in Namibian spiny rock lobster, *Jasus lalandii*

From: K. Grobler and H. Ndjaula

During the early 1990's a new tagging program on Namibia's spiny rock lobster, *Jasus lalandii*, was initiated. The tagging method followed was similar to that used in South Africa (as well as in Namibia during the mid-1980's). In this method each lobster was tagged in the right hand side, dorsal telson muscle, underneath the posterior carapace margin, using plastic T-bar tags and a tag applicator. Although a few thousands of lobsters were tagged in Namibian waters during the early-mid 1990's, using this method, tag return rates were extremely low. During the four fishing seasons from 1994 to 1997, a total of only 34 tagged lobsters were returned by the lobster fishing industry, despite a financial incentive offered to the fishermen for each tagged lobster returned. Due to the huge effort (vessel time, financial costs and manpower) involved in the tagging project, the low tag return rates (less than 1%) yielded the project too costly and all tagging work was halted temporarily.

During 2005, when a second biologist (H. Ndjaula) was appointed in the Namibian lobster research team, the lobster tagging program was re-initiated. The concerns regarding the unsuccessful tagging program of the 1990's still held, and after considering various options whilst studying dissected lobsters, Ndjaula decided to test a different tagging method. This entails inserting the tag at a 45^{o} angle, laterally into the right-hand side of the first tail segment (Fig. 1), just above the first narrow, calcified bar (that encircles the ventral side of the tail).

Figure 1: Lobster tag positioned laterally in the first tail segment.

During May 2005 a total of 1745 lobsters were tagged (using the new method), of which 735 were from the commercial lobster fishing grounds. The rest were from a lobster sanctuary around one of the manned islands). In total 88 tagged lobsters were recaptured during the following fishing season (November 2005 to April 2006). Of these recaptures 59 were from the commercial fishing grounds, thus representing an 8% tag return rate.

The rest of the recaptures came from the sanctuary (mainly from island staff).

Only lobsters larger than 59 mm CL were tagged. A summary of the growth data for male lobsters is presented in Fig. 2. The growth was much higher for the males than for females (for which growth was almost non-existent). This was mainly due to the fact that males went through one moult before the lobster fishing season commenced in November 2005, whilst females moult only towards the end of the 2005-6 fishing season. Overall male lobsters showed a percentage increment ranging from 3 to 14% (Fig. 2). The average growth increment (in mm) was calculated at 6.4 mm for lobsters of 60-61 mm CL and 4.4-5.3 mm CL for lobsters of 62 - 75 mm CL. One larger individual of 76.7 mm CL showed an increment of 3.1 mm CL (Fig. 3).

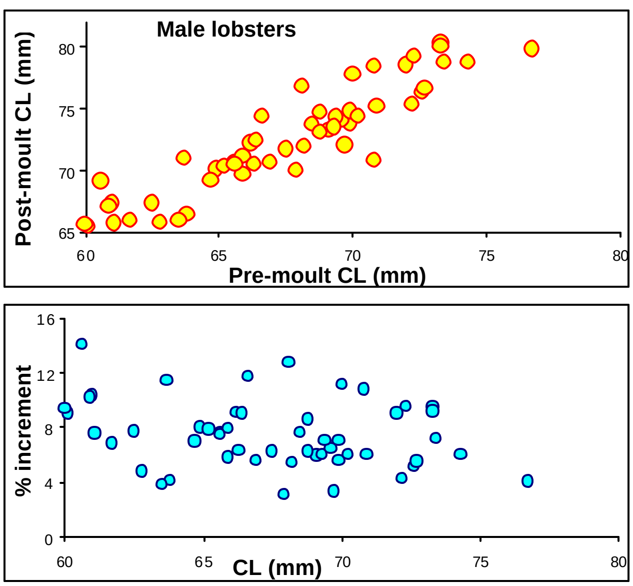

Figure 2: Tag return results from male *Jasus lalandii* tagged off Namibia during May 2005, and recaptured during January – April 2006, after one moult season.

When comparing the two tagging methods, a distinct difference was observed in the state of the wound created at the tag insertion point in recaptured lobsters. Those tagged by the old method (dorsally in the telson muscle) often left large wounds and blackened scars with possibly infections underneath (Fig. 4). During this tag method the tag applicator needle needed to be inserted relatively deep into the muscle to apply the tag, often resulting in a relatively large cut in the muscle. Additionally the insertion point is very close to the internal organs. The Namibian lobster is relatively small (most individuals caught and tagged are in the size range 60-75 mm CL) and the risk of internal damage thus high.

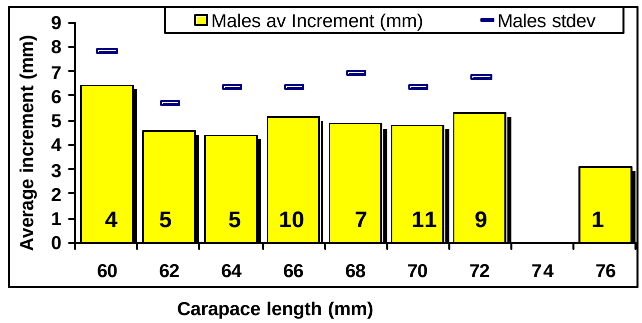

Figure 3: Average increment (mm) per 2 mm size class for male lobsters of 60-76 mm CL. Numbers at bottom of bars = sample size.

Figure 4: Large wound and scar tissue in recaptured lobster tagged in the dorsal telson muscle.

Even when the South African method of tagging females dorsally between the 2nd and 3d tail segment was followed, some recaptured females had large wounds with much black scar tissue (Fig. 5).

Figure 5: Large wound and scar tissue in recaptured lobster tagged dorsally between second and third tail segment.

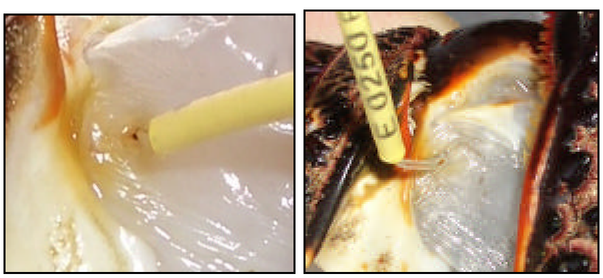

Figure 6: Clean entrance hole of lobster tag (using the new method) even after more than eight months at sea and having survived one moult season.

Lobster tagged according to the new method, however, showed generally very small scars, with the tag entrance hole clean and sometimes hardly visible (Fig. 6). Additionally, during the tagging process only the tip of the applicator needle needs to be inserted to apply the tag, and thus the internal damage to the muscle is minimised. The tag is still clearly visible (Fig. 1), thus the risk of fishermen missing the tag during sorting at sea, is not expected to be higher compared to the old method.

Although it is not clear why the new method yielded higher tag return rates compared to the method previously used, we believe that the old tag method caused high mortalities amongst the tagged lobsters due to one or more of the following:

o The old method often caused serious internal infections due to the relatively large wound at the entrance hole of the tag.

o With the old method there was a high risk of damaging the internal organs in the thorax.

o Handling of the lobster during the old method was more “forceful”, since each lobster had to have its tail and thorax slightly twisted in opposite directions in order to insert the applicator needle into the telson muscle, underneath the thorax.

o With the old method, the tag stood out at a slightly vertical angle to the thorax. This would cause problems whenever a lobster enters its shelter, since it tends to fold its tail in underneath its body (which would increase the vertical angle between tail and tag), and moves into its sh elter in reverse, thus tail first. In narrow rock shelters this would result in the tag getting stuck against the rock walls, and the resulting grinding action of the T-bar in the muscle would suppress healing and increase the risk of infection in the wound. This would negatively affect growth too.

With the new method, the wound caused during tagging is very small since only the tip of the applicator needle needs to be inserted. Additionally the tag position is clearly visible and easily accessible, without pulling and twisting the lobster! The tag filament lies in the same 45^{o} angle as the legs, and is very flexible at the base of the T-bar where it bends easily. It is believed that with the new position of the tag, any pressure on the tag (e.g. walls of a rock shelter) will be sidewise as the lobster move forward or backward, into or out of, its shelter, and much of this pressure will be deflected away from the wound as the tag bend at its base. In the old method (with the tag in line with the direction of movement of the lobster) the same pressure would be directed onto the tag such that it is transferred down the axis of the tag filament and into the wound. This would cause frequent friction of the T-bar anchor inside the wound.

Testing of this new tagging method will continue, and further studies will include laboratory experiments to test tag retention ability during moulting.

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Initial trials for sampling *Palinurus elephas* with baited underwater video

From: Ben Stobart, Raquel Goñi and David Díaz

Baited underwater video (BUV) is increasingly been used to sample fish species (see review by Cappo *et al.* 2003). This technique has gained popularity with the advent of cheaper video systems, increasing image quality and improved methods for digital video storage and analysis. For many authors the principal advantages of video are that images can be checked by several observers as many times as necessary, they provide useful records of abundance, richness and behavior, and the technique is non-extractive and not depth limited as are surveys conducted by divers.

We set out to design and build a cost effective BUV apparatus to sample *Palinurus elephas*, a Mediterranean deep-water spiny lobster (5-200 m). Lobsters are potentially good candidates for sampling with BUV as they are attracted to bait due to their scavenging habits and a great proportion of the population lives at depths that cannot be sampled by divers. BUV is also a non-intrusive technique well suited to study lobster populations in marine protected areas.

The video sampling unit

When considering BUV for sampling lobsters at depth we designed an economical, easy to build Lobster Video Evaluation (LoVE) unit (similar to the fleet of BUVs designed by the Australian Institute of Marine Science; e.g. See Cappo *et al.* 2003) in order to be able to construct several low cost units and ensure adequate replication. Our design consisted of a digital video camcorder (Sony DCR-TRV60E high resolution mini DV with 0.7x wide angle converter) held inside a “home made” gas tubing underwater housing with acrylic viewing port. The housing was mounted vertically on a 40 mm PVC tubing octopod with a 50 mm PVC tubing octagonal base (Fig. 1). This structure has the advantage of being very strong and stable, and the PVC tubing can be put together with “off the shelf” joints to reduce manufacture costs. The octopod base was ballasted using chain threaded inside the tubing, which reduces the risk of snagging (additional ballast tied to the frame for trials will be incorporated in future designs). The camera gave a field of view of 90 x 60 cm, in the center of which was located a 60 x 40 cm bait bag. A 10w lamp with red filter provided 5 hours of illumination using the infra red setting on the camera. The red filter was considered useful to reduce the chance of light interfering with lobster presence as lobsters do not to see red light as well as white light (Myer-Rochow and Tiang 1984).

The LoVE unit was held from four hoist points at the base, and a small buoy stopped the hoist lines from interfering with the camera view. A strong 100m line with surface buoy was used for deployment and retrieval. A secondary weight (50kg) was used to avoid current dragging the unit during its deployment. Deployment was carried out just after dark with recovery the following morning, but effective recording time was restricted to 5 hours due to the duration of the lamp battery. Prior to each deployment approximately 8 crushed sardines or mackerel were placed inside the mesh bait bag. The video recorder was set for time lapse (recording 2 seconds every half minute). The LoVE unit was either deployed directly from the RV Odon de Buen, or it could also be deployed by two people from a small inflatable boat. Recovery was always using a winch from the main vessel.

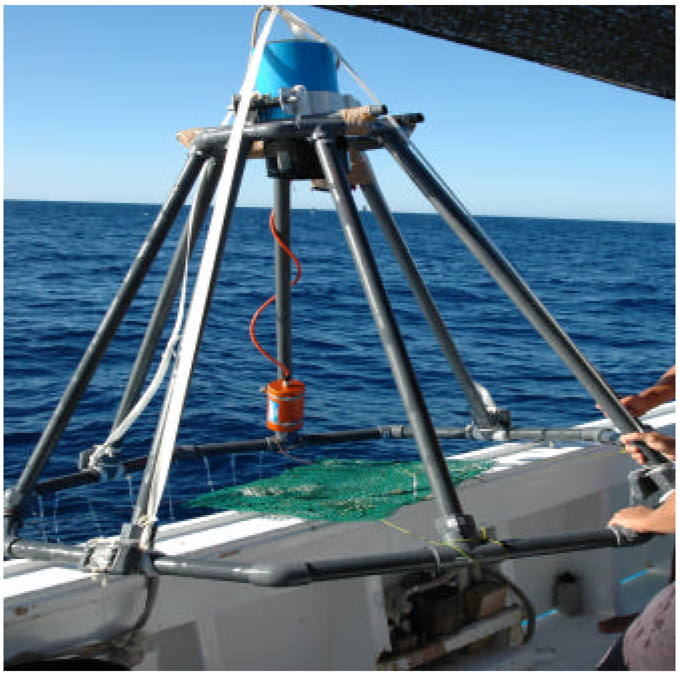

Figure 1: Baited Underwater Video system for lobsters (LoVE).

Analysis and preliminary results

Three camera deployments were performed at the Columbretes Islands Marine Reserve in August 2006, two at the same location at a depth of 45-50m, and a third at 70m. Video images were transferred to DVD for easy viewing on a PC where the total number of lobsters per 7.5 min. time interval (to follow abundance over time), time of first appearance for each lobster and size (total length, carapace length and left/right antenna length) were recorded. The standard method of estimating abundance with BUV is by recording the maximum number (MAXn) of individuals visible at any one point on the tape (e.g. Willis and Babcock, 2000). This ensures that the same individuals do not get counted twice as they enter and leave the field of view of the camera, but tends to underestimate the true number of individuals present. For lobsters we found it possible to use images of unique body patterns or damaged antennae for identifying individuals over time, and thus obtain an abundance estimate closer to the true number of lobsters having attended the bait. This does however have a viewing time cost which increases considerably when there are more than three or four lobsters present at the bait, as each one has to be tracked over time. Video footage also provided data on the presence of potential lobster predators such as groupers, moray and conger eels that in the future can be used for species interaction studies.

Time of first arrival varied from as little as 5 minutes to 4:40 hrs (Fig.2), and some lobsters remained at the bait for as long as 4:30 hrs. The average maximum (MAXn) number of lobsters at the bait for the three sites showed a similar pattern to first arrival times, though it peaked slightly later at between 1 and 2 hours (Fig. 3). Rather than reflecting first arrival, the mean MAXn reflects the accumulation of lobsters at the bait and the reduction of numbers as the bait begins to loose its effectiveness. The highest MAXn was 6 lobsters in the field of view (Fig. 4), which was lower than the total number of lobsters estimated by identifying individuals in all three recordings (total of 7, 8 and 11 individual lobsters for the three deployments). This highlights the extent of underestimation of abundance derived from MAXn estimates (Mean MAXn = 4 as opposed to 8.6 by tracking individuals).

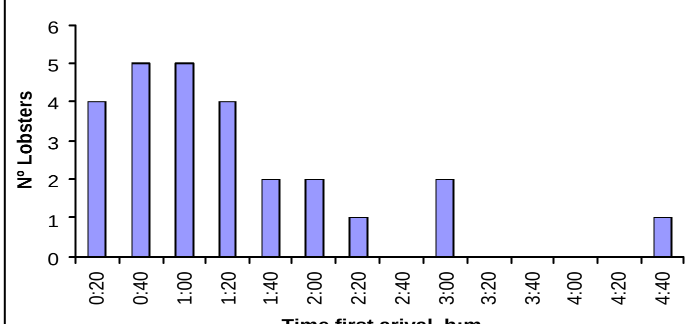

Figure 2. Frequency of first arrival time of lobsters at the bait.

Measurement of lobster total length, carapace length and antennae was trouble free with the coefficient of variation of all measurements being low, and antennae being the least easy to measure accurately. All measurements were excessively high due to a calibration problem (related to lobster height above the bait bag), a problem that is easy to resolve for future studies.

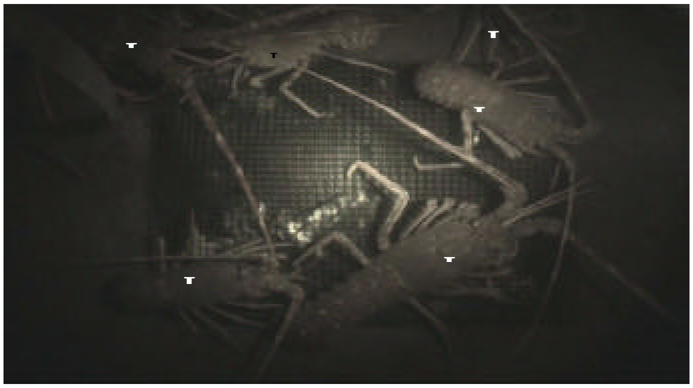

Figure 3: Mean MAXn of lobsters at the bait during deployment time (n=3 deployments) and polynomial fitted curve.

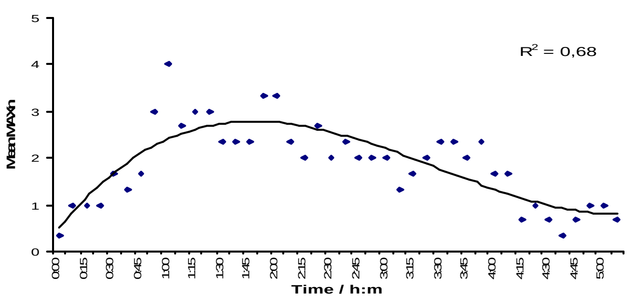

Figure 4. Maximum number of lobsters (MAXn = 6) as seen on BUV during the trials (individual lobsters marked L1, etc).

Our results demonstrate that the LoVE system tested can provide useful data for lobster studies and that the data are easy to retrieve from the recordings. Taking into account the relatively low cost of the units, which will allow cost efficient sampling with several units, coupled with the ability of this system to work to depths impractical for visual surveys, we propose that this non-intrusive method will be useful for sampling deep water lobsters. Future work by this team will involve correction of the calibration problem for measuring lobsters, and establishing whether the system can be used effectively to sample in fished areas at which lobster abundances are low. This is a prerequisite for using the method for comparative studies between fished and unfished areas.

LITERATURE CITED

Cappo, M., Harvey, E., Malcolm, H., Speare, P. 2003. Proc..“Aquatic Protected Areas – what works best and how do we know?”, World Congress on Aquatic Protected Areas, Cairns, Australia, August 2002,. p 455-464.

Myer-Rochow, V.B., Tiang, K.M. 1984. Zoologica, 134: 1-58.

Willis, T.J., Babcock, R.C., 2000. Mar. Freshw. Res. 51, 755-763.

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Research and management response to interactions, and accidental mortality, of the Australian Sea Lion, *Neophoca cinerea*, in the West Coast Rock Lobster Fishery

From Richard Campbell, Max Coyne, Nick Caputi

The West Coast Rock Lobster Fishery (WCRLF) is Australia’s most valuable single species fishery, with annual production averaging in excess of 11000 t. Sales generate about AUS$300- 400 million annually in export to markets including Taiwan, Japan, Hong Kong, China, USA and Europe. In

March 2000 the WCRLF became the world's first fishery to receive the Marine Stewardship Council Certification (MSC). The MSC is an independent, global, non-profit organisation whose role is to recognise, via a certification programme, well-managed and sustainable fisheries, and to harness consumer preference for seafood products bearing the MSC label of approval. The WCRLF successfully completed its first 5-year re-assessment, in December 2006.

Included in the principles and criteria of MSC rated sustainable fisheries is that "the fishery is conducted in a manner that does not threaten biological diversity at the genetic, species or population levels and avoids or minimises mortality of, or injuries to endangered, threatened or protected species" (MSC, see www.msc.org for more details).

One of the issues highlighted and deemed a moderate risk in the WCRLF, was the accidental drowning of Australian sea lion pups in rock lobster pots as they attempt to rob pots of either bait or lobsters. The Australian sea lion, *Neophoca cinerea*, is Australia's only endemic pinniped species, and current population estimates of 12-14,000 make this one of the rarest sea lions in the world (Goldsworthy *et al.* 2003). This species is currently listed as threatened (Vulnerable category) under Commonwealth legislation (Environmental Protection and Biodiversity Conservation Act 1999), partly based on the premise that population declines are likely to continue. Reports of incidental mortalities in this fishery from a variety of fishery-dependent sources for five fishing seasons starting in 1999/2000 suggested that a minimum of four mortalities occurred every fishing season. This rate must be considered a minimum, as there may be a degree of under-reporting of incidental mortalities of protected species by the commercial fishing industry.

The west coast of Western Australia supports a small population of approximately 700-800 Australian sea lions (Gales *et al.* 1994). There are four breeding colonies and a number of key haul-out (non-breeding) sites along this coast, and their distribution overlaps with the WCRLF (Fig. 1). A Scientific Reference Group (SRG) was established to provide the knowledge and research required to address the issue of accidental sea lion mortalities. Key findings from this group suggested that the low level of reported interactions is of significant concern to the small population of this species along the western coast of Western Australia. Young sea lions between 6-24 months were particularly vulnerable to capture and all captures occurred in relatively shallow waters (<20m) at distances up to 25 kilometres from a breeding colony.

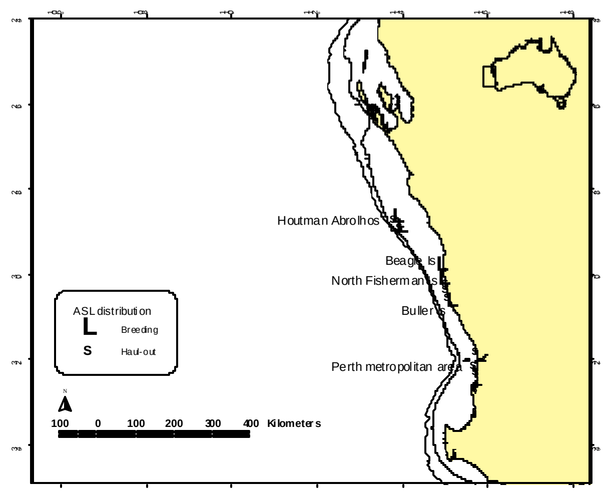

Figure 1. Location of breeding and important haulout sites for the Australian sea lion on the west coast of Western Australia. Note that the map boundaries delineate the northern and southern extents of the fishery. The continental shelf edge (100-200m) shown on the map describes the seaward extent of fishing activity in the fishery.

Management Response

Management plans were devised to address the interaction on the basis of the biological knowledge and the risk posed to this small population of Australian sea lions. Research to date has shown that sea lions can be prevented from entering lobster pots by the use of a sea lion exclusion device (SLED), which can be fitted to all types of pots currently used in the fishery. It was proposed that the bycatch of Australian sea lions be effectively eliminated by making the use of SLEDs mandatory in a zone that encompasses the distribution of young sea lions (pups and juveniles) on the central west coast (DoFWA 2005). The non-annual breeding season of the sea lion meant that the pot modifications would need to be used for the entire fishing season (mid November until the end of June).

A research programme was devised in consultation with industry representatives, fishermen and Department of Fisheries researchers and managers. Three aspects of research were proposed; (a) video trials investigating the efficacy of various SLED designs, (b) research trials investigating the impact of SLEDs on catch rates of lobsters and (c) commercial trials investigating the impact of SLEDs on catch rates of lobsters.

Figure 2a. SLED design consisting of a straight metal bar through the neck of the pot.

Various SLED designs were initially trialled, including a straight bar placed through the widest part of the neck of the pot (Fig. 2a), while a second design to keep sea lions from becoming trapped consisted of a single straight upright, a minimum of 10mm in diameter, attached to the bottom of the pot, which finishes at the base of the neck structure (Fig. 2b). Commercial and Research trials of these devices in fishing operations were conducted to establish their impact on the catch rate of lobsters, as industry were concerned over the possible loss of catch due to the pot modifications. Trials have indicated that the initial device (Fig. 2a) resulted in an overall drop (18%) in catch, but subsequent designs (Fig. 2b) had little effect on catch rates of legal size lobsters. Importantly, no difference in catch of larger, or 'jumbo', sized lobsters was attributed to the use of the SLED.

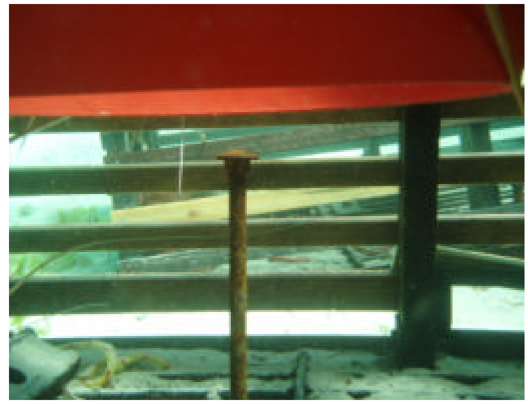

Figure 2b**.** SLED consisting of an upright attached to the bottom of the pot and finishing near the bottom of the neck.

Extensive video trials were conducted adjacent to a sea lion breeding colony at Fisherman's Island, north of Jurien bay. Lobster pots with SLED devices, as well as standard pots without a SLED (control pots), were set in shallow water of 3-5 metres. The pots were loaded with lobsters obtained from a local fisherman to attract the sea lions to the experimental site. Under-water video cameras were set on a tripod overlooking the experimental area, as well as inside the pots to enable a 'lobster view' of the predatory sea lion feeding attempts. Behaviour of sea lions around the pots was recorded and analysed to classify the level of interaction with the two pots. All attempts at entry into the pot, as well as successful feeding dives, were classified according to the age class and sex of the animal where possible.

Observations of sea lion behaviour as they attempted to feed on the lobsters showed the SLED device to be extremely efficient at excluding sea lions from lobster pots (100% exclusion of sea lions aged 20-26 months, with SLED set at 20mm below base of pot neck). The ease at which the sea lions were able to take lobsters from control pots (without SLED) was instrumental in changing the attitudes of some fisherman as they realised the SLEDS may actually help retain lobsters in the pots. During the video trials, depredation from the control pots was 3 times greater than from SLED pots. Figures 3a and 3b show underwater footage of lobster pots with and without SLED.

Figure 3a**.** Modified lobster pot with SLED.

Figure 3b. Entry into a standard lobster pot (without SLED).

It is clear that the SLED is efficient at minimising the amount of possible entry into a lobster pot by a sea lion, and consequently reduces the chance of accidental drowning, while also reducing predation of lobsters by the sea lion. SLED modifications were introduced to the WCRLF and the associated recreational fishery at the beginning of the 2006/2007 fishing season in an identified SLED zone. Further background reading can be found in the SRG Report document (Campbell 2005a) and the assessment of historical abundance of sea lions in Western Australia (Campbell 2005b).

LITERATURE CITED

Gales, N.J., Shaughnessy, P.D., Dennis, T.E. 1994. J. of Zool., Lond., 234: 353-370.

Goldsworthy, S.D., Bulman, C., He, X., Larcombe, J., Littan, C. 2003. In Gales, N., Hindell, M. and Kirkwood, R. (eds.), *Marine mammals and humans: towards a sustainable balance*. CSIRO Publishing, Melbourne, pp. 62-99.

Campbell, R. 2005a. Report to the Sea Lion Scientific Reference Group. DoFWA, Marine Research Laboratories, March, 2005.

Campbell, R. 2005b. Fisheries Research Report No. 148. Dept. of Fisheries, Western Australia.

DoFWA. 2005. Western Rock Lobster Environmental Management Strategy. Department of Fisheries, Perth, Western Australia. March, 2005.

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FISHERIES & AQUACULTURE UPDATE

Caribbean Sustainable Fisheries about to commence production of *Panulirus argus*

From: Robert Power

Caribbean Sustainable Fisheries Corp. (CSF) is a British Virgin Islands (BVI) company formed nearly three years ago to explore the potential to create a commercially viable enterprise based on sustainable harvest of *Panulirus argus* pueruli

The company was awarded a license in January 2007, allowing the company and its local partner to harvest pueruli, culture them and market lobster on a commercial scale. Minor revisions have been sought, and the reissue of this license will allow CSF to move into the farming stage of a sustainable fisheries system for the Caribbean spiny lobster.

Initial Research: CSF represents nearly nine years of evolution from what originally began as a WorldFish Center initiative, started by John Munro, with the objective of addressing a variety of important questions about the role of post-larval supply in recruitment and the replenishment of fish and invertebrate stocks in marine protected areas (MPAs). As with other concurrent research the project highlighted the significance of settlement stage survival as a major population bottleneck in and around MPAs.

The extent of this population bottleneck warranted the creation of a small sideline project to look at the potential for intervention at the settlement stage, in order to boost recruitment to MPAs. The project focused on low technology, low cost, options for harvesting and rearing post-larval reef organisms.

This evolved into a revaluation of the entire fisheries equation, with the focus on post-larval harvest and grow out, rather than targeting wild breeding populations.

Based on field research in the BVI the two species that offer the greatest potential for this approach are *Panulirus argus* and *Ocyurus chrysurus* (the yellowtail snapper). Preliminary research into the concept was greatly accelerated by a Gulf and Caribbean Fisheries Institute presentation given by Megan Davies and Andrew Jeffs, that provided considerable support for the concept with *P. argus*. Since then the project has leaned heavily on research from a multitude of colleagues, with superior experience, from around the World. The original project team consisted of myself and John Munro.

In 2003 the project was transferred and executed in collaboration with the local community college, where the Centre for Marine Studies was under construction. Mr. Clive Petrovic was the Director and was instrumental in allowing the project to be hosted by the college. It was hoped that it was the ripple that would form the start of a wave of exciting marine work at the College.

A year of rudimentary harvest and grow-out work laid the foundations for a sketchy economic model and the basic technology (Power *et al.* 2004). At the end of this phase I stayed on at the College to help build the Marine Studies curriculum and continued to search for funds to extend the work. John Munro retired in 2004 and now lives in Australia.

Financing: Substantial financing was required to develop the technology and test the viability of the economic model. All signs pointed to venture capital, although initially it was difficult to see how commercial business could become involved without serious distortion of the sustainable objective.

The BVI saw a change of Government in 2003 and the new incumbents tightened the fiscal belt, with the result that all embryonic sections of the Community College were nipped off in the bud.

Whilst I prepared to put the final nail in the proverbial project coffin, a supportive lawyer arranged for me to meet with a BVI venture capital company known as the Venulum Group. The lawyer had introduced the sustainable fisheries concept to the chairman of the Venulum Group who immediately saw the tremendous potential for creating a sustainable lobster resource.

Initial meetings showed there was some synergy with the goals of the Venulum Group, whose team had experience in a range of sustainable ventures.

Company Formation: CSF was formed by the Venulum Group and myself to develop a business model with the objective of creating a modular grow-out system and a robust harvest system. The principles of CSF include: that the company would cease all operations the moment there was reasonable evidence that the activities would lead to a non-sustainable product; that the company would seek to attain credible independent certification of its practices, such that products qualify for eco-labeling; that the company source feeds from a sustainable source; that the company take measures to assure that the harvest systems have no significant effects on the localized lobster populations; that the company do its best to ensure that modular grow-out technology is robust and affordable; that the company commit to responsible market activity (especially in sensitive local markets).

Business Model: The CSF business model allows local BVI Islanders to buy into the fishery once the fishery has been established. CSF has devised a series of technologies that can be protected by patent, and thus regulated through licensing. Once commercial viability of the fishery is proven, and a satisfactory regulatory mechanism has been put in place, the technology will be made available to local fishermen and entrepreneurs.

Recent Developments: The last two years have been spent negotiating with Government departments, local partners, doing careful research and fund raising through the Venulum Group client base.

CSF faces an ambitious work load and very lofty commitments in order to establish the sustainable fishery. On paper the systems look very good and it may even be possible to make them 80% energy self sufficient. The first hurdle will be to calibrate a standardized harvest array to ensure sufficient natural settlement such that a modest population bottle neck, due to den availability, persist in harvest areas

If all goes well CSF hopes to have 5000 to 7000 market- sized lobsters by the first half of next year.

LITERATURE CITED

Power, R., Munro, J.L., Diffenthal, M., Lane, G., 2004. Proc. Gulf Caribb. Fish. Inst. 56: 633-648.

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Feeding strategies for aquaculture of post-puerulus and juvenile tropical rock lobster *P. ornatus*

From: Clive M. Jones

A series of experiments with *P. ornatus* in land-based systems have provided good baseline data on growth and survival of various stages from juveniles of 5 g and above through to adult lobsters greater than 1 kg, and helped to define appropriate husbandry (Jones *et al.* 2003, Jones *et al.* 2001). However, due to the difficulty of collecting post-puerulus (approximately 0.4 g) of this species, there is little data on growth of this early life stage through to juvenile stage (approximately 5 to 20 g). During the recruitment season of 2006 (September to November), post-puerulus *P. ornatus* were more readily available than in previous years, and approximately 200 individuals were captured enabling an experiment to be established to gather baseline data for this early life stage

Prior experience and unpublished data have shown that cannibalism is particularly acute during the earliest stages of the growth cycle. For larger lobsters, the frequency of feeding had a significant impact on survival (Jones *et al*. 2003), and this was attributed to a reduction in cannibalism. Information from other feeding frequency studies of crustaceans has been mixed. Cortes *et al*. (2003) found feeding 4 to 6 meals per day to juvenile redclaw crayfish (*Cherax quadricarinatus*) improved growth rate and survival relative to fewer meals per day. Similarly, Sedgwick (1979) and Robertson *et al*. (1993) demonstrated increased growth rates in shrimp fed more frequently each day. In contrast, Thomas *et al*. (2003) found for juvenile lobsters (*Jasus edwardsii*) feeding more than once per day, provided no benefit to survival or growth. For juvenile *P. ornatus* it is hypothesised that continuous or frequent introduction of fresh pellet food through the night, when lobsters are most actively foraging, will sate appetite and minimise predation on vulnerable, post-moult individuals, particularly in light of the limited period for which immersed pelleted feeds remain attractive (Williams *et al*. 2005).

As Williams *et al* (2005) demonstrated that a combination of mussel flesh and pelleted shrimp diet, generated the best growth for juvenile P. *ornatus*, we chose to use both food sources also. In the first of two experiments, lobsters were provided with mussel flesh each day in the late afternoon, after which a pelleted shrimp diet was introduced either as a single ration, or as a 12 hour trickle from an automatic belt feeder. In a subsequent experiment, the flesh component was provided either in the late afternoon, or in the early morning, with pellets at the reciprocal time.

Juvenile lobsters *Panulirus ornatus* were captured by hand collection from wharf pylons in Trinity Inlet in the port of Cairns on the northeast coast of Australia during episodes of extreme low tide. At such times, the bio-fouling on the pylons becomes exposed, and from this, juvenile lobsters can be easily observed and removed. In September 2006, approximately 200 lobsters were collected in this manner for allocation to the experiments.

An experimental lobster growout system was established at Northern Fisheries Centre for the conduct of husbandry experiments. The system consists of a rectangular fibreglass tank, 4.6 m long x 1.8 m wide, divided into 16 rectangular chambers, each 0.90 m x 0.56 m. Thus each chamber has a floor area of 0.52 m^2. Clean seawater was provided on a flow-through basis, filtered to 10-15 µm before entering the tanks. Tank chambers were siphoned daily to remove waste, and scrubbed weekly whilst survival counts were conducted.

In experiment 1, two feeding treatments were applied each with four replicates (i.e. 8 tanks stocked). The treatments relate to night-time feeding of pelleted food, of equal ration, which for the first treatment was provided as a single feeding at dusk, and for the second treatment, was trickled continuously for 12 hours through each night using an automatic belt feeder (AKG).

The pelleted food was a commercial Kuruma shrimp (*Penaeus japonicus*) diet. Initially the ration was 19% of biomass per day, adjusted on the basis of visual observation. As a supplement to the pellet diet, fresh mussel (*Perna* spp.) flesh was provided at a ration of 10% (dry weight equivalent) of biomass per day, fed once at 9 am.

Each tank was furnished with shelter, consisting of a multi-layered, perforated pipe stack; a fixed structure consisting of thirty-two, 175 mm lengths of 60 mm diameter, perforated polythene pipe, placed in a stack 4 high by 8 wide. Two pipes on the bottom row and one on the top row were filled with concrete to facilitate sinking and to ensure that the habitat remained upright throughout the experiment. Tanks were kept dark using a shade cover made from 70% garden shade cloth.

152 post-puerulus lobsters, (0.4 ± 0.01 g; mean ± SE) (7.07 mm ± 0.06, mean CL ± SE) were stocked into experimental tanks at a density of 36.5 m-2, (19 per tank).

Carapace length and weight of all individuals was recorded at the beginning and not again until the termination of the experiment. Weight and survival data were analysed with ANOVA using Genstat 8 (Anon. 2005). Daily growth coefficient (DGC) was calculated as per Bureau *et al.* (2000) and Cho (1992).

DGC = 100 x (FBW1/3 – IBW1/3)/D

where: FBW is final body weight (g)

IBW is initial body weight (g

D is the duration of the growth period in days

A second experiment was established using the pooled lobsters from the first, and in the same system. Two treatments were applied with six replicates (i.e. 12 tanks stocked). The treatments relate to the time at which flesh food (mussels) was fed. The ration for each tank was the same, and for the first treatment was provided as a single feeding in the late afternoon. For the second treatment, the ration was provided in the morning.

A commercial shrimp pellet was fed as a supplement at the reciprocal time to the flesh feeding. Thus, for treatment 1, pellets were fed in the morning and for treatment 2, in the afternoon. Initially the flesh ration was 10% of biomass per day (dry weight equivalent)(i.e. approximately 2 g), adjusted on the basis of visually observation. For pellet diet, the ration was 5% (dry weight equivalent) of biomass per day. The mussel flesh used was chopped finely and pellets were crushed and screened to provide a crumble with particle size between 500 and 1000 micron.

108 post-puerulus lobsters (0.94 ± 0.02 g, mean ± SE) (9.0 ± 0.1 mm, mean CL ± SE) were stocked into experimental tanks at a density of 17.3 m-2, (9 per tank).

Water quality remained at acceptable levels throughout the experiments, and there were no indications of disease or other health related issues.

For experiment 1, initial and final weight, daily growth coefficient and survival are summarised in Table 1. There were no significant differences between treatments for any variables

Table 1. Summary statistics for shelter assessment experiment. Statistics represent means ± standard error.

Treatment	Initial Weight (g)	Final Weight (g)	DGC (%/day)	Survival (%)
Single feeding	0.33 ± 0.01	0.59 ± 0.03	0.49 ± 0.07	62.5 ± 6.3
Continuous feeding	0.36 ± 0.01	0.62 ± 0.02	0.48 ± 0.03	61.3 ± 3.2

Survival was quite poor for both treatments, with almost 40% of lobsters dying within the 30 day period of the experiment (Fig. 1). The mortality was primarily attributable to cannibalism, as evidenced by lack of moribund individuals that would likely have been seen if death was due to health related causes. Although the shelters provided were relatively massive given the small size and low number of lobsters, they may have been inadequate in providing refuge for moulting individuals. The provision of a regular supply of food, for the continuously fed treatment, was also inadequate to overcome the cannibalistic tendency of intermoult lobsters to predate on their captive brethren.

Although the particular pellet food used had been effective in other studies of the same species (Jones *et al.* 2001) for larger sized lobsters, in this experiment it appeared not to be attractive, while the supplemented mussel flesh (fed in the morning) was more completely consumed. It may be necessary to confirm the attractiveness and suitability of the diet, and possibly consider alternatives before repeating the experiment to conclusively determine the efficacy of frequent feeding for post-puerulus *P. ornatus*.

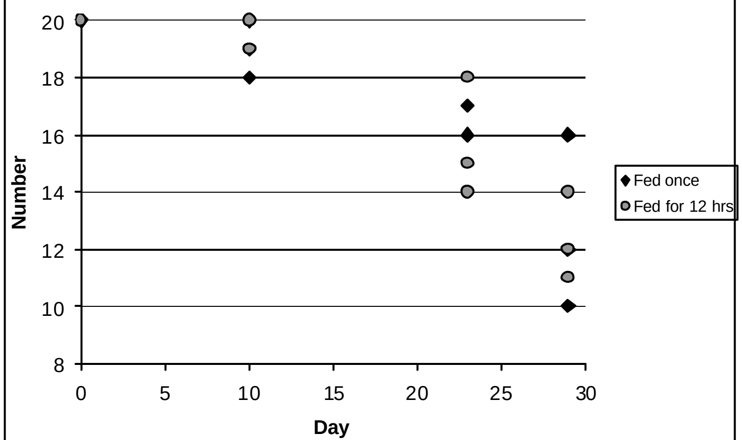

Figure 1. Survival of post-puerulus *P. ornatus* through a 30 day period when fed either once per day, or continuously over 12 hours per night.

Growth rate during the experiment averaged 0.48 % d-1 (DGC). This is substantially lower than that of juvenile *Jasus edwardsii* in which DGC ranged from 0.54 to 0.85 % d-1 (calculated by deduction) (Thomas et al. 2003), and of 0.72 to 1.38 % d-1 for *P. ornatus* (Smith *et al.* 2005), although in both cases the data represents considerably larger lobsters with initial weight of 5.3 and 2.5 g respectively. Glencross *et al.* (2001) reported growth rates of 0.31 to 1.46 % d-1 DGC for *P. cygnus* initially stocked at 0.5 g. Notwithstanding the likelihood that growth rate for this immediate post-puerulus stage is less than subsequent stages, as the growth curve follows a typical sinusoidal model (Aiken 1980), the growth of *P. ornatus* in our study was low, and likely to be greatly improved under more optimal conditions. Dennis *et al* (1997) reported growth rates equivalent to 1.9 % d-1 DGC for wild juvenile *P. ornatus* (4 g and above), and equivalent growth rates will need to be achieved for captive lobsters before economically viable aquaculture can be established.

Although this experiment did not provide conclusive evidence of the benefit of frequent feeding, further examination of this issue is warranted to minimise mortality, particularly in regard to cannibalism.

For experiment 2, initial and final weight, daily growth coefficient, survival and biomass gain are summarised in Table 2.

Although there was no significant difference for survival or growth between the two treatments, the feeding of flesh at dusk appeared to provide a benefit for both survival and growth. Mortality was relatively high for both treatments, and again was attributable primarily to cannibalism. The result however suggests that feeding flesh at dusk may help to mitigate against cannibalism by satisfying hunger prior to the most active evening period when the risk of cannibalism may be at its highest.

Table 2. Summary statistics for time of feeding experiment. Statistics represent means ± standard error.

Treatment	Initial Weight (g)	Final Weight (g)	DGC (%/day)	Survival (%)	Gain in tank Biomass (g)
Flesh fed pm	0.93 ± 0.05	2.42 ± 0.33	1.35 ± 0.19	53.5 ± 9.8	6.29 ± 0.93
Flesh fed am	0.95 ± 0.08	2.09 ± 0.37	1.07 ± 0.28	38.5 ± 3.8	3.72 ± 1.11

Growth rates were in excess of 1 % d-1 expressed as DGC for both treatments, a marked increase over that recorded for the earlier stage post-pueruli in the first experiment. This suggests that the diet and feeding strategy may have been more effective, although the nutritional influence of cannibalism must also be considered. The relatively high mortality suggests that other aspects of the environment and husbandry were not effective. In particular the nature of shelter provided is thought to have been inadequate, especially in regard to providing safe haven for soft, post-moult individuals. It was apparent that even with adequate nutrition and feeding practices, the tendency for post-puerulus stage *P. ornatus* (0.04 to 3.0 g) to cannibalise each other is strong.

On the strength of these results, it may be concluded that once per day feeding may be adequate for post-puerulus *P. ornatus*, as it was for juvenile *Jasus edwardsii* (Thomas *et al.* 2003). To confirm adequacy of feeding practices, and to achieve more acceptable survival rates however, the influence of cannibalism must be removed, and this is most likely to be achieved through provision of appropriate shelter.

LITERATURE CITED

Aiken, D.E. 1980. In *'The Biology and Management of Lobsters. Vol.1. Physiology and Behaviour'.* Eds. J.S. Cobb & B.F. Phillips. Pp. 91-163. Academic Press, New York.

Anon. 2005. Lawes Agricultural Trust (Rothamsted Experimental Station). VSN International.

Bureau, D.P., Azevedo, P.A., Tapia-Salazar, M, Cuzon, G. 2000. In *Avances en Nutricion Acuicola V. Memorias del V Simposium Internacional de Nutricion Acuicola. Eds.* L.E. Cruz-Suarez, D. Ricque-Marie, M. Tapia-Salazar, M.A. Olvera-Novoa, & R. Civera-Cerecedo. Pp. 111-140. Conference Proceedings: *19-22 November, 2000*., Merida, Yucatan, Mexico.

Cho, C.Y., 1992. *Aquaculture* 100: 107-123.

Cortes Jacinto, E., Villarreal Colmenares, H., Rendon Rumualdo, M. 2003. *Hidrobiologica (Iztapalapa)* 13:151-158.

Dennis, D.M., Skewes,T.D., Pitcher, C.R. 1997. *Mar. Fwater. Res.* 48: 663-670.

Glencross, B., Smith, M., Curnow, J., Smith, D., Williams,K. 2001. *Aquaculture* 199: 119-129.

Jones, C., Linton, L., Horton, D., Bowman, W. 2003. Final Report for Research Activity in 2000 and 2001 on *Panulirus ornatus* Aquaculture. Pp. 77. Department of Primary Industries Queensland, Cairns.

Jones, C.M., Linton, L., Horton, D., Bowman, W. 2001. *Mar. Fwater. Res.* 52: 1425-1429.

Robertson, L., Lawrence, A.L., Castille, F.L. 1993. *Aquacult. Fish. Man.* 24: 1-6.

Sedgwick, R.W., 1979. *Aquaculture* 16: 279-298.

Smith, D.M., Williams, K.C., Irvin, S.J. 2005. *Aquac. Nutr.* 11: 209-217.

Thomas, C.W., Carter, C.G., Crear, B.J. 2003. *Aquaculture* 215: 45-65.

Williams, K. C., Smith, D.M., Irvin, S.J., Barclay, M.C., Tabrett, S.J. 2005. *Aquac. Nutr.* 11: 415-426.

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Managing Variations in Stock Abundance – A New Zealand Lobster Industry Initiative

From: Daryl Sykes

The CRA 4 (Wellington / Wairarapa / Hawkes Bay) rock lobster industry has implemented a voluntary commercial catch reduction for the 2007 / 08 fishing year in response to observed declines in stock abundance over the two most recent seasons.

The CRA 4 fishery has a Total Allowable Catch (TAC) of 771 tonnes, of which 577 tonnes is designated as the Total Allowable Commercial Catch (TACC). Commercial landings in recent years have been less than the TACC and commercial catch per unit of effort (kgs / potlift) has declined in three consecutive seasons. The industry initiative, which commenced in April 2007, has reduced the commercial catch limit to 338 tonnes. No reductions to non-commercial fishing were proposed.

The reduced commercial catch limit is a tactic intended to arrest stock decline sooner than would have been possible had the normal TAC/TACC setting process overseen by the Ministry of Fisheries been invoked. The catch reduction was accomplished by having quota owners agree to transfer 44% of the available catching rights across to the NZ Rock Lobster Industry Council (NZ RLIC), to be held unused and "in trust" for the duration of the current fishing year.

The reduced commercial catch limit was arrived at by operating a management procedure developed for the CRA 4 industry by stock assessment scientists contracted to the NZ RLIC. A series of industry meetings were held in 2005 and 2006 at which the parameters of the procedure including a within-season decision rule driven by CPUE were agreed. The procedure was further refined in February 2007 in order to reassure those industry participants reluctant to "shelve" 44% of their catching rights. The industry had previously agreed a high threshold of support for the voluntary catch reduction to be implemented – owners of at least 95% of the quota shares had to be contracted to transfer catching rights to the NZ RLIC.

The CRA 4 management procedure will be operated again in October 2007 and the catch projection generated will become the basis for a further "shelving" initiative effective from April 2008.

There will be inevitable redundancies and possible retirements from the CRA 4 fleet as a consequence of the industry initiative and that outcome warranted very careful attention to the matters raised by the quota share owners initially unwilling to support it. There was no outright objection from any of the CRA 4 quota share owners to reducing the commercial catch limit but moving from support in principle to a binding contractual agreement to forego a significant proportion of gross income for one or more seasons was a challenge for all CRA 4 Industry participants.

The CRA 4 industry is not supporting just a one-off reduction. This initiative has been developed around a decision rule that will be implemented for at least five fishing seasons. Commercial catch limits will be adjusted in every season in response to observed stock abundance.

The decline in abundance has been variously attributed to a period of low settlement due to adverse environmental conditions; a re-distribution of fishing effort causing increased gear and spatial conflicts and localised depletion within the fishery; and/or changes in lobster behaviour and availability associated with recent weather conditions and sea temperatures along the east coast of the North Island of New Zealand.

The CRA 4 fishery is one of nine rock lobster management areas in New Zealand and is the second largest in terms of commercial production. There are ninety two quota share owners for the stock and an estimated 65 vessels operating across the extent of the fishery.

Figure 1: The CRA 4 rock lobster fishery management area, New Zealand.

"Shelving" catch entitlements has been implemented in other rock lobster fisheries in recent years and is backed up by comprehensive stock monitoring and catch balancing, and a range of initiatives to reduce handling and predation mortalities and damage. The benefits for the fishery and for commercial participants are that future increases in stock abundance will accrue to industry (to the limit of the TACC), thus creating the incentive for industry to "invest" time, effort and resources in stock rebuilding.

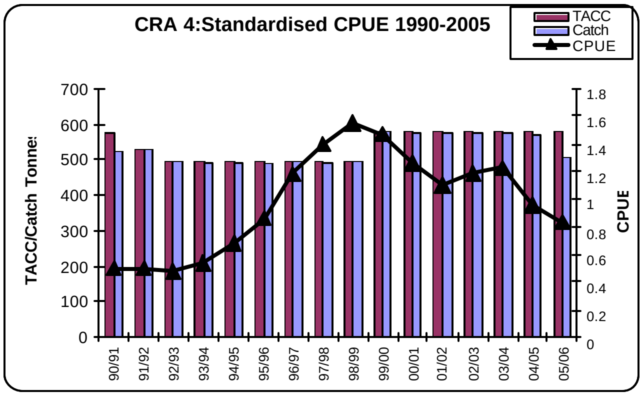

Figure 2: Standardised CPUE for the CRA rock lobster fishery, New Zealand.

Figure 3: Lobster boats – Island Bay, New Zealand.

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Sensory evaluation of tropical rock lobster, *Panulirus ornatus*

From: Clive Jones

The relative culinary attributes of the various commercially important rock lobster species has primarily been discussed from a parochial perspective. In Australia at the annual National Rock Lobster Congress, a feature of the conference dinner is a 'national taste-off' where the various species are compared, with spurious moderation, and the winner is inevitably the species from the host State.

The commercially important Australian species include *Jasus edwardsii, J. (Sagmariasus) verreauxi, Panulirus cygnus and P. ornatus*. Each has strong and well defined markets with little overlap. Nevertheless, the lobster fishers are often at pains to claim the superiority of their species. In addition to possible species differentiation, the prospect of lobster aquaculture and product grown on manufactured diets adds another dimension.

To generate some baseline data on the relative sensory attributes of lobsters, the Queensland Department of Primary Industries and Fisheries, Centre for Food Technology in Brisbane was commissioned to perform formal sensory evaluations of wild and aquacultured *P. ornatus* and wild *P. cygnus*. The aquacultured *P. ornatus* were of market size (800g +), and had been grown-out from juvenile (5g) in tank systems at the Northern Fisheries Centre in Cairns on a diet of shrimp pellets, and fresh mussel and squid flesh.

Whole frozen lobsters of each species were transported to the food laboratory and held at -18°C. Thirteen experienced seafood tasters were first trained using known samples to standardise responses according to rating scales, as described in Australian Standards AS 2542.2.3 1988.

Sample lobsters were placed in boiling water with 0.3% salt in a gas fired shrimp cooker until the internal temperature reached 80°C. Once cooked, the lobsters were removed and placed in ice slurry until the internal temperature dropped to 15°C so they could be handled. Lobster shells were removed and samples were cut widthways across the animal.

For each attribute examined, average panellist scores for each sample at each session were compared using a randomised block analysis of variance. At each of two sessions all samples were compared and this was considered as a blocking factor in the analysis. Where a significant ($P<0.05$) F ratio was found then pairwise comparisons were made using Fisher's least significant difference procedure.

Sensory evaluations found no significant differences ($P > 0.05$) between samples for the flavour, aftertaste or overall quality characteristics. The aquacultured tropical rock lobster (*P. ornatus*) and the wild caught western rock lobster (*P. cygnus*) were firmer than the wild caught tropical rock lobster, although this may be attributable to the size of the lobsters rather than treatment differences. The colour intensity of the wild caught tropical rock lobster was paler than that of aquacultured tropical and western rock lobsters.

The results contradict the common wisdom that the table qualities *of P. ornatu*s are inferior to the iconic western rock lobster, *P. cygnus*. The point is somewhat moot, as *P. ornatus* are primarily marketed to China as a sashimi (uncooked) product. Of greater significance is that aquacultured product is of equal quality to wild caught.

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Australian Rock Lobster Industry Focuses on the Global Market

From: Alice Hurlbatt

With funding agencies focusing more recently on the "Development" side of Research and Development, the Australian lobster industry under the guidance of Western Australia's Western Rock Lobster Development Association (WRLDA) is taking advantage of the opportunity, having secured the funding to develop an Australian based 'Global Lobster Market Database'.

The project funded by the Australian Government through the Fisheries Research and Development Corporation commenced in September 2006, and WRLDA is in the process of writing the first of a series of quarterly reports for the industry. WRLDA has been collecting official trade data on the import and export of lobsters into key markets since 2004, for use by the Australian lobster industries when developing their strategic plans for the future.

Data from more than 40 countries (including the EU countries, as well as those in Asia, North and Latin America) and all the Australian states has been collected on a monthly basis with data from 1995 in most cases, to 2006/07; including information on the quantity, value and unit prices of imports and exports of lobster products locally and internationally.

Using the globally accepted Harmonised System of commodity coding (HS Codes), products are identified based on whether they are frozen, live, cooked, chilled etc, with consistent naming used by the Customs Organisations of the different countries, allowing consistent comparisons of similar products, and using the official trade statistics provided by Customs Organisations from their import and export regulations. This data will build up a profile of what competing countries are doing in the long term, with the aim of using the information to help the industries with their decision making processes.

Typical of the data and information gathered are the following snapshots of recent and interesting developments in Brazil and Vietnam. Similar 'snapshots' will be provided to stakeholders where items of interest have occurred in other lobster producing countries impacting on the overall global supply situation. These reports are anticipated to assist with market analysis and gauging future trends.

Preliminary analysis of the information in the database shows the export of frozen lobsters from Brazil has increased more than 13.7% in terms of export value in the year ending April 2007 to a total of US$85 million, with Brazil's main export markets coinciding with those of the Australian lobster industries; namely the USA and Japan. This increase shows most significantly in the exports to Japan, which increased more than 9000% in the same period. Japan however, makes up only a small proportion of the Brazilian lobster market, with the United States purchasing most of the Brazilian product (94% by value).

The quantities of lobster exported by Brazil reflected similar trends, with substantial increases in the volume of product exported to Japan, (2.1 million kg) in the year ending April 2007, reflecting an increase in export quantity of 111% from 2006.

Vietnam, a recently emerging supplier of live lobster into the Asian market however had substantial decreases in the lobsters purchased by neighbouring countries in 2006. With the majority of lobsters sent from Vietnam to Taiwan, Hong Kong, Singapore and Japan and China, the live lobster trade to Taiwan and China decreased by 63.9% and 77.3% respectively, while the volume of Vietnam live lobsters to Hong Kong and Singapore increased by 79.5% and 234.4% respectively for the year ending October 2006.

Imports of live lobsters from Vietnam into the aforementioned countries is fairly volatile, with changes in total volume ranging from 78,000kg in 1999 to 565,000kg in 2001 to 147,000kg in 2005, and it is possible this decrease in volume in 2006 is a reflection of these fluctuations.

Datasets and information for other countries in Asia, the Americas and Europe competing with, and importing from, the Australian lobster industries are also available, along with information such as market price for various products in the United States, foreign exchange rates and media information.

With the focus on strategic marketing and the availability of these datasets as an information tool, the challenging part for the Australian lobster industries will be how they address the market requirements, encouraging them to be price makers rather than price takers, and essentially in control of their own future, as lobster becomes more of a commodity than a luxury item.

The database will be linked to the WRLDA website (www.western-rock-lobster.com) in the near future, with industry members able to access and search data on an 'as –needs' basis.

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Transporting southern rock lobster (*Jasus edwardsii*) in South Australia: a review of current literature and recommendations for future research.

From Adrian Linnane

Fishery Background

The southern rock lobster (*Jasus edwardsii*), has been fished in South Australian waters since the 1890s, but the commercial fishery did not develop until the late 1940s and early 1950s when overseas markets for frozen tails were first established. The fishery is divided into two zones for management purposes: a southern zone (SZ) that extends from the Victorian border to the mouth of the Murray River and a northern zone (NZ), from the mouth of the Murray River to the Western Australian border (Fig. 1). Since the 1960s, both fisheries have shared a range of input controls including limited entry, pot restrictions, minimum landing size, and seasonal closures. In 1993 and 2003, output controls in the form of total allowable catches (TACs) and individual transferable quotas (ITQs) were implemented into the SZ and NZ respectively (Copes 1978; Zacharin 1997).

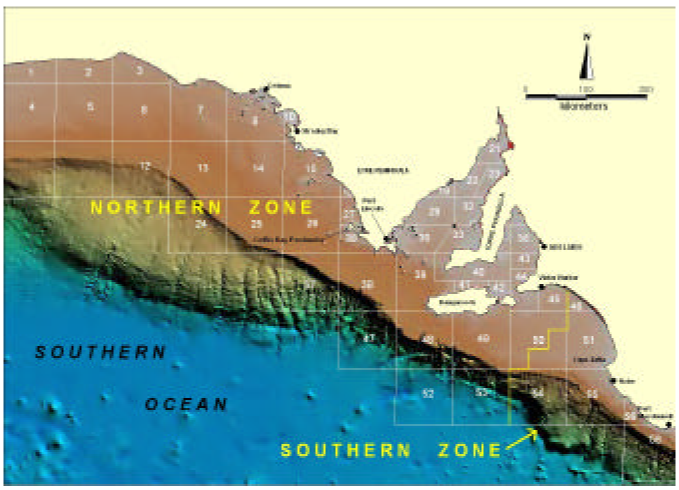

Figure 1. Northern and Southern zones of the South Australian rock lobster fishery.

Fishing is undertaken from October to May, the majority of the catch being taken in the first 4 months of the season (Linnane *et al.* 2005). Fishers use baited pots that are generally set overnight and hauled at first light, with over 90% of the catch in both zones landed in depths of <60 m. The catch is initially stored live in holding wells on boats and then transferred to live holding tanks at the numerous processing factories. The fishery for southern rock lobster is South Australia's most valuable fisheries resource, peaking in 2001 at ~$180 million in beach price. In recent seasons however, this has declined by up to 50% due to a fall in global market prices.

Research Need

While initial markets concentrated on frozen products, there has been a gradual change to live export. Currently, over 90% of the commercial catch is exported live, with almost all transported exclusively to China. Recent developments in market trends however, have identified the need to source new buyers. Two sectors that have been targeted are the U.K and U.S. This have been driven by market research that identified these sectors as having the ability to pay premium prices for quality branded product provided a consistent supply chain can be established.

The current live lobster transportation system used in South Australia is not technologically advanced consisting of foam styrene boxes, wood wool, chiller packs and a lobster chilling process in the factory prior to pack-out. Current observations indicate that these transport conditions are only sufficient for journey times of up to 40 hours. Even then, associated problems relating to unpredictable transport climate and supply chain logistics have resulted in variable lobster quality and overall survival. As a result, it has been clearly identified that one of the major shortcomings in delivering premium live southern rock lobster to alternative marketplaces like the USA and the U.K is the high risk of lobster mortalities due to the increased transportation time.

Physiological adaptations of crustaceans

Much of the pioneering work on the physiological consequences of aerial exposure in lobsters was undertaken the U.K. in the early 1990s (Whiteley and Taylor, 1990; 1992). This research demonstrated that lobsters, in their normal aquatic environment, take up oxygen and expel carbon dioxide through the gills. Ammonia, produced continuously as a by-product of the animals' metabolism is also excreted through the gill membrane. During emersion (removal from water), the gill organs collapse, and under stressful conditions, the hemolymph becomes hypoxic (low in oxygen) and hypercapnic (high in carbon dioxide). As oxygen levels continue to fall, lactic acid is accumulated and the pH of the blood decreases (Morris and Oliver 1999). This cumulative effect causes ammonia levels in the blood to rise. If conditions worsen, ammonia levels in the hemolymph reach toxic levels and mortality occurs.

Live aerial shipment of lobsters is achieved by the fact that under favourable conditions, lobsters have a compensatory process that attempts to stabilise the acid-base imbalances caused by emersion. Specifically, lobsters utilise internal stores of $CaCO_3$ to act as a buffer to elevated acid metabolites. This allows them to conserve available oxygen combined to the pigment hemocyanin thus restoring oxygen transport and allowing animals to survive aerial exposure for certain time periods.

Factors affecting limits of physiological adaptation

Lethal physiological responses to post harvest stressors are the main source of mortalities in commercial lobster fishing. Adverse reactions occur through exposure of lobsters to environmental stressors that initiate an acute stress response or cause a marked alteration in physiological processes such as oxygen uptake, nitrogen metabolism or ion regulation. Fotador *et al.* (2001) studied the effect of air exposure on the immune system of *P. cygnus* and showed that exposure periods as low as 2 hours tended to result in low haemocyte counts, high clotting times, low granular cell numbers and high bacteraemia levels implying increased susceptibility to infection and lowered immunity. Similar effects of aerial exposure on the immune system and hence on the overall health status, have been identified in *H. americanus* (Stewart *et al.* 1967) and freshwater crayfish *Cherax tenuimanus* (Evans *et al.* 1999).

Clearly, attempts must be made to reduce stress levels from the moment of landing. A number of practical measures aimed at minimising chronic stresses to lobsters during initial on-deck handling have been identified (Stevens 2004). These include:

· Handling lobsters by the base of the antennae rather than applying pressure to the tail or gill areas

· Limiting lobster exposure on deck to less that 10 minutes, thus avoiding extreme heat and wind conditions

· Holding lobsters in a low light environment

· Avoiding contamination with toxic substances such as oil, diesel or chlorine

· Grading of damaged or newly moulted individuals

· Limiting trip length to the vessels carrying capacity

· Maintaining overall vessel hygiene and sanitation

While these practices limit stress levels at the initial phase of handling, long-term survival of lobsters is dependent on maintaining high water quality standards in both onboard and processing lobster holding systems.

Criteria for water quality during storage

Water quality conditions during handling and holding prior to market have been identified as one of major factors affecting lobster survival during commercial transportation. Specifically, levels of ammonia and oxygen are critical to maintain low mortalities. Ammonia levels increase in holding and transport facilities via natural release from lobsters during excretion, as well as the bacterial decomposition of faeces, excess food and dead animals. Crustaceans are highly sensitive, even to low concentrations of ammonia, the toxicity of which increases when combined with low dissolved oxygen, low salinity and low pH.

A major study by Battaglene *et al.* (2004) studied the effects of ammonia toxicity on southern rock lobsters (*J. edwardsii*) and western rock lobsters, *Panulirus cygnus*. Southern rock lobsters at 13 C were found to be more tolerant to ammonia than western rock lobsters at 18 C. However, when temperature was taken into account, the 96 h LC50 (the concentration of ammonia that killed 50% of lobsters over 96 hours) for unstressed lobsters was similar for both species at 0.85 – 1.17 mg l-1 NH3-N for *J. edwardsii* and 0.98 – 1.20 NH3-N for *P. cygnus.*

Observed increases in hemolymph ammonia levels under unfavourable water quality conditions have also been observed in the rock crab *Cancer productus* (DeFur and McMahon 1990), the karuma shrimp *Penaeus japonicus* (Chen and Chen 1998) and in both the spiny lobster species *Panulirus argus* (Vermeer 1987) and *P. japonicus* (Huang and Chen 2001). Overall, most species responded better to poor water quality at lower temperatures (5 to 15 C) due to lower levels of ammonia, urea, urate and lactate acid as well an increased ability to buffer using either CaCO3 or HCO3.

Level of dissolved oxygen (DO) is another variable that determines success of live lobster holding (Crear and Forteath, 2001). In particular, levels of DO are critical to the recovery of crustacean species after extended periods of activity or emersion. In both the southern and western rock lobster, re-immersion respiratory rates have been to increase by up to 2.5 times the pre-emersion rate resulting in very high levels of oxygen consumption (Taylor and Waldron 1997; Crear and Foreath 2001). Results showed that DO concentrations of 50-60% saturation or less slowed the rate of recovery from stressed conditions but all lobsters recovering in DO of 10-20% or less died within 12 hours of re-immersion. Similar respiratory responses to low DO levels have been identified in the European lobster *Homarus gammarus* (Taylor and Whitely 1989), the shore crab *Carcinus maenus* (Taylor and Butler 1978) and the freshwater crayfish *Austropotamobius pallipes* (Taylor and Wheatly 1981). Based on these findings, it is recommended that lobsters be allowed to recover for a minimum of eight hours between stress episodes, whilst maintaining DO concentrations of 70-80% saturation or above.

As DO concentrations are directly related to temperature, ranges for long term holding (at 70% saturation) for *J. edwardsii* should be 9 – 13 C at a flow rate of 0.27 – 0.5 L kg-1 min-1 (Battaglene *et al.* 2004). The design and layout of holding tanks was also identified as being critical to lobster survival. Specifically, tanks must allow water (and thus oxygen) to be distributed evenly to all parts of the unit with no "dead spots" of stagnant water flow.

Measuring stress indicators during shipment

Several studies have investigated the stress responses of larger decapods, including *J. edwardsii* to simulated commercial post harvest practices (Waldron 1991; Taylor and Waldron 1997; Morris and Oliver 1999). Roberts and Carragher (in press) have recently attempted to link stress responses with basic handling practices in commercially caught lobsters. Three indicators were identified as suitable measures namely lactate acid, pH and potassium. High levels of lactate acid and the resulting low pH levels are indicators of hypoxic and hypercapnic hemolymph conditions previously described in stressed lobsters. Increases in blood potassium levels are correlated to levels of tissue damage where cells have ruptured and leeched potassium into the blood. The research revealed significant variations in baseline stress indicators between lobsters sampled on the seafloor, during different post harvest handling stages and over time in holding tanks. The presence of an octopus in the pot, boat the lobsters were supplied from and differences in post harvest transportation, all impacted on stress levels in lobsters. In addition, after 72 hours in factory holding tanks, hemolymph ions were still not stable indicating that some lobsters were still recovering from the stress of harvest.

Increasing journey time: future research areas

Crustacean anaesthetics

The ability to lower lobster metabolic rate and therefore ammonia production and oxygen consumption during transportation has obvious commercial benefits. Clove oil, the active ingredient of which is eugenol, has been evaluated as an anaesthetic on a number of crustacean species namely the Dungeness crab (*Cancer magister*), hairy shore crab (*Hemigrapsus oregonensis*) and northern kelp crab (*Pugettia producta*) (Morgan *et al*. 2001) and more recently the American lobster (*Homarus americanus*) (Waterstrat and Pinkham 2005).

Bath treatments of clove oil were successful in immobilising all species with no apparent distress. Induction times were dose dependent and varied between species. Immobilization was most effective in kelp crabs ranging from 2 to 54 minutes at concentrations of 0.015 to 0.25 ml l-1. Shore crabs demonstrated the longest immobilization times that ranged from 87 – 188 minutes and also required the highest dose concentrations (1–3 ml l-1). Recovery times for all species ranged from 10 to 65 minutes and were independent of dosage applied. Clove oil is currently available for testing under the brand name AQUI-STM, a water soluble anaesthetic approved for food use in fish. Effects of eugenol on *J. edwardsii* are currently unknown.

Oxygen supersaturation

Oxygen supersaturation has been identified as a possible tool to increase survival over extended out-of-water journeys. Head and Baldwin (1986) suggested that excess oxygen in lobster hemolymph might be utilised to 1) metabolise anaerobic end products 2) re-establish resting oxygen concentrations in body tissues 3) Replenish high energy phosphate reserves and 4) meet energy costs associated with increased branchial chamber ventilation and hemolymph circulation. Effects of supersaturation on journey times of *J. edwardsii* have not been tested to date.

Innovative packaging

Walker *et al.* (1994) surveyed packaging systems in relation to the commercial transportation of the western rock lobster *P. cygnus*. From this study, the following recommendations were made:

· Better insulated foam boxes with thicker walls and lid should be developed

· Alternative gel packs to be tested

· Further research be conducted into the necessity for and benefits of, holes punched into boxes

· Development of protocol to maintain temperatures within boxes

· Further research to be conducted on coolant materials, alternative fillers and better insulation.

Currently a range of innovative packaging aimed at maintaining low temperature and thus low metabolic rates are being developed specifically for commercial lobster transportation. These include waxed containers with heat-reflective foil surface that have the ability to fit different thicknesses of polystyrene foam to insulate against heat gain/loss. In addition, new gel chill packs with enhanced chill duration properties, as well as CO2 absorption packs are currently available for testing through Sud-Chemi Ltd.

Recommendations

Develop an industry code of practice in South Australia similar to that already established in Western Australia for *P. cygnus*.

Determine effectiveness of new innovations in live export practices to improve southern rock lobster survival and product quality to existing and new marketplaces.

LITERATURE CITED

Battaglene, S., Cobcroft, J., Powell, M., Crear B., 2004. Fisheries Research and Development Corp. Final Report. 2000/252.

Chen, J.C., Chen, J.M., 1997. Mar. Ecol. Prog. Ser. 153, 197-202.

Copes, P., 1978. Resource management for the Rock Lobster Fisheries of South Australia: A report commissioned by the Steering Committee for the Review of Fisheries of the South Australian Government.

Crear, B.J., Forteath, G.N.R., 2001. Recovery of the western rock lobster, *Panuliris cygnus*, from emersion and handling stress: the effect of oxygen concentration during re-immersion. J. Shellfish Res., 3: 921-929.

DeFur, P.L., McMahon, B.R. 1990. Physiol. Zool. 57: 151-160.

Evans, L., Fotador, S., Fan, A., Jones, B. 1999. Fwater. Crayfish 12: 356-370.

Fotedor, S., Tsvetnenko, E., Evans, L. 2001. Mar. Fwater. Res. 52: 1351-1355.

Head, G., Baldwin, J. 1986. Aust. J. Mar. Fwater. Res., 37: 641-646.

Huang, C., Chen J. 2001. Crustaceana 74: 1041-1058.

Linnane, A., Ward, T.M., McGarvey, R., Xiao, Y. Feenstra, J., 2005. Final Stock Assessment Report to PIRSA Fisheries. SARDI Aquatic Sciences Publication No. RD03/0153-2.

Morgan, J., Cargill, C., Groot, E. 2001. Bull. Aquacultural Assoc. Can. 101: 27-31.

Morris, S., Oliver, S. 1999. Comp. Biochem. Physiol. Part A 122: 299-308.

Roberts, M.J., Carragher, J.F. 2005. In press.

Stewart, J.E., Cornick, J.W., Dingle, J.R. 1967. Can J. Zool. 45: 291-304.

Taylor, H.H., Waldron, F.M. 1997. Mar. Fwater. Res. 48: 889-897.

Waldron, F.M., Taylor, E.W. 1991. Ph.D. dissertation. University of Canterbury, New Zealand.

Whitely, N.M., Taylor, E.W. 1990. J. Thermal Biol. 15: 47-56.

Whitely, N.M., Taylor, E.W. 1992. J. Crust. Biol. 12: 19-30.

Stevens, R. 2004. FRDC project Nr. 2002/237.

Taylor, E.W., Butler, P.J., 1978. J. Comp. Physiol. 127: 315-323.

Taylor, E.W., Wheatly, M.G. 1981. J. Exp. Biol. 92:109-124.

Taylor, E.W., Whitely, N.M. 1989. J. Exp. Biol. 144: 417-436.

Vermeer, G.K., 1987 Fish. Bull., U.S. 85: 45-50.

Walker, M. H., Walsh, P. B., Gibson, A. P., Roe, J.A. 1994. FRDC Rep. No. 92/125.09.

Waterstrat, P.R., Pinkham, L. 2005. J. World Aquacult. Soc. 36: 420-423.

Zacharin, W., Ed. 1997. Man. Plan for the South Australian Southern Zone Rock Lobster Fishery. Adelaide, Primary Industries and Resources South Australia: 1-29.

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Development of lobster feeds by NutrKol Pty Ltd

From: Judith Kolkovski

During the past four years my partner and I, who are the founders of NutraKol Pty Ltd, a West Australian based company, have been developing new nutritional additives and feeds for rock lobsters. Our company utilising my skills as nutritionist and naturopath and my partner Dr Sagiv Kolkovski as an expert in marine fish larvae physiology and nutrition. Our joint expertise has resulted in several products that are 'tailor-made' to species and requirements. These products currently include, Artemia enrichments both for lobsters phyllosoma and marine finfish larvae, broodstock nutritional additives and boosters, as well as, algae paste (*Dunaliella salina*) boosts with nutrients such as vitamins and immune stimulants.

We found that there is no product available in the market for nutritional experiments - designed to determine the effect of specific nutrient or nutritional requirements. If a scientist or hatchery manager does not know, or cannot manufacture enrichments or additives, the only other option is to compare commercial available products, effectively comparing 'apples to oranges'. Moreover, when working with new species, it might be that specific ingredient or different ration of ingredients is needed, these specific requirements are not usually cater or available in of-the-shelf products. I, therefore, put my expertise as naturopath and chef into practise and developed several liposome-based enrichments and additives. These were initially used as a tool to determined nutritional requirements in different marine organisms (Ritar *et al.* 2005; Bransden *et al.* 2004; Kolkovski *et al.* 2000, 2005) including western rock lobster, *Panulirus cygnus*, phyllosoma. For example, in an experiment conducted by Liddy *et al.* (2005) western rock lobster, *P. cygnus*, phyllosoma were grown from hatching to stage IV. Larvae were fed with *Artemia* enriched with a (i) base enrichment (Base) containing squid oil or enrichments in which oils high in polyunsaturated fatty acid (PUFA) have been added at the expense of squid oil (ii) base enrichment supplemented with docosahexaenoic acid (DHA) rich oil, (iii) base enrichment supplemented with arachidonic acid (AA) rich oil, or (iv) base enrichment supplemented with DHA and AA (D + A) rich oils. The authors found that by stage IV, the larvae fed the DHA or AA enriched *Artemia* were significantly larger than larvae fed the Base or D + A enriched *Artemia* (Fig. 1). It was found that the addition of AA, and to a lesser extent DHA, to enrichments resulted in increased levels of those FA in *Artemia* and phyllosoma compared with the Base enrichment.

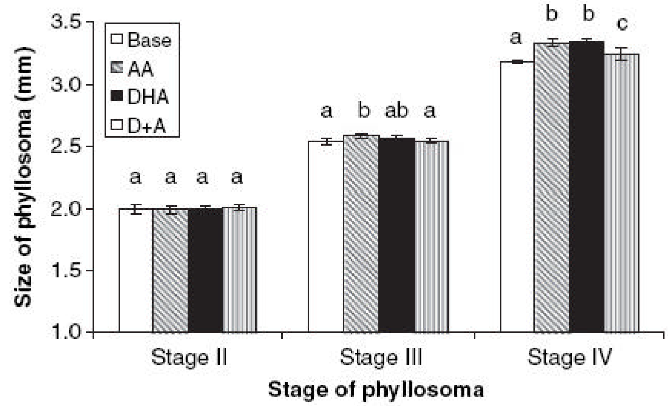

Figure 1 Size of western rock lobster (*Panulirus cygnus*) phyllosoma (mm) after moulting to stage II, III and IV fed the different enrichments (10 larvae from each tub counted, three tubs per enrichment).

Nutrakol has been developing nutritional additives, boosting and enrichments formulas for several research organisations such as the Queensland Department of Primary Industry (QDPI) and Tasmanian Aquaculture and Fisheries Institute (TAFI) and NIWA, New Zealand, as well as commercial companies involved in the development of techniques to propagate *P. edwardsii* and *ornatus* spiny rock lobster. The nutritional additives are incorporated in live diets to improve egg quality, larval quality and to enhance the stress resistance of phyllosoma. During the past three years, collaboration links have also been established with commercial companies and R&D centres in U.S, Mexico, Chile, Spain and Portugal.

NutraKol has also been concentrating on the development of semi-moist diet for lobster puerulus and juveniles. The diet is already stable in the water for 24 hr and juveniles have been found to be extremely attracted by it, resulting in high ingestion rates. However, growth rates are yet to be determined.

Judith in the lab, preparing new remedies.

Another area that we are dipping our fingers in is natural remedies and natural antibacterial and anti-fungal. With the understanding that antibiotics are not sustainable practice and my knowledge as naturopath, we developed several products that can be used during the Artemia enrichment and directly in the phyllosoma rearing tanks. These products are currently been tested and would be soon registered with the Therapeutic Goods Administration in Australia (TGA) for aquatic animal use.

NutraKol is seeking collaboration with other R&D centres as well as companies to test the products and collaborate on nutrition and health issues related to lobsters.

LITERATURE CITED

Bransden, M. P., Dunstan, G. A., Battaglene, S. C., Cobcroft, J. M., Morehead, D. T., Kolkovski, S., Nichols, P. D. 2004. Lipids 39 (3): 215-222.

Liddy, G. C., Kolkovski, S., Nelson, M. M., Nichols, P.D., Phillips, B. F., Maguire G. B. 2005. Aquac. Nutr. 11 (5): 375–384.

Kolkovski, S. 2005. Larvi'05, European Aquaculture Society, special publication, No. 36: 238-242.

Kolkovski, S., Czesny, S., Yackey, C., Moreau, R., Cihla, F., Mahan, D., Dabrowski, K. 2000. Aquac. Nutr. 6: 199-206.

Nichols, P. D., Brown, M. R., Ritar, A. J., Kolkovski, S., Nelson, M. M., Crear, B. J., Dunstan, G. A., Smith, E. G., Thomas, C. W. 2004. Aquaculture 239: 351-373.

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