VOLUME THIRTEEN DECEMBER 2000 NUMBER TWO

The Lobster NEWSLETTER

EDITORIAL

An Electronic Newsletter

With this issue of *The Lobster Newsletter* we begin our transition to an electronic medium. As noted in our final paper issue, the cost of printing and mailing a paper newsletter that had no subscription fee or formal sponsorship was the major reason for this change. We hope that an electronic format will enable us to reduce the production time for the newsletter, but this depends on you - the readers of *The Lobster Newsletter*. By far the most time consuming aspect of producing the newsletter is obtaining a sufficient quantity of articles for an issue. So please send us those intriquing preliminary research reports, provocative letters-to-the-editor, timely announcements, or amusing tidbits concerning clawed, spiny, or slipper lobster biology, fisheries, aquaculture, or management. Given our electronic format, we can now also accomodate color graphics. If you or one of your colleagues are not yet on our electronic mailing list, please complete the mailing list update form on the last page of this newsletter and mail, fax, or email the completed form to us.

- The Editors

RECENT EVENTS

The Sixth International Lobster Conference - a Kiwi perspective

From: John Booth

Of course I would have to say it, wouldn't I, that of the four major meetings in Key West, Florida in mid September 2000, the most interesting was the Sixth International Conference and Workshop on Lobster Biology and Management. Over the weekend before the lobster meeting there was a national gay women's convention, and the weekend after it 26,000 Harley and Harley-clone motorcycles came to town. During the lobster meeting itself there was a recreational fishing meeting as well.

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The lobster meeting was held at the grand and elegant Casa Marina Resort. Built in the 1920s at the end of the Overseas Highway that links Key West with the rest of the Florida Keys and with the mainland, it has seen many hurricanes. During 10-18 September, the time of the lobster meeting and the post-conference field trip, it saw three more. Fortunately two of them were well offshore and had little effect. But the third was more of a threat and I have a great photo taken from the hotel balcony of coconut palms bent groundward by the wind.

Among these coconut palms, on the lawn in front of the hotel, was where the sumptuous conference dinner was held mid-week. This magical setting, right next to the swimming pools, was also where many discussions among the conference folk took place, although it's not altogether clear that many of these involved lobsters.

The Welcome Social on Sunday night set what I felt was the overall tone for the week, which I can summarise like this: 1) a gathering of friendly, interested, and interesting people with overlapping research interests; 2) hosts who were most keen to ensure that everyone got what they expected from the meeting and from Key West, and more; 3) quality research papers and posters that described the vast range of research issues in spiny, clawed, and slipper lobsters worldwide. For those attending one of these meetings for the first time, I doubt that they would have found it a cliquey crowd. For me, it was great to catch up with lobster people in what is now a well established round of meetings; a week is long enough to re-establish without being too long to start getting annoyed with them!

I'm going to leave it to the organisers to tell you more about the nitty gritty of the meeting. Suffice to say that many of the papers will be published in a forthcoming issue of Australia's *Marine and Freshwater Research* and most of us have been refereeing contributions. The proceedings are due out within a year of the conference. Instead I want to tell you about my recreational highlight - seeing the fabulous treasure in Mel Fisher's Maritime Museum. The Atocha was a Spanish galleon on its way home from Cuba when it was wrecked - quite close to where the Lobster meeting was held.

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A magnificent $1 million raw emerald is on display (in what seemed a rather insubstantial case, but the armed guard nearby kept things in perspective). Among the exhibits were gold bars, and gold and precious stone jewellery. And all this from seafloor that is probably within one of Mark Butler's experimental sites.

One of the items on display was a gold boatswain's whistle, which still worked after 400 years in the water. Strangely, at Key West Airport on the way home I found a golden boatswain's whistle on the pavement. Although it was made of brass, it was a nice memento to bring home – and it does work!

About thirty went on the post-conference trip out of Long Key. Here we were able to snorkel in the juvenile lobster habitat of Florida Bay and later to scuba or snorkel the adult grounds on the outer reef. Some inspected puerulus collectors, and were staggered at how small this species is at settlement. We did all this on the edge of a hurricane that was ravaging the coast of western Florida further north. A topic of conversation was just what a great and relatively benign research environment these Florida Keys are, but also what grand use has been made of it by the many lobster researchers who have been publishing all that interesting and very good science over the last couple of decades.

Any low points? The only one I can think of was the poor and falling exchange rate several of us had to endure. Some had to multiply everything by seven!

A wooden plaque with enough date plates to take us well into the century is now passed on to each new conference host. The Tasmanians took the plaque home with them, where the next meeting is to be held there in about three years time.

Congratulations and thanks to Mark Butler, his Conference Organizing Committee, and his student helpers for a great meeting.

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RESEARCH NEWS

Battle within the sexes: the response to adult sex ratios

From: Valerie Debuse, Julian Addison, and John Reynolds

High levels of exploitation in lobster fisheries may lead to decreasing stock sizes and changes in size distribution and size-at-maturity. Less understood is the impact of fishing on breeding systems due to changes in the adult sex ratio. Skewed adult sex ratios will arise if one sex is more heavily exploited than the other (see MacDiarmid et al., 1999), biasing the ratio of males to females that are ready to mate. In clawed lobster (*Homarus* spp.) fisheries, for example, legislation designed to protect mature females is likely to lead to female-biased sex ratios.

The availability of mates may also be strongly determined by the time and energy that each sex contributes to offspring production. If the sex ratio is equal, the sex that contributes more to the young should limit the reproduction of the opposite sex, resulting in more intense competition among members of the limited sex. Clawed lobsters are interesting subjects for studying sexual competition because females contribute more to offspring production than males, by aerating the developing eggs for approximately 10 months. However, unlike many female-care species, the males contribute more than just the production of the spermatophores by mate-guarding the female before and after copulation, which reduces the possibility of extra-pair matings, but may reduce the male's potential reproductive rate.

Using laboratory experiments we investigated whether mate competition among European lobsters (*H. gammarus*) could be predicted by models that relate the intensity of mate competition in both sexes to (1) the adult sex ratio and (2) the time that each sex is unavailable to mate with the opposite sex, which includes time spent in parental care, replenishing somatic and energetic resources, and mating and mate-guarding.

The Models

We ran three models to encompass uncertainty in the details of the reproductive cycle of European lobsters. The first model assumed that a female reproductive cycle lasts one year, during which each female mates with only one male. The second and third models assumed a 2-year female reproductive cycle. For the second model we assumed that females were unreceptive to males during the period of egg retention prior to extrusion (which may last up to one year), whereas the third model assumed that the female remained receptive throughout the egg retention phase. Each model predicted the intensity and direction of sexual competition for a male-biased sex ratio of 4 males:2 females and a female-biased sex ratio of 2 males:4 females, which matched the sex ratios used in our experiment. (For further information on the models, please refer to Debuse *et al*. 1999):

Predictions

The models predicted that male-male competition should predominate over that among females in both male- and female-biased sex ratios, unless females undergo a prolonged period of receptivity (model 3). In this case, we would expect that male-male competition should only predominate in male-biased conditions.

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In addition to testing the models, we were also interested in how competition within each sex responded to changes in the sex ratio. From general evolutionary theory, we expect that both sexes should increase their competitiveness in response to an increase in numbers of their own sex. For example, males should compete more frequently for females in male-biased sex ratios, where there are more potential competitors.

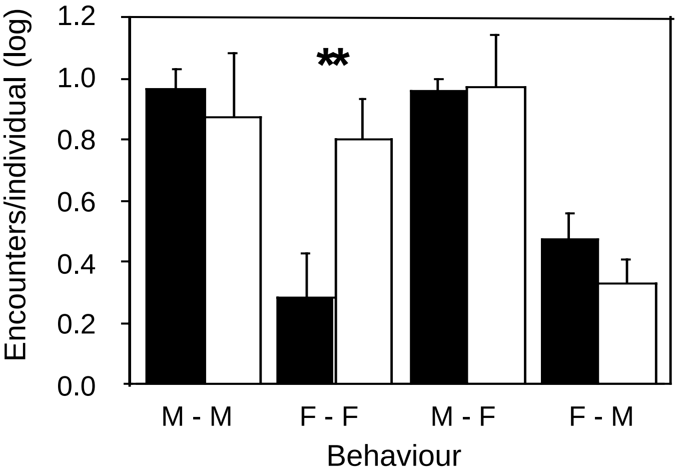

Figure 1. Competition among and between the sexes between males (M) and females (F) in male-biased (solid bars) and (open bars)female-biased treatments (N = 8). M-F and F-M represent encounters in which either males or females respectively were considered as winners. Asterisks indicate significant differences between male- and female-biased treatments ** P <0.01.

Did the models get it right?

We found that male-male competition predominated only in the male-biased conditions (Fig. 1), but competition between females was as frequent as that between males in female-biased sex ratios. Thus the pattern of competition was predicted only by the third model, which incorporated a long period of female receptivity. This may suggest that females may be receptive for longer periods than has been previously thought. Females may gain genetic benefits from this strategy by improving their chances to mate with a genetically superior male, particularly if the sperm of the last mated male has precedence over that belonging to earlier-mated males.
Male competitiveness was unaffected by sex ratio.

Male competitiveness was unaffected by sex ratio

Whereas females increased their competitiveness under female-biased conditions, we were surprised to learn that male-male competition was not more frequent in male-biased sex ratios (Fig. 1). Male-male encounters were longer, but were less intense (measured as the proportion of encounters including claw contact) in male-biased than in female-biased sex ratios. Conversely, females increased the frequency and duration of their encounters with other females in the female-biased as compared with male-biased sex ratios. Two explanations for why males did not increase their competition under male-biased sex ratios are possible. Firstly, males may compete primarily for shelters and not females. In our experiment there were sufficient numbers of available shelters for males even in male-biased conditions which may have suppressed the effects of sex ratios. Secondly, and more likely, is that the frequency of competitive encounters may be a misleading measure if the potential costs of aggression are high and var between the sexes. In our experiment, 46% of male-male encounters included some form of claw contact, in comparison with only 16% for encounters between females. Thus, high costs of aggression in males may have prevented an increase in their competition in male-biased conditions. Exploitation patterns in clawed lobster fisheries may result in female-biased sex ratios, and the relative parental contributions of the sexes would typically predict that such skewed sex ratios would have little impact on female reproduction. Our results however suggest that

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in female-biased conditions, competition for mates is as strong between females as between males and thus female reproduction may be more limited than suggested by the relative parental contributions of the sexes.

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Potential synergistic stressors trigger a mortal infection in juvenile *Homarus americanus*

From: Michael Tlusty, Don Lightner, Jason Goldstein and Brenda White

The American lobster (*Homarus americanus*) has recently been subject of several severe disease outbreaks. The 1999 Long Island Sound fishery was decimated by paramoebiasis and shell disease to the point that federal monies were necessary to assist in the relief effort (NY CT Sea Grant 2000). It is likely that there is one or more stressors in the environment, be it an environmental change, a toxin or a shift in food resources, which is a major factor in making these animals more susceptible to pathogens (Prince et al. 1995, Sindermann 1989). However, the role of stress in triggering or producing disease in lobsters is poorly elucidated.

Of the 1,669 citations for "stress and disease" found in the NISC Aquatic Biology, Aquaculture & Fisheries Resources database from 1971 to the present (NISC 2000), only 15 were concerned with "lobster". The one published example of multiple stressors influencing the subsequent health of lobsters was discussed by Lavallee et al. (1998). They observed that adults caught using mackerel (Scombridae) as bait were more likely to be graded as "weak" at the processing plant compared to animals caught with other bait types. Their rationale was that unrefrigerated mackerel had high bacterial loadings, and this stressor, coupled to post capture handling stress resulted in significant decreases in health indices. As a compliment to this observation, we present an observation of mortality in captively cultured juvenile lobsters that appear to be a result of the synergistic effect of multiple stressors.

The New England Aquarium (NEAq) has operated a lobster hatchery and rearing facility (LRF) since 1987 that has historically provided quality animals of known larval stage or juvenile age for use by neurobiology and molecular biology researchers (Goldstein 1998, Tlusty unpub. data). Hatchery disease incidents tend to be extremely low and for the most part nonexistent. We attribute this primarily to our efficient system design and life support, consistent, disciplined, and well documented husbandry protocols and cultured animals, which are raised individually as opposed to communally. Because embryos are obtained from the wild, gravid females are put through a strict quarantine process before being integrated into

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the rest of the system. Some of the major life support components that contribute to maintaining low disease incidence includes mechanical seawater filtration to 5 µm, UV sterilization, venturi foam fractionation, fluidized filter beds, and gravity sock filtration (Goldstein unpub. data). The worst we have suffered in the past is a minor outbreak of *Leucothrix mucor*, but the excellent attention to water quality and animal husbandry (Goldstein unpub. data) has made the occurrence of disease a rare event.

In March of 1999, the NEAq-LRF shipped 115 fourth stage (0.5 g average weight) early benthic phase American lobsters to the University of Arizona (UAZ) to test if they were susceptible to White Spot Syndrome Virus (WSSV). These animals were all from a single female. While at the aquarium, these animals were fed live enriched *Artemia* nauplii during stage I and II, then weaned to frozen enriched adult *Artemia* at stage III. At stage IV, the animals were placed in “condo trays”, a system used to rear animals individually. Each condo tray measured 12 cm x 24 cm, and was divided into 36 – 4 cm x 2.5 cm compartments, with each compartment holding one animal. These animals all appeared healthy, and the cohort that remained at NEAq-LRF all survived, and grew well.

Pathology

The lobsters were packed for shipping to UAZ in three condo trays, with seven being placed individually in plastic film canisters. They were shipped Federal Express overnight, which is NEAq-LRF’s usual methodology. When the animals arrived at UAZ, they had a high prevalence and severity of bacterial infections. These infections were typically presented in lobsters with an atrophied hepatopancreas (HP) with no (grade 0 or G0) stored lipids. Such HPs showed a generalized intratubular hemocytic congestion interspersed with melanized and unmelanized hemocytic nodules (HEN). Rod-shaped bacteria were apparent in the centers of many of these HEN. While the HP lipid content was not a good indicator of disease state, the other signs of these infections were near 100% prevalence in lobsters that died prior to, or early in the study, but absent in lobsters that survived to termination (day 14) of the study. Of the 16 animals histologically examined, three had HP lipid scores greater than G0, with two of these surviving to day 14. However, 10 of the 11 animals that died during the study had severe HP atrophy, while all five that were sampled on day 14 did not exhibit this condition. This result is identical for the presence of HEN where those dying early in the study were HEN positive, and those five sacrificed at the end of the study were HEN negative. Other signs of symptomatic disease, such as susceptibility to protozoan infection, did not demonstrate any significant trend. Three of the five animals sampled at day 14 had G2 or greater loricate protozoan fouling of the appendages, similar to those that died earlier in the study.

This opportunistic observation on disease mortality in American lobsters is instructive since it links multiple stressors to a mortal bacterial infection. However, the multiple stressors cannot be exactly pinpointed. Shipping stress likely involves a change in water quality or elevated temperature, but could also include physical jarring. As for the physical condition of the lobsters, either chronic infection or poor diet can result in HP atrophy. Thus, while a link between physiological status and stress is suggested, we cannot

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implicate a strict causal chain. However, in this case, the prevalence of HP atrophy and G3 HEN in animals that died upon arrival at UAZ suggests that this state was present prior to shipping. The time between arrival and mortality was to brief to allow for HP atrophy and HEN development. The animals that remained at NEAq demonstrated the importance of the shipping stress in advancing the disease state. When the shipping stress was absent, the animals exhibited virtually no mortality

What this observation suggests is that the NEAq-LRF animals had the ability to survive a single stressor, but it was the synergistic combination of stressors that resulted in a disease state. The rod shaped bacteria and disease state most likely implicate vibriosis. *Virbrio* is ubiquitous in the water at NEAq (Dr. B. Turnbull, NEAq veterinarian, pers. comm.). The *Artemia* are cultured at room temperature for 24 to 48H at 22ºC, conditions that are prone to increased bacterial loadings (Dehasque et al. 1991). Thus, even with UV sterilization, the animals are subject to increased bacterial contact. This background loading makes the lobsters subject to severe disease difficulties when appropriate conditions prevail. Any factor to increase stress in an animal, such as shipping, can decrease the animal's ability to defend against this bacterial load leading to a severe disease state.

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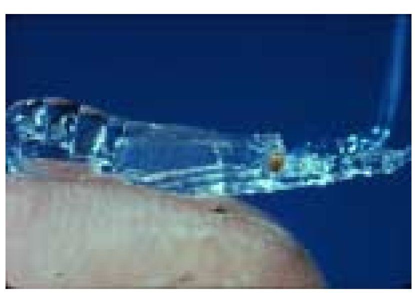

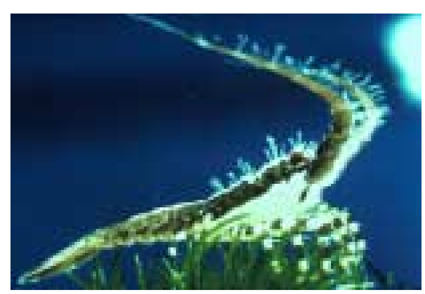

Age vs. size-based growth modeling of spiny lobsters

From: Rodney D. Bertelsen

In August 2000, I developed a preliminary simulation model to "grow" spiny lobsters (*Panulirus argus*) with parameters that would alter the variance of size at a given age. The purpose of this model was to manipulate factors affecting variation of growth in lobsters and examine how the onset of egg production might be affected. An initial discussion of these results was presented at the 6^{th} International Lobster Conference in Key West in September 2000. While experimenting with refinements of this model, I came across an interesting property in the algorithms that calculate growth that I did not anticipate (but in hindsight, should have).

The genesis of these "growth experiments" with the model is that currently, we cannot pick up a spiny lobster in the field and determine it's age. Age is often inferred by size. Larger lobsters are older. Generally, small lobsters have a higher growth rate and this gradually slows with age. However, studies in our wet lab (unpub. data) and elsewhere have shown that starved or injured lobsters will molt with a reduced growth increment or with no growth increment (see Hunt and Lyons, 1986 and Marshall, 1948). Nonetheless, carapace length vs. age figures have been formulated for the Florida Keys lobsters (Muller *et al.*, 1997). I used their formulations as a base equation to calculate an "expected growth" for lobsters in my computer model. This simple model does not factor molt increment or interval but rather averages out monthly growth. Two approaches were then used to calculate growth. One way is to base growth on age. The other is by size. If one takes the size-based approach, expected growth becomes the expected size at age $_{(i+1)}$ minus the expected size at age $_{(i)}$ (i= age in months). These calculations are made despite the current true size of the "virtual" lobster. If one takes the size-based approach, first the current true size is factored into the inverse of the growth equation to obtain a size-based estimate of age (age$_{(hat)}$). Then expected growth becomes expected size at age$_{(hat(i+1))}$ minus expected size at age$_{(hat)}$.

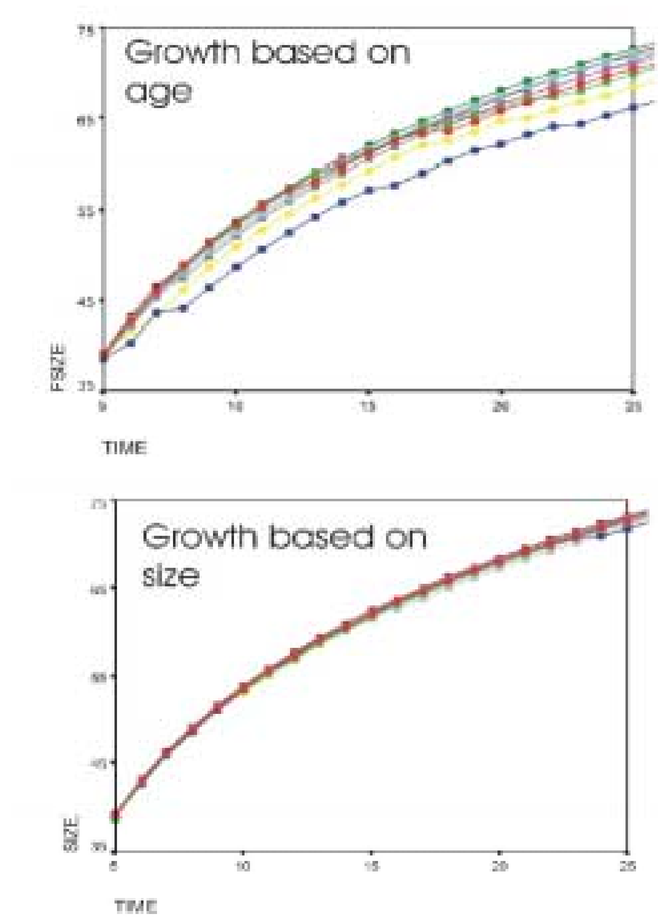

Figure 1: Simulation results for growth based on age (top panel) and size (bottom panel).

Within both approaches, I applied what I assume is a high probability of injury to clearly distinguish properties between the two algorithms. In both simulations, each lobster had a 25% chance of injury each month that could

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reduce expected growth by 10% to 99%. The resulting growth curves for the first ten lobsters in each model run are given in Figure 1. Variation in size at a given age is much greater in the age-based run than the size-based run. In the size-based approach, older but smaller individuals (idiomatically known as "runts") quickly grow back into the mainstream of the population because they receive a greater expected growth rate from the model than their same-aged but larger cohort members. In the age-based approach, receiving a large growth inhibiting injury in an early month, is likely to leave that individual smaller than it's cohort members throughout the model's run.

Are any conclusions possible? Perhaps. "Runts" do exist in nature but their existence does not prove or disprove either of the growth algorithms in this simple model. Growth could have both size- and age-based components as well as individually-based genetic components. However, one thing is for sure, without knowing the age of lobsters defining biological processes from size-based data is an interesting challenge.

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FISHERIES & AQUACULTURE UPDATE

Growth of *Jasus verreauxi* juveniles in captivity

From: Bradley Crear

Jasus verreauxi is being investigated as an aquaculture species in New Zealand (Moss & Tong 1999). Kittaka et al. (1997) and Moss & Tong (1999) commented on the main attributes of this species for larval rearing: the larvae are hardy and have a comparatively short development time. However, little is known of the growth of juveniles in captivity. In the summer of 1998/99 a small number of *J. verreauxi* pueruli were captured in Tasmania and maintained at ambient temperatures (10-18°C) at the Marine Research Laboratories (MRL) of the Tasmanian Aquaculture and Fisheries Institute near Hobart. Their growth was very encouraging even though they were at temperatures much lower than they would normally experience in the wild. Further studies were needed.

Gardner et al. (2000) reported on the capture of a large number of *J. verreauxi* pueruli over the summer of 1999/2000 at Bicheno on the east coast of Tasmania. Some of those animals were brought to the MRL, to see how they would grow at 23°C. Seven pueruli (mean weight = 0.57 g) were placed in a 200 l recirculating glass aquarium. Poor water quality resulted in the death of four of the lobsters when they were around 20 g in weight. The whole group was then replaced with smaller animals that had been held at ambient temperature. All animals were tagged to monitor individual growth by gluing (Loctite) a small piece of numbered

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waterproof paper onto the carapace. When the lobsters reached about 60 g in weight they were antennal tagged using cable ties with small pieces of waterproof paper. They were mostly fed mussels (*Mytilus edulis*), although their response to a formulated prawn diet was also examined. Growth of the lobsters is shown in Figure 1.

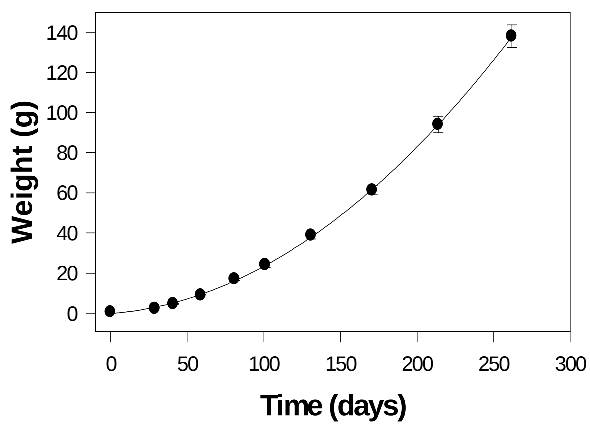

Figure 1: Growth of *Jasus verreauxi* juveniles in an aquarium at 23°C.

The growth rate ($r^2 = 0.99$) is described by the equation:

$$Wt\ (g) = 0.0018\ Time^2 + 0.055\ Time - 0.091$$

Based on this growth curve, *J. verreauxi* would reach a weight of ~ 260 g after 1 yr, considerably larger than Lie's (1969) prediction of 100 g in the wild. However, 23°C is a higher mean temperature than these lobsters would normally experience in the wild. On the other hand, the growth observed in the aquarium was probably lower than the maximum possible. The lobsters had a voracious appetite and when they became heavier than 50g it was difficult to keep up the food supply without fouling the water.

Tagging allowed intermoult periods and moult increments (% weight increase relative to pre-moult weight) to be determined (Fig. 2). As the lobsters grew there was an increase in the intermoult period and a decrease in the moult increment. The moult increment was close to or exceeded 100% for the first 3 moults from puerulus. The response of both parameters to weight (g) is described by two equations:

Intermoult period (days) = 8.78 Ln(Weight) + 5.6 ($r^2 = 0.94$)

Moult increment (%) = -11.98 Ln(Weight) + 103.3 ($r^2 = 0.89$)

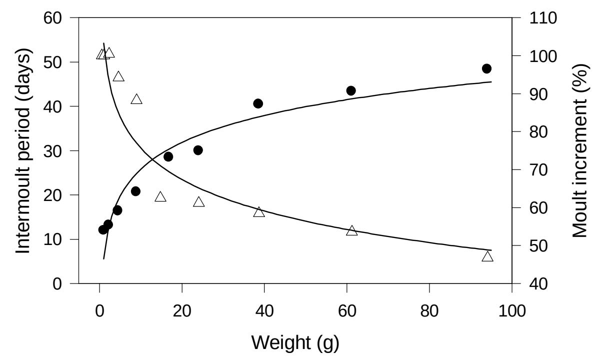

Figure 2: The intermoult period (days)(?) and the moult increment (%)(?) of *Jasus verreauxi* juveniles held in an aquarium at 23°C.

Juvenile lobsters were attracted to and ate not only mussels, but also the formulated prawn diet, and may even prefer the diet. The lobsters were however mostly fed mussels as the high level of carotenoid in the formulated diet caused discoloration of the water. *Jasus verreauxi* appears to be a very social species and no cannibalism was observed. Nor were there any disease problems. However, pueruli and early juveniles appear to be susceptible to low water temperatures: recently caught lobsters held at around 13°C died for no apparent reason but mortalities stopped when they were moved to 18°C water. Older juveniles appear to be able to tolerate and grow in temperatures around 13°C. .*Jasus verreauxi* juveniles grow well in captivity. Further studies are required to determine the optimum culture conditions and the suitability of formulated diets.

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FIRST ANNOUNCEMENT & CALL FOR PAPERS

"Life Histories, Assessment, and Management of Crustacean Fisheries"
September 10 - 14, 2001 A Coruna, Galicia, SPAIN

A Conference Organized by the European Decapod Fisheries: Assessment and Management Program and the European Union

This conference will address a number of themes that have direct relevance to the development of sustainable fisheries for decapod crustaceans starting at the level of life history and progressing through methods of assessment to management policy and regulation. The conference will be in English. Conference themes and keynote speakers include:

Relevance of life history characteristics in assessment and regulation - Dr. Stanley Cobb
Metapopulation concepts - Drs. Nick Caputi, Richard Wahle, and Michael Fogarty
Assessment of the population - Drs. Julian Addison, Andre Punt, F. Maynou, and Mark Butler
Regulatory policies and Methods - Dr. Paul Breen

Oral presentations and poster contributions are now invited. Abstracts of now more than 200 words indicating the relevant conference theme and subtheme, the presenting author, affiliation and whether an oral or poster contribution are now invited. Abstracts should be sent by email to:

otully@tcd.ie

The conference will be held at the Universidade da Coruna (a Coruna, Galicia, Spain), which enjoys panoramic views of the bay and is close to the historical city center and hotels. International air travel connections are available via the a Coruna (Alvedro) and Santiago airports. A list of hotels and registration details will be provided in the second announcement.

Conference Organizers:
Dr. Oliver Tully (EDFAM Coordinator - Trinity College, IRELAND), Dr. Juan Freire (Conference Host - Universidade da Coruna, SPAIN), Dr. Julian Addison (CEFAS Laboratory, UNITED KINGDOM), Dr. Stefanos Kavadas (National Centre for Marine Research, GREECE), and Mr. David Symes (University of Hull, UNITED KINGDOM).

THE LOBSTER NEWSLETTER MAILING LIST UPDATE

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Contact any Editor about submission of articles.

Comments on final editing and production should be sent to Mark Butler.