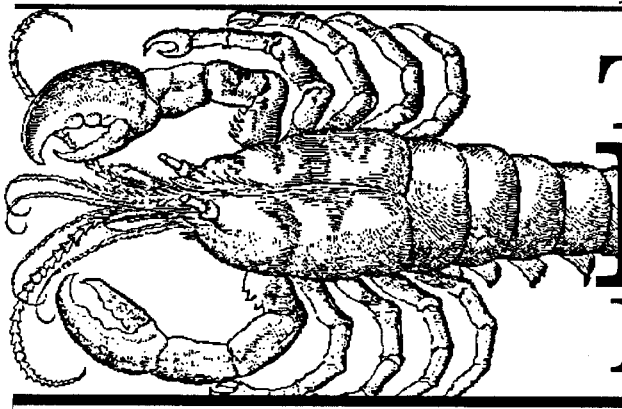
VOLUME THREE JULY 1990 NUMBER TWO



The Lobster NEWSLETTER

RECENT EVENTS

Conferences in Cuba and Canada

Lobster researchers could have spent a lot of time travelling recently. During the time from June 12 to July 9 three important meetings featured lobster research. First was the International Workshop on Lobster Ecology and Fisheries, held in Havana, Cuba from June 12 to 19, 1990. Second was the ICES Shellfish Symposium in Moncton, Canada June 25-29. Finally was the Third International Crustacean Conference in Brisbane, Australia, July 2-9. We will report on the first two here, and expect that one of our intrepid and well-travelled readers will let us know about the third.

About 85 people from 16 countries attended the Lobster Workshop at the International Conference Center in Havana, Cuba. The workshop was hosted by the Ministry of Fisheries, and well organized by a committee headed by Dr. Julio Baisre. The topics ranged from larval and juvenile ecology to population dynamics, stock assessment and resource management. The majority of the papers presented during the five-day workshop were about spiny lobsters, with greatest representation being research from Australia, Cuba and Mexico. Simultaneous translation was available, thus papers presented in either Spanish or English could be understood by the entire audience. Elsewhere in this issue are reports of the session chairmen, presented as a summing-up at the end of the conference. A Proceedings of the Conference will be published, but will not be available for at least a year. Thus, it seemed appropriate to have a more rapid dissemination of this informal summary of the meeting through The Lobster Newsletter.

The International Council for the Exploration of the Sea, along with Fisheries and Oceans Canada, sponsored the symposium, "Shellfish Life Histories and Shellfisheries Models" in Moncton, N.B., Canada. The meeting was somewhat larger than the Cuba workshop, with 134 participants from a wide variety of countries, mostly from the northern hemisphere, and, by and large, concentrating on North Atlantic shellfisheries. Papers from this symposium will be gathered in a single issue of the ICES Rapports et Proces-Verbaux. Highlights of the symposium (from the point of view of a lobster researcher) also are found elsewhere in this issue.

CONTINUED ON PAGE 2

RESEARCH NEWS

Serial Monogamy in *Homarus americanus*

Although mating in American lobsters has never been seen in the field, it is easily observed in large aquaria. Here, I will summarize the results of skewed sex ratios on courtship and mating behavior. In my experiments, the sex ratio was skewed in three ways: toward females (2M:5F); toward males (4M:2F); and females in the absence of males (0M:5F) in 5,600 liter naturalistic aquaria. Varying the sex ratio has a dramatic effect on the timing of molt female molt. We recently have reported these results in the literature (Cowan and Atema 1990), but thought they would be of interest to readers of The Lobster Newsletter.

Typically, when a mature female lobster is about to molt, she seeks a mate and moves into his shelter. A few to several days later, she molts inside this shelter. It takes about 1/2 hour for her shell to harden enough to permit her to stand. The male then approaches, and helps her to roll over. The pair fan their pleopods against one another just before the male intromits. Copulation lasts a few seconds, after which the female tail flips out from under the male. The female remains in the male shelter for one to several more days, then leaves, never to return.

CONTINUED ON PAGE 2

RECENT EVENTS

CONTINUED FROM PAGE 1

Lobster Hatchery Fire

Several months ago, a fire damaged the lobster hatchery on Martha's Vineyard, Massachusetts. The hatchery was constructed in 1949 following the passage of an act by the state legislature of Massachusetts. According to an article in the Boston Globe newspaper, it is "... the oldest, continuously operating lobster research station and hatchery in the world" (any challenges to this claim?). The fire caused considerable damage to the upstairs portion of the structure, destroying laboratory bench space, library and offices. The hatchery proper was not affected, nor was there a loss of broodstock or larvae. The State is undergoing fiscal restraint. It appeared as if State funds for rebuilding would not be forthcoming; hence, townfolk and the Massachusetts Lobstermen's Association have rallied in support of the hatchery. A fund-raising group, Friends of the Lobster Hatchery, was formed and a benefit dinner held. The State Division of Capital Planning Operations has now allocated funds for structural repairs, but monies for books, desks, etc. destroyed in the fire, will have to be obtained elsewhere. It appears that the hatchery will be continue to supply larvae to the coastal waters of Massachusetts, the objective being to enhance natural lobster production.

The founding director of the Hatchery , John Hughes, retired in 1984. Current hatchery information can be obtained from station chief Michael Syslo at The Massachusetts Lobster Hatchery, P.O. Box 9, Vineyard Haven, Massachusetts, USA.

RESEARCH NEWS

CONTINUED FROM PAGE 1

When two mature male and five mature female lobsters were communally held in large aquaria, the females staggered the timing of their molts at precise intervals throughout the summer to mate with the dominant male. This molt staggering resulted in a mating system of serial monogamy. In this situation, the males lived in shelters at opposite ends of the tank. The females lived in intervening shelters or in cinderblocks at the rear of the aquarium. Each night the dominant male ("M"), made excursions through the tank, without hesitation evicting whoever happened to be in the shelters. When "M" returned to his own shelter, the other lobsters investigated his shelter entrance.

About a week after the beginning of the experiment, a female moved in with "M" molted and mated with him in his shelter, remained a few more days, and then moved out. Another female then moved in, molted, mated, stayed a few more days, moved out, then another female moved in, and so on, until all of the females had mated with the shelter of the dominant male. The order in which the females molted was not related to dominance or to the amount of shelter checking. The subordinate male usually remained alone, but he did sneak at least one copulation while the dominant male was out of his shelter.

This unusual mating pattern was seen in four experiments when the sex ratio was skewed toward females. Molting is an important and inevitable physiological event under hormonal control. What's particularly intriguing about the lobster mating system is that the female molts are timed in such a way that each female in turn mates with the dominant male. How can female lobsters stagger the timing of molting?

Skewing the sex ratio toward males resulted in utter chaos. Initially, Sara Ellis and I introduced 4 males and 2 females into each tank, but the aggression was so intense that we removed one of the males after two days. There was no consistent male dominance and not one male ended the experiment with all appendages intact. One male was crawling around on his maxillipeds at the end of the season. Another male attempted intermolt mating by dragging one female into his shelter, mounting, and trying to turn her over, but each time she escaped. The females in these two experiments delayed molting. Two out of four molted, but apparently couldn't decide which male to pair with and moved in and out of up to three male shelters each day (for over 10 days) before molting.

When five females were housed together in the absence of males, most simply put off molting. In four replicates of 5 females each, only four out of 20 females molted. All of the females who molted sustained serious injuries (loss of claws and/or walking legs). This suggests that the male protects the female from injury and predation while her shell is

The Lobster NEWSLETTER

Editors:
J. Stanley Cobb
Department of Zoology
University of Rhode Island
Kingston RI 02881 USA

John Pringle
Fisheries and Oceans
PO Box 550
Halifax B3J 2S7
CANADA

The Lobster Newsletter is cosponsored by Fisheries & Oceans, Canada and the Rhode Island Sea Grant Program

Design & Layout: Ken Davignon
Mailing & Coordination: A. Juinio
The Lobster Newsletter is published twice yearly. Please send change of address to John Pringle.

soft during postmolt cohabitation.

In summary, when a dominant male is in the tank, females molt; when a male is not present, they generally don't molt. Perhaps female lobsters have some sort of control over their molting and therefore, reproduction. In mammalian social systems such control over reproductive events is known to be mediated by primer pheromones. For example, olfactory cues synchronize menstrual cycles of women in college dormitories. In mice, exposure to male urine accelerates the onset of puberty while exposure to female urine causes delays. Since lobsters can discriminate sex based on odors and have a sensitive olfactory system it seems possible that chemical communication may similarly influence the timing of molting in female lobsters.

While the female is checking at the dominant male shelter, odors are exchanged via three currents generated by the lobster. First, by fanning his pleopods, the male creates a strong current, drawing water through the shelter. Second, the female gill excurrent projects into the male shelter. And thirdly, the female, by fanning the expodites of the third maxillipeds, reverses the direction of the gill excurrent. Urine is released directly into the gill excurrent. Lobsters, like dogs and other mammals, may have informative urine, in lobsters it may contain metabolites of molting hormones, and indicators of sex, age, maturity, and perhaps dominance and social rank.

Currently, I am testing the hypotheses that male odors accelerate the timing of female molting, that female odors delay the timing of female molt, and some combination of male and female odor causes molt staggering such that serial monogamy results. In the situation with two males and five females, if the first female to mate smelled only male odor when she checked the male shelter entrance, perhaps her molt was thereby accelerated. The next female may have smelled both male and female odor every time she checked the she checked the shelter entrance, influencing her to wait. Once a female is in the male shelter she probably gets nothing but male odor, and so she molts.

This work enhances our knowledge of mating system ecology, social behavior, and chemical communication in general. It may also have implications for fisheries management and for lobster aquaculture.

REFERENCE

Cowan, D. E. and J. Atema 1990. Animal Behaviour 39: 1199-1206.

Diane F. Cowan
Boston University Marine Program
Marine Biological Laboratory
Woods Hole, MA 02543, USA

Slipper Lobsters in Australia

Attention paid to Scyllarid lobsters ("Slipper Lobsters") has been minimal in comparison to both clawed and spiny lobsters, primarily because of their lesser commercial significance. In northern Australia however, Scyllarid lobsters of the genus *Thenus* are well represented in the commercial penaeid catch, and as such provide a valuable ' by catch'. Less than 15 years ago these odd-looking crustaceans were considered as trash and treated accordingly. Now, however, they are much sought after and fetch a premium price as a gourmet seafood.

Consequently, there was sufficient economic justification for primary research, conducted, over the period 1984 to 1988, within the Fisheries Research Branch of the Queensland Department of Primary Industries (Jones, 1988). In addition to the collection of fishery statistics and formulation of resource management options, considerable effort was focused on describing the basic biology of this lobster, and what a fascinating biology was discovered!

What was originally considered to be a single species, *Thenus orientalis*, emerged as two allopatric species (the second of which is yet to be described), which are effectively separated by mutually exclusive substrate preferences (Jones, in press). Unlike the majority of lobsters, *Thenus* is an inhabitant of the open unconsolidated sediments lying between the coast and adjacent coral reefs and between reefs further offshore. *Thenus orientalis* inhabits the more coastal areas where soft muddy sediments prevail, while *Thenus sp. nov.* prefers inter-reef areas characterised by coarser sand sediments.

Thenus has developed a lifestyle, apparantly unique amongst lobsters; it actively swims during noctural foraging, covering large distances. This serves to meet its relatively specific and predatory feeding habit. The 'free-swimming', like the escape response, involves backward movement generated by regular tail flips. Gross morphological modification, including dorso-ventral compression, lateral expansion of the carapace, and extreme reduction of antennae and body spines have resulted in a very streamlined, energy efficient, swimming shape. The marginal positioning of the eyes allows backward vision.

In the context of optimal foraging theory, I have hypothesised that bursts of free-swimming, during each foraging period, serve to regularly relocate lobsters in an environment characterised by patchy distribution of potential prey. Swimming provides an energy-efficient means of moving up to several hundred metres at a time, to where preferred prey may be more abundant. If food searching activity does not result in capture of prey, swimming allows the animal to relocate. *Thenus sp .*

CONTINUED ON NEXT PAGE

RESEARCH NEWS

CONTINUED FROM PREVIOUS PAGE

spend up to 70% of their active period, during hours of darkness, in food searching and feeding. While resting, this lobster conceals itself by burying into the soft substrate leaving only the eyes and antennules exposed.

Experiments have suggested that bivalve molluscs and some small benthic fish and crustacean species are preferred. It is clear from exhaustive tank observations that *Thenus*, using predominanatly chemotactic cues, will lunge forward and grasp food organisms with all five pairs of pereiopods. Their particular preference for bivalves is facilitated by a well developed and finely co-ordinated ability to manipulate and open these molluscs.

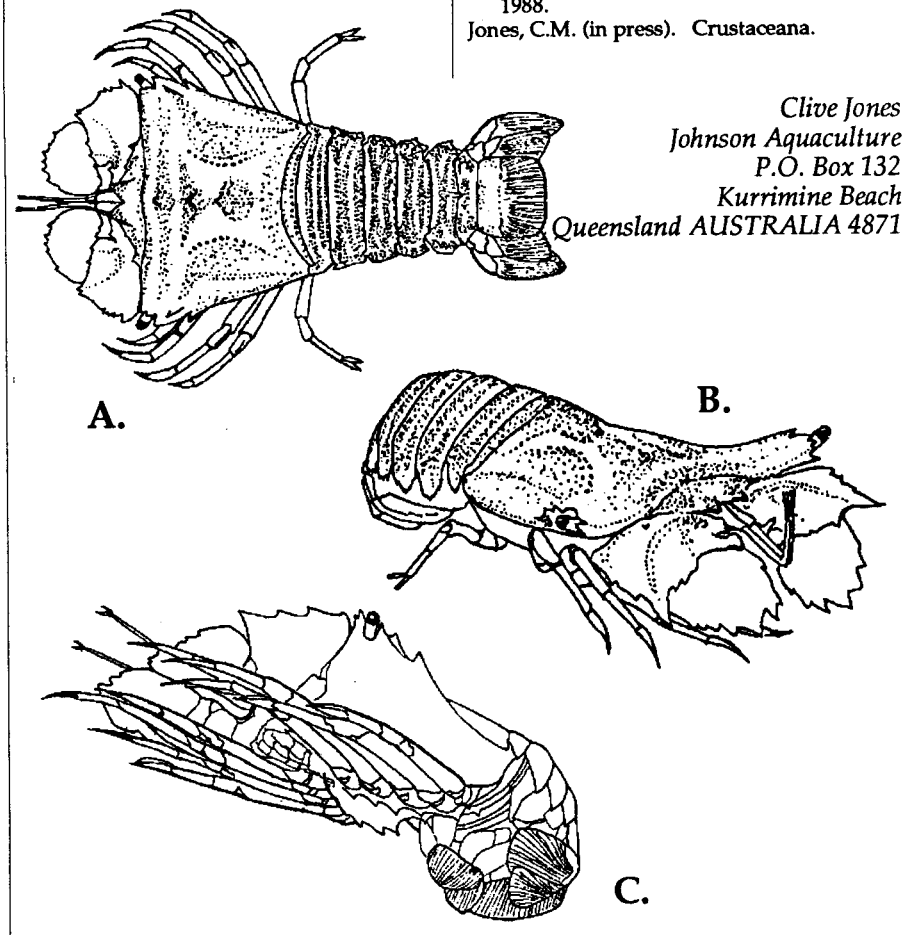
A conspicuous absence of agonistic behaviour and of dominance/subordinate hierarchies suggests that individuals of these species rarely interact. Courtship and mating behaviour, as described for clawed and spiny lobsters, were similarly absent. Again, environmental effects are considered responsible. The coastal sedimentary environment is characterised by its limited complexity and relatively low carrying capacity. Nevertheless, *Thenus* effectively exploits this environment, primarily by virtue of advanced mobility. Although this genus has much in common with spiny and clawed lobsters, its specialized morphology and behaviour are truly remarkable!

REFERENCES

Jones, C.M. 1988. The Biology and Behaviour of Bay Lobsters, *Thenus spp.* (Decapoda : Scyllaridae), in Northern Queensland, Australia. Ph.D. Thesis. University of Queensland, Australia, 1988.

Jones, C.M. (in press). Crustaceana.

Clive Jones
Johnson Aquaculture
P.O. Box 132
Kurrimine Beach
Queensland AUSTRALIA 4871



Three views of Thenus: *A: Dorsal; B: Fronto-lateral;, C: Ventral (in swimming position).*

Immuniobiology of the Indian Sand Lobster *Thenus orientalis* (Lund)

The intensive culture methods of shellfishes such as prawns and lobsters imposes physiological stress on the animals and increases the incidence of diseases. In aquaculture practice, only antibiotics are routinely used to control the growth of pathogenic organisms (Pillai 1984). However, prophylactic measures to prevent occurrence of diseases in cultivatable organisms are desirable. This requires a sufficient knowledge of immune system function.

The internal defense system of invertebrates is known to discriminate self and non-self, but the mechanisms of this recognition remains elusive (Ratcliffe et al. 1985). Agglutinins (=lectins), glycoprotein/protein molecules capable of binding to specific carbohydrate moieties (Goldstein et al. 1980) are widely distributed in the tissue and body fluids of invertebrates (Yeaton 1981; Mullainadhan and Renwrantz 1989), have long been implicated to be involved in internal defense reactions. Recent studies in a mollusc and a prochordate have unambiguously demonstrated the participation of humoral agglutinin in non-self recognition and subsequent stimulation of phagocytic activity of circulating blood cells or hemocytes (Renwrantz and Stahmer 1983; Coombe et al. 1984). This suggests that humoral agglutinins of invertebrates probably act as recognition molecules and may well function during immunobiological events.

We have recently started research on a marine lobster *Thenus orientalis* (Lund), in the family Scyllaridae, found in the coastal water of India. The aim of this work is to acquire knowledge on the functioning of the immune system with particular reference to the role of humoral agglutinins in the immune reactions of the lob-

ster. The proposed research work in *T. orientalis* involves (1) preparation and purification of agglutinins from blood, (2) physico-chemical, serological and immunological characterization of purified agglutinins, and (3) testing the participation of humoral agglutinins in lobster immune functions such as recognition, phagocytosis and encapsulation of foreign materials. The outcome of this research work should be useful in formulating prophylactic measures for the control of diseases associated with insufficient functions of immune system of cultivatable shellfishes.

REFERENCES

Coombe, D.R., P.L. Ey and C.R. Jenkins, 1984. J. Comp. Physiol., 154B:509-521.

Goldstein, I.L., R.C. Hughes, M. Monsigny, T. Osawa and N. Sharon, 1980. Nature, 285:66.

Mullainadhan, P. and L. Renwrantz. 1989. J. Comp. Physiol., 159B: 443-452.

Pillai, C.K. 1984. Hand book on diagnosis and control of bacterial diseases in finfish and shellfish culture, CMFRI Spl. Publication No. 17, Cochin, India, 50 p.

Ratcliffe, N.A., A.F. Rowley, S.W. Fitzgerald and C.P. Rhodes, 1985. Int. Rev. Cytol., 97: 183-350.

Renwrantz, L. and A. Stahmer, 1983. J. Comp. Physiol., 149B: 535-546.

Yeaton, R.W. 1981. Dev. Comp. Immunol., 5: 391-402.

P. Mullainadhan
Department of Zoology
University of Madras, Guindy Campus
Madras 600025, INDIA

Mediterranean Lobsters in Ancient Times

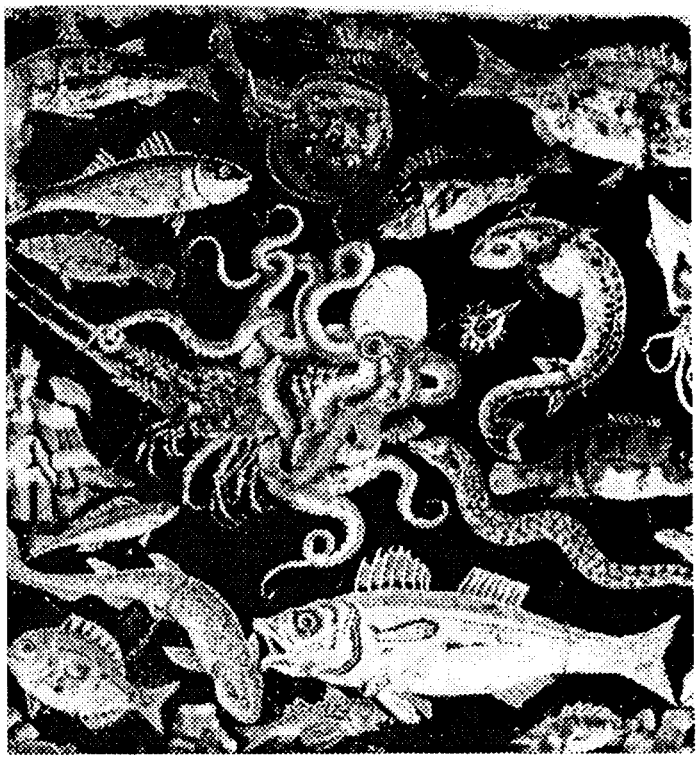
The people from the Hellenistic-Roman era probably did not have a lobster newsletter, yet, they were well acquainted with lobsters. This can be witnessed from the writing of Athenus (3 century A.D.) "The eating of the spiny lobster was extremely popular, as may be shown by many passages in comedy ...(Diepnosophistae III, 104-105).

Our ongoing research on the Mediterranean slipper lobster *Scyllarides latus* was supplemented by information (writing and art) from ancient sources. Different species of lobsters share many behavioral and ecological characteristics (Phillips et al., 1980), thus, we used historical information on lobster species other than *S. latus* to extend the biological knowledge on *S. latus* in the Mediterranean area (for further details see: Almog-Shtayer, 1988; Almog-Shtayer et al., 1988).

Reference to lobsters in the classical Hellenistic-Roman period are found mainly in the writings of Aristotle, Pliny the Elder, Plutarch, Oppian and Aelian. Lobsters were illustrated mainly in Roman mosaics. The most difficult problem we had with ancient sources is that of identification. The written evidence, as well as that from art, indicated that the ancients had knowledge of the general groups of edible crustaceans. However, they did not always use the same name for the same genus or species. Two main terms were used to describe lobsters - "Astacus" and "Carabus". The first term was identified usually with the European clawed lobster, *Homarus gammarus*, but sometimes it stood for the Norway lobster *Nephrops norvegicus*. Both are found in Mediterranean waters. The term "Carabus" was used in some instances to describe the common Mediterranean spiny lobster *Panulirus elephas*, but sometimes it was used, again, to describe the Norway lobster. It is possible that the family Scyllaridae was mentioned by Aristotle under the name Arctus, but the information offered by Aristotle is insufficient to prove this.

The ancient sources dealt mainly with lobster habitat, mating behavior, molting, migration homing and fishing methods. Their most significant contribution to modern

CONTINUED ON PAGE 12



Part of a mosaic from Pompeii illustrating the predator-prey interaction of lobsters and octopus

MEETINGS

International Council for the Exploration of the Sea Symposium: Shellfish Life Histories and Shellfisheries Models

The theme of the symposium dealt with "Shellfish life histories and shellfishery models — description and modelling of life cycles for survey and management of invertebrate stocks." This theme covered a wide variety of topics applied to several groups of invertebrates, among which lobsters of all kinds were represented. It was particularly interesting for me to see the recent developments on lobsters, since I was just back from a 5-year interruption of my active "lobstering" activities. Presentations on lobsters reflected the diversity of interests and problems regarding the numerous species involved. In the account that follows, the names cited within parentheses refer to the authors as listed in the abstracts for the Symposium.

The early life history of homarid lobsters remains a major topic of research. The transport of *Homarus americanus* larvae from the offshore deepwater canyon areas towards coastal Rhode Island could be modelled using wind, current and larval swimming (Katz and Cobb.) The critical importance of the postlarval stage for the overall survival was emphasized by several studies. Temperature and food availability affect the RNA/DNA ratio over the molt cycle, which could lead to the development of an indicator of the nutritional status of postlarvae in nature (Juinio and Cobb). Laboratory studies of benthic postlarvae reiterated their well-defined shelter preference (Boudreau, Bourget and Simard), and stressed modifications in behavior induced by the presence of a predator (McKenzie and Cobb). Field studies showed that hatchery-reared *Homarus gammarus* released in nature survived to adult stage and could potentially contribute to the commercial catch. The short-term (van der Meeren) and long-term survival of released lobsters were documented in Norway (Tveite and Grimsen) and in England (Bannister, Addison and Howard, presented at the International Lobster Workshop in Cuba). Although the economic viability of stock enhancement is still to be demonstrated, recaptures of released animals should provide important information on growth and dispersion of small individuals.

The measurement of growth rates remains a topic of interest, and techniques for aging lobsters are particularly needed. The implantation of a piece of lobster cuticle in the abdominal musculature of a specimen results in the formation of a cyst which is surrounded by a layer of cuticle at each subsequent molt allowing the cyst to be "read" like tree rings (Shelton and Chapman). Thorium and radium activity in the exoskeleton was used to determine the time elapsed since the last molt of an animal (Latrouite, Reyss, Noel and Brichet). Growth, life history parameters and population size can also be evaluated indirectly through a variety of models (Idoine; Bennett; Waltz; Castro; Burr, Galluci and Orensanz; Jayakody). Methods relying on population size structure derived from trap-caught animals should allocate for gear selectivity on size, since catches do not necessarily reflect actual population structure (Miller; Pezzack). The availablity and accuracy of other basic population parameters (Sarda) such as life-history sequence (Ennis; Bannister, Addison and Bennett), recruitment processes (Fogarty), fecundity (Estrella and Cadrin) and size at maturity (Free, Addison and Tyler) also are important for the understanding of factors regulating populations under exploitation. Composite satellite images of primary productivity in the Mediterranean showed strong influences of cities and rivers; might the increased local productivity be associated with the continued high production of fish and lobster stocks (Caddy)?

Over 100 papers and 40 posters were presented during the week, which was also punctuated by various (planned as well as impromptu) social activities, including a banquet and a beach party. As is often the case with such meetings, informal discussions outside the conference halls (especially with a cool drink, to compensate the warm weather) were also very enlightening.

Partly because of the North American location of the Symposium, homarid lobsters were better represented than the other groups. Informal talks with colleagues kept bringing forward the contrasts rather than the similarities betwen "populations" (loosely defined at best.) Variability appears to be high among populations of *Homarus americanus* with respect to life history parameters, as well as other ecological and behavioral characteristics (for example, larval dispersion versus retention, extent of larval vertical migration, adult seasonal movements versus long distance migrations.) Is *H. americanus* such an adaptable species that no generalized pattern can be inferred? However, one remarkable common feature is represented by the general, yet so far unexplained, increase in landings observed through the last few years throughout the range of *Homarus americanus*. Are we looking so closely at the beast that we are

oblivious to their global regulation by a few limiting factors? As far as catch predictions are concerned, the success story with the Western Rock Lobster (*Panulirus cygnus*) in Australia shows that it can be done (Caputi, Brown and Phillips; Hall and Brown.)

Christiane Hudon
Department of Fisheries and Oceans
P.O. Box 550, Halifax N.S.
CANADA B3J 2S7

International Workshop on Lobster Ecology and Fisheries

The Cuba workshop embraced a wide variety of topics and inspired considerable discussion. A proceedings of the workshop will be published, but The Lobster Newsletter offered to print the summaries of each of the sessions as submitted by each of the session chairmen. This is not meant to be a complete review of the conference, but to give a flavor of the papers and the discussion. Each summary, of course, represents the personal view of the chairman, and not an official statement of the workshop.

Postlarval Habitats, Artificial Shelters and Stock Enhancement

As the title suggests, this session focussed on habitat relationships of the youngest benthic stage lobsters. Among the ten papers in the session, six were on aspects of the ecology of postpueruli of *Panulirus argus* in Cuban waters, two reported on *P. cygnus*, one on *Homarus gammarus*, and one was a theoretical approach to juvenile growth and mortality. Following are some of the highlights:

- There has been a lot of work on the ecology of the postpueruli of *P. argus* on the southwest shelf of Cuba. The pueruli are found in quite high densities and are associated with the red alga *Laurencia*. An ecological study of the Bocas de Alonso suggested that it is a nursery area for juvenile *P. argus*. There is a seasonality to the size structure of the population, suggesting specific times of recruitment of postpueruli and of emigration of older juveniles.

- A close examination of the fauna on larval collectors showed that it varied monthly and was not correlated with numbers of puerulus collected.

- *P. argus* postpueruli eat small prey such as forams and copepods, and a comparison of stomach contents with prey available suggests that they are opportunistic feeders.

- The use of artificial shelters for *P. argus* was tested in the laboratory; preference tests indicated a choice of black colored shelter.

- Juvenile *P. cygnus* include plant material in their diet, but only coralline algae, as opposed to seagrass and fleshy algae, seems to contribute significantly to the energy requirements of the animal.

- The importance of testing assumptions when making estimates of abundance and mortality was emphasized by the Western Australia experience. A review of research on juveniles showed that the early notion of density dependent mortality of *P. cygnus* on nursery reefs was predicated on assumptions that there was no movement between patch reefs and that the lobster trap is an unbiased sampling device. Neither of these assumptions have withstood close examination.

- The technique chosen to assess the merits of restocking of *Homarus gammarus* by the release of young juveniles into specific areas off the English coast is proving successful. Animals microtagged and released several years earlier are showing up in the fishable stock, and in about the same location as they were released.

- Crevice-dwelling animals must become habitat limited as they grow larger. The fractal nature of the substrate predicts that crevice availability declines with size. Theoretical consideration was given to the size frequency of the radii of holes needed to complete the life history of a crevice-dwelling animal with given mortality and growth schedules.

The nature of the majority of the contributions might be called "descriptive ecology," which might seem a bit surprising for the relatively well-developed field of lobster ecology. A comparison with the 1985 lobster recruitment workshop seems appropriate in this regard. At that time, we were still fumbling for stock-recruitment relationships (SRRs) by measuring larval abundance and recruits to the fishable stock. The Australians had not yet developed correlation coefficients between larval abundance and stock that most of us would envy for a length-weight relationship. But at that time, there was a very large gap in our knowledge — we did not know where the newly settled animals lived, and most of the early benthic ecology was a mystery. Nobody had found *Homarus* early benthic phase animals in any quantity, the Australians still thought that *Panulirus cygnus* lived among *Posidonia* fronds, and the *Laurencia—P. argus* relationship was only just being described by Bill Herrnkind.

Where are we now? We know that *P. cygnus* lives in limestone holes, not *Posidonia*, and the nursery habitat of *P. argus* has been described in some detail in both Florida and Cuba. Rick Wahle, of the University of Maine, one of the many Americans who was unable to come to the workshop, has shown us how to sample quantitatively for early

CONTINUED ON NEXT PAGE

MEETINGS

CONTINUED FROM PREVIOUS PAGE

benthic phase *Homarus americanus*, adding significantly to Christiane Hudon's work with newly settled and juvenile lobsters in Canada. These findings are in one sense, nothing more than good, descriptive ecology. In another sense, they are a breakthrough, for it means that we can now follow up and really learn something about the early life history of these animals. It may, for instance, allow us to test some of the fractal dimension theory that John Caddy has been advocating, suggesting complex relationships among crevice size, animal size, migration and mortality. This is an important topic to investigate, since in the juveniles of both spiny and clawed lobsters, the animals live individually in small crevices, molting is frequent and moving from a crevice that has become too small can be dangerous. Since the last workshop in '85, Caddy's theoretical approach has taken another step but we still have no experimental data.

It appears to me that we still need a great deal of work on the basic natural history of early benthic phase lobsters, both spiny and clawed. Unfortunately, these stages are not easy to sample: the cautionary tale from Western Australia illustrates what can happen. The problem of sampling warrants considerable attention. Very little is known about growth rates of the young juveniles in the field. Measurement of growth and experimental approaches to understanding what factors influence growth rates in the field may be a critical next step. Understanding natural mortality is much harder, but of equal importance. Caddy has provided part of a theoretical framework; now lab and field work have to catch up.

J. S. Cobb
University of Rhode Island
Kingston, RI 02881 USA

Ecology and Movement

This session contained 6 papers on ecology (particularly with respect to feeding) and movement. One paper dealt with clawed lobsters, the rest with spiny lobsters. An additional paper summarised catch information for both groups of lobsters throughout the world, and also presented satellite images of production in the area.

Stan Cobb presented a paper examining the influence of predation risk and food deprivation on the activity and feeding behaviour of juvenile American lobster in aquaria. In the presence of a predator, lobsters deprived of food for 60 hours spent less than one third as much time foraging and ingested one third as many calories as in the absence of a predator. Lobster deprived of food for 12 hours spent equal amounts of time foraging in the presence and absence of a predator, but decreased the number of calories consumed when a predator was present. Lobsters appeared to trade off energetic considerations against risk of predation when foraging. To lessen risk of predation they reduced the time spent feeding and their caloric intake.

Alejandro Herrera presented a paper on the food and feeding of *Panulirus argus* at depths of 7-30 m south of Los Indios Cays, off Cuba, in relation to the macrobenthos. Greatest amounts of potential food were available in sea-grass areas at depths of 7-10 m. The most abundant items in the gut were gastropods, anomurans, brachyurans, bivalves and urchins. There was no difference in gut content between sexes, but there was a significant difference between size of lobster and prey size. Food and shelter were abundant in the study area.

Alejandro also presented a paper on the ecology of the reefs within and at the edge of the south-western Cuban shelf, with particular reference to *Panulirus argus*. Reef development was limited. The circulation within the macrolagoon strongly influencing the geomorphology and ecology of nearby areas. Lobsters were most abundant in areas with little reef development, where currents could entrain larvae and carry them seaward. Observations made from a submersible indicated that vertical walls from 30 to 300 m deep offered little shelter, had strong downward currents, and carried higher numbers of large predators, and are therefore unlikely to sustain large populations of lobsters.

Gaspar Gonzales spoke on the bioecology and behaviour of *Panulirus argus* near the edge of the shelf off south-western Cuba. Lobsters in these deeper waters are larger than those inshore, and females are almost twice as abundant as males. These animals did not increase movement when cold fronts passed by, as did lobsters in nearby shallow areas. Lobster abundance was greater in the deep waters near sites of continuous water flow toward the ocean. Although only a small portion of tagged animals were recovered, evidence points to lobsters in the deeper areas being relatively independent from those in shallower waters. However, deep water lobsters may constitute an important component of the total breeding population.

Julio Baisre described the effects of climatic factors on movement and the fishery for *Panulirus argus* in the Batabano Gulf (Cuba). Catches peak just after the the fishing season starts on 1 June. During September, when catches are at their lowest, there is a shift in climatic conditions and wind direction. Lobsters leave shallow areas at this time, forming mass migrations which lead to large increases in commercial catches. These movements result from the passage of cold fronts, and other disturbances such as hurricanes; the intensity of the event can

influence the scale of catches made soon after. Although lobster catches fluctuate as climatic conditions change, they remain relatively high until the end of February, when they decrease dramatically and the fishery closes.

Patricio Arana described movements of tagged *Jasus frontalis* at Juan Fernandez Island. He used tail punching as well as T-tags inserted into the epibranchial region; no tag loss or adverse effects from tagging were noted. Both sexes undertook marked movements between depths, the direction of the movement being related to the depth at which the animals were originally tagged. Both sexes concentrated in depths of 90-180 m at the end of summer, the beginning of the mating period. The tendency of lobsters at Robinson Carusoe to cluster in the southern part of the island during autumn is probably also associated with reproduction.

John Caddy updated the catch statistics for the major clawed and spiny lobster fisheries of the world. Landings for each group have been relatively stable over the last 20 years, although significant changes in CPUE have occurred in some species. Satellite images indicated that areas of some high lobster landings often coincide with areas of high primary production.

Papers in this session added in particular to our understanding of the ecology of lobsters in the very important Cuban fishery, and pointed out the importance of breeding stock in deeper waters there. Movement patterns described for *Panulirus argus* and *Jasus frontalis* were generally consistent with those previously reported for the same or closely allied species elsewhere; however, the stimulus, and reason, for movement between the two species appears to be different. The tagging technique used in Juan Fernandez generated considerable interest. The study of *Homarus* behaviour was an example of a well-designed and executed laboratory experiment leading to results which may be useful in management; in particular that predation risk could lead to lower growth rates.

John Booth
Ministry of Agriculture and Fisheries
PO Box 297
Wellington, New Zealand

Population Dynamics, Stock Assessment and Management-Opportunities for Future Research: A Personal Overview

Stock Units

The nature and boundaries of unit stocks seem well established for those Palinurid populations associated with large-scale oceanic features. The situation is much less clear for *P. argus* , with populations distributed over wide areas, within which smaller oceanic subsystems (such as the gyre described south of Cuba), may indicate the existence of one or a series of local stocks. For *H. americanus* the situation is also unclear, and further research is needed to determine stock units, and possibly, degree of genetic differentiation between regions.

Growth

The transition from von Bertalanffy models to approaches that better reflected the two components of growth, moult increment and moult frequency, continues to be impeded by a lack of data particularly for palinurids. Data obtained by microtagging *H. gammarus*, and the long prerecruit stage of *H. americanus*, suggest variable growth rates. New biological tagging techniques based on implanted carapace tags, and on mineral composition of the exoskeleton should yield better growth data.

Mortality

Few new field data were presented on mortality rates, although for *P.cygnus*, it was suggested that predation mortality is low, and mainly confined to the early postlarval and juvenile stages. The extensive use of 'casitas' in Mexico and Cuba suggests that shelter may be a factor limiting predation mortality and population density and deserves further experimentation. The importance of predators in influencing feeding behavior of *H. americanus* points to the presence of predators as a significant factor in growth and feeding for homarids also.

Theoretical reasons were discussed for supposing that in combination with high density and rapid growth, highly dissected substrates could be conducive to predation mortality. This is a consequence of the fractal nature of substrates, which predicts a sharp decline in crevice numbers with increasing size. Doubt was expressed that this model applies to heavily fished lobster stocks after the early juvenile stage, although the picture is less clear for *Homarus*. The theory, nonetheless, offers a potential mechanism for 'bottlenecks' and for recruitment stabilisation, especially if density-dependent growth applies. This points to at least one possible cause for migration.

Fecundity

Measures of population fecundity are regularly calculated in some fisheries (e.g. Newfoundland and W. Australia). The question was raised for some areas (e.g. Cuba, the Abrolhos Is., S.W. Nova Scotia and Yucatan), about the importance and relative contribution of certain stock components, such as those in deeper water, to the overall population fecundity. A conservative approach to exploiting such "spawning refugia" seems indicated.

CONTINUED NEXT PAGE

MEETINGS

CONTINUED FROM PREVIOUS PAGE

Gear Selection and Artificial Shelters

Experience in escape gap use was presented, and in particular; improved mathematical procedure for selectivity calculations was reported from Chile. Escape gaps have reduced handling mortality, and deserve widespread adoption.

The question of whether trap catches are a good index of abundance continues to be highlighted. Seasonal interspecific and intraspecific interactions at the trap site are highly significant for *H. gammarus*. There is evidence for shallow water Palinurid stocks that artificial habitats (e.g. casitas) may provide reasonable abundance estimates, and one that allows for easy experimentation.

Recruitment estimates

The success of recruitment forecasting for palinurids by puerulus collectors is well established in Western Australia, but needs to be tested elsewhere. They now are being used in New Zealand and the Caribbean. This will need a sustained effort over many years. Indices based on puerulus collectors should be compared with indices of juvenile abundance, which in Western Australia provide reliable short-term predictors.

The ability to predict fishery yield from pre-commercial abundance has three components that need further investigation:

1.) The impact of environmental changes on the probability of larval return to the parental stock area;

2.) Design of collectors to avoid problems of saturation of sampling gear; and

3.) The possible degree of density dependence of growth and mortality and interspecific competition in post settlement stages.

Work on these problems has been initiated in Western Australia, where density dependent effects seem limited. The main area in need of clarification for *P. cygnus* appears to be the extent and duration over which the limited effects of density dependence apply. Comparing larval and juvenile indices for large and small cohorts may be the approach to use.

Elsewhere, the importance of density dependence may be greater. In the Mexican fishery predation is probably more important, and presence or absence of shelter appears to be a significant factor. This could lend itself to experimental investigation of the effects of density on recruitment, production, and growth.

Serious problems remain in measuring recruitment in homarids, and significant funding will be needed in order to make headway. Whether the emphasis should be on plankton sampling, the development of a yet-hypothetical stage 4 collector, or an also hypothetical stage 5 and benthic collector, is an open question. The absence of a monitoring method is a major constraint on our ability to provide useful predictions, although prerecruit indices have been used.

There appears to be a growing appreciation that recruitment variation is more related to environmental conditions than to adult biomass. Elucidating the key factors that determine year class strength is still a top research priority.

Modelling

In the absence of recruitment estimates, production models will continue to be used, but demand effort calibration such as was recently carried out in Merida. Modelling approaches that incorporate biological realities are being used ever more widely, and that presented for the Western Australia fishery demonstrates the power of this approach.

A fundamental decision needs to be made early on in modelling, between the conventional finfish model (where exploiting the mature adults, and protecting immatures is axiomatic(?), and the model effectively followed in many lobster fisheries, namely, intensely exploiting young, often immature recruits, and protecting a nucleus of spawning stock by means of a refugium (e.g. that provided by depth, or trap entrance size).

Bioeconomics

Since market price varies seasonally with size, shell condition and color, and is highest for intermediate sizes, yield models, as well as seasons and ages captured, should be tuned to optimal economic yield. Some progress is bring made in this direction in Cuba, Australia and Mexico.

In fisheries where lobsters are only one component of a mixed species catch by multiple gears, bioeconomic analysis is the only sensible approach, and is being pioneered in Mexico. Socio-economic factors on fishermen seem also to demand further investigation in order to determine the impacts and efficiency of different regulations.

Final Thoughts

There is remarkable stability of most lobster fisheries, particularly given the high unit value and often uncontrolled effort. An example is the New Zealand fishery, where yields continue to be stable, despite significant decline in some juvenile indices. This seems to imply considerable population resilience, perhaps due to a high degree of density

CONTINUED NEXT PAGE

CONTINUED FROM PREVIOUS PAGE

dependence somewhere in the system.

The dramatic increase in landings of *H. americanus* over the last decade merits careful consideration. This has occurred despite high levels of fishing effort and no geographical expansion of the fishery. Determining the cause of this seems a top priority for future research. Temperature fluctuations do not seem to offer a convincing explanation. *Nephrops norvegicus* and *P. argus*, like *H. americanus* , are species found on continental shelves subject to coastal influence. They too have shown increased landing trends. What distinguishes these species from *H. gammarus* whose landings have remained remarkably constant?

Some overexploitation probably occurs in terms of biological yield for most lobster fisheries and an even higher degree of economic overfishing is probably more general. This emphasizes the need to control fishing intensity, and the number of participants in the fishery. Controlling effort in an open access fishery leads to exclusive access by fixed numbers of fishermen. The assignment of exclusive fishing areas is perhaps the main reason for the spectacular increase in yield achieved in Cuba. There may even be a case for TURF's (Territorial Use Rights for Fishermen), and in Mexico, this approach appears to be adopted from some fisheries with casitas. In this way, fishermen have a vested interest in adopting effective measures for conservation and stock enhancement.

John Caddy
Fisheries Department, FAO
Via delle Terme di Caracalla
Rome, IITALY 00100

Identification of Larval Stocks and Larval Distribution

This session consisted of six papers, five of which addressed spiny lobsters. Unfortunately, the full text of all the papers presented were not available to me, hence my analysis will be relatively brief. Following are the titles of the papers:

- Corrientes geostroficas al S. de Cuba, by C. Garcia, A. Chirino and J. P. Rodriguez
- Distribucion-abundancia de las larvas filosomas de *Panulirus argus* alrededor de Cuba by I. Alfonso, M.P. Frias, A. Campos and J.A. Baisre.
- Analysis genetico bioquimico de larvas de *Panulirus argus* de la zona economica exclusiva del S de Cuba. by G. Espinosa, R. Diaz and V Berovides
- Genetic variation in the spiny lobsters *Panulirus argus, P. laevicauda* and *P. japonicus* by M. Ogawa, G.M. Oliviera, K. Sezaki, S. Watabe and K. Hashimoto.
- Occurrence of mid-and late- stage phylosoma larvae and pueruli of *Jasus edwardsii* in relation to puerulus settlement. by J. D. Booth
- Effets du climat et de l'hydrographie sur le recruitment du homard americain (*Homarus americanus*) dans le nord du Golfe du Saint-Laurent. by C. Hudon.

As a worker on phyllosoma larvae and pueruli, my attention was naturally drawn to the paper presented by Irma Alfonso and colleagues from Cuba. The preliminary data were very interesting and I look forwardto seeing the written version. Unfortunately at this stage I cannot unequivocally support the conclusion that the stock of spiny lobsters in Cuba is self-sustaining, although the evidence presented supports this hypothesis. It was obviously of great interest to see the progress being made by Carlos Garcia and his colleagues on describing the currents of the south of Cuba, and these data will considerably aid the interpretation of larval biology.

Two papers involving genetic analysis were presented during the session, one by Georgina Espinosa and the other by Dr. Ogawa. Both papers were based on the electrophoretic technique and presented informationindicating various degress of separation which had been determined between the samples collected. Within the full text of the paper on the genetic analysis of *Panulirus argus* in Cuba, it was not possible to reach definite conclusions, but I would comment that although one could determine differences by these techniques, it is not possible to determine that the animals are all part of a common stock, as was suggested by the authors. It was of interest that some other work by Jeffery Silberman and colleagues from the University of Miami (presented informally at the meeting) approached the same problem using mitochondrial DNA. This is another techniquewhich has applicability to the problem, but the same problems of sampling and conclusions apply with whatever approach is adopted. A strong case might be made for performing both an electrophoretic and a mtDNA analysis of the same material simultaneously.

Bruce F. Phillips
(address below)

Progress in Lobster Culture

Five papers were presented in this session. I have not attempted a detailed review because full texts were not

CONTINUED ON NEXT PAGE

MEETINGS

CONTINUED FROM PREVIOUS PAGE

available to me at the time of writing. The titles were:

- Culture of spiny lobsters from egg to puerulus stage by J. Kittaka
- Metabolismo energetico de postlarvas de langosta *Panulirus argus* sometidas a diferentes condiciones experimentales by R. Brito, E. Dias, E. Rodriguez and R.N. da Lima Conceicao
- Relacion glicemia vs proteinemia de jeveniles de langosta *Panulirus argus* de la plataforma Cubana by E. Diaz and R. Brito
- Crecimiento de postlarvas de langosta *Panulirus argus* en condiciones de laboratorio. by E. Diaz, R. Brito and M. Baez
- Microbiota bacteriana de la hemolinfa de *Panulirus argus* by R. Bobes.

Obviously all members of the workshop were looking forward to hearing from Professor Kittaka of the results of the exciting studies and on what he has achieved on the culture of spiny lobsters in Japan over the last few year, and we were not disappointed. It is too early to say that the culture of larvae is routine, but we look forward over the next few years to finding that that the cultivation of these larvae could become available to a range of workers throughout the world, thereby permitting experimental studies of behavior, physiology, etc., on larvae and laboratory reared post-puerulus.

The other papers presented in this session included studies on bacteria in the hemolymph, growth, and detailed examination of different aspects of the biology of *Panulirus argus*. The main benefit, I believe, of attending a workshop such as this, is the ability to learn of ongoing research. We all have a tendancy to present results which are completely synthesized, and often from published material. In this way we are likely to receive the least criticism and greatest accolades. This is not the purpose of a workshop. At a workshop, one should be encouraged to present information in the formative stages, or at least not published. I believe that our Cuban colleagues followed the correct approach in this matter, and they are to be congratulated.

I look forward to the publication of all of these papers and believe they will make useful contributions to the spiny lobster literature.

Bruce F. Phillips
CSIRO Marine Laboratories
P.O. Box 20, North Beach, W.A.
AUSTRALIA 6020

RESEARCH NEWS

CONTINUED FROM PAGE 5

science was in relation to predator-prey interactions. Aristotle, Pliny the Elder, Plutarch, Oppian and Aelian described the relationships between the Octopus, the Carabus and the moray eel as Aelian wrote: "The moray loathes the Octopus and the Octopus is the enemy of the Carabus and to the Moray the Carabus is most hostile" (On The Characteristics of Animals, I, 32).

In at least two mosaics from Pompeii, a struggle between an octopus and a spiny lobster is illustrated (see Figure on page 5). Adjacent to this scene is a moray eel with its head pointing to the struggling animals.

Is the octopus one of the natural predators of Mediterranean lobsters? What is the function of the moray eel in this association? We have confirmed that *Octopus vulgaris* indeed preys on *S. latus*, at least under laboratory conditions (Almog-Shtayer, 1988). And, these lobsters were frequently observed in the same shelter as *Muraena helena* in an artificial reef off the coast of Israel. No apparent predator-prey interactions between these two animals were observed. We suggest a symbiotic relationship between *S. latus* and *M. helena*. The benefit to the lobster in this association is a protection by a fish which is a predator of the octopus. Such a triangular association was also postulated for the South African spiny lobster *Panulirus homarus* , the local moray and octopus (Berry1971).

Ancient sources and traditional information can be useful in understanding the ecology not just of the Mediterranean lobsters, but of other lobster species as well.

REFERENCES

Almog-Shtayer, G. 1988. Behavioral-ecological aspect of Mediterranean lobsters in the past and of the slipper lobster *Scyllarides latus* in the present. M.A. Thesis, University of Haifa, Israel (in Hebrew) 165 pp.

Almog-Shtayer, G. , E. Spanier, & M. Artzy. 1988. In E. Spanier, Y. Steinberg and M. Luria, eds. Environmental Quality and Ecosystem Stability Vol. IV-B, ISEEQS pub. Jerusalem, Israel, 1989, pp. 371-379.

Berry, P.F. 1971. Ocean Res. Inst. S. Africa Invest. 27:1-23.

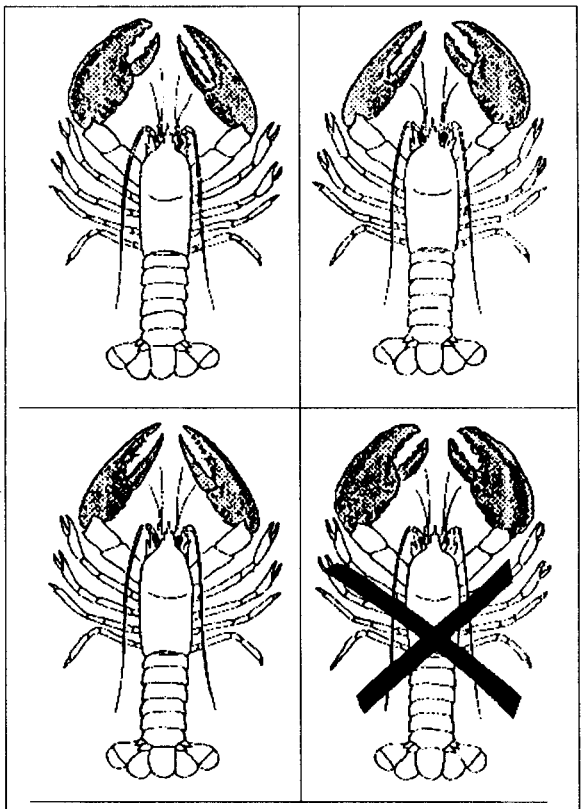
Phillips, B.F., J.S. Cobb and George, R.W. 1980. In Cobb, J.S. and B.F. Phillips, eds. The Biology and Management of Lobsters, Vol. I, New York: Academic Press, pp. 1-82.

Galit Almog-Shtayer
Ehud Spanier
Recanti Center for Maritime Studies
University of Haifa
Mount Carmel, Haifa 31999
ISRAEL

Claw Handedness in Lobsters

Lobsters, like humans, have a bilaterally symmetric body — the right half is a mirror image of the left. Superimposed upon this basic body plan are often found asymmetries, the best known being handedness in humans: most of us are right handed, only a few are left handed or ambidextrous. Clawed lobsters (*Homarus americanus*) also show handedness: their enlarged clawed limbs or chelipeds are bilaterally asymmetric. One of the chelipeds is a stout, molar-toothed crusher claw capable of closing relatively slowly but with enough force to crush the shells of bivalves. The other cheliped is a slender, incisor-toothed cutter claw capable of closing rapidly enough to catch fish. The differences in closing behavior arises because the closer muscles are made up exclusively of slow fibers in the crusher and predominantly (90%) fast fibers in the cutter (reviewed by Govind, 1984). Unlike humans, however, handedness in lobsters is not restricted to the right side of the body. The crusher claw appears with equal probability on either side of the body demonstrating the random nature of claw handedness or laterality (Herrick, 1895).

Even more interesting, the paired claws and their closer muscles are symmetrical throughout the larval (first three instars) and early juvenile (4th and 5th instars) stages; both are slender and cutter-like in appearance and have a mixture of fast and slow fibers . Only in subsequent instars do they gradually diverge, developing into a cutter and crusher type. That the paired claws are equipotent in these early stages and subsequently become determined was shown by Emmel (1908), who found that removing one of the claws in the 4th or 5th instars invariably led to the intact claw becoming a crusher. Removal of a claw at any other stage did not affect laterality. Clearly, the 4th and 5th instars represent a critical period when handedness is determined. The question we asked was how does this happen? More specifically, in Emmel's experiment, what made the intact claw become a crusher? Is it simply its activity which presumably transforms fast fibers to slow in the closer muscle and which influences claw shape and size? The evidence from our experiments pointed in this direction.



Lobsters showing all four configurations of paired claws of which the asymmetric configurations (upper sketches) with the crusher on the right or left side is the norm, while of the symmetric configuration (lower sketches) a few are found with paired cutter claws but none with paired crusher claws

In these experiments, we observed the effects on handedness when the environment or the claws were manipulated during the critical 4th and 5th instars (reviewed by Govind, 1989). Lobsters were reared individually in plastic trays with a few broken oyster shells as substrate. Under these conditions they develop both crusher and cutter claws. But if a graspable substrate was not present they developed only cutter claws (Lang et al., 1978). This suggested that a threshold level of claw activity is essential in forming a crusher, a view that was confirmed in experiments in which the claw was manipulated. For instance, cutting the muscles or the nerve to one of the claws prevented it from developing into a crusher (Govind and Kent, 1982). Even more reassuring was our finding that exercising one of the claws, by inducing it to grip the bristles of a paint brush during the critical stages, made it develop into a crusher even when the lobsters were reared without a graspable substrate. Handedness, it seemed, was regulated directly by activity of the claw itself with an activity threshold ensuring the development of a crusher claw.

This proved not to be the case, for when both claws were reflexly exercised neither developed as a crusher, demonstrating that it is not activity per se which determines claw type. Rather, the differential between the two sides seems to determine claw type.. The reflex activity of the paired claws is monitored by the thoracic ganglion in the central nervous system (CNS). The ganglion becomes lateralized into crusher and cutter side if the bilateral differences are significant. If the differences in the reflex activity between the two sides are trivial, the ganglion does not lateralize. Once the fate of the CNS is determined, it is transmitted, via unknown pathways, to the periphery resulting in the differentiation of paired asymmetric (crusher/cutter) or symmetric (cutter/cutter) claws.

CONTINUED ON NEXT PAGE

RESEARCH NEWS

CONTINUED FROM PREVIOUS PAGE

According to this view claw handedness is initially determined in the CNS, and depends on the balance in sensory and proprioceptive input from the paired claws. We may think of the process of determination as a child's see-saw, which remains in a horizontal position provided the forces, no matter how great, are balanced on both sides. This would be the case when lobsters are reared without a graspable substrate and/or the claws are exercised on both sides. In both cases the input would be bilaterally equal and the CNS would not become lateralized. Under conditions in which the input is greater on one side, such as with exercise or removal of the contralateral claw, the see-saw would tilt to that side making the hemiganglion on that side into a crusher type while the counterpart hemiganglion automatically becomes a cutter type. According to the teeter-totter model we would predict that the paired claws would be either asymmetric with the crusher on the right or left or symmetric with a cutter on both sides but not a crusher on both sides. These predictions are true in the wild (Herrick, 1895) as well as in the laboratory. The majority of lobsters have asymmetric claws with the crusher appearing on either side in equal numbers, a few have paired cutter claws and none that we know of have paired crusher claws (see Figure). Although extremely rare, lobsters with paired crusher claws have been found. However, closer examination of one of these revealed that only one claw was a true crusher, while the other showed the behavior and closer muscle of a cutter (Govind and Lang, 1979).

Finally, we should note that the brief critical period when claw handedness may be determined occurs at a most propitious time in the life of a juvenile lobster. Determination occurs during the 4th and 5th instars when juvenile lobsters switch from a free-floating planktonic lifestyle to a bottom-living benthic one (Cobb et al, 1989). The ocean floor provides a rich substrate for the claws to grip, thereby ensuring their activity at a time when the CNS may be lateralized. Thus while the critical period for claw handedness is genetically specified, the trigger for lateralization is influenced by the environment. How handedness is determined in lobsters therefore provides us with a simple yet elegant system in which we can explore the interaction between the genome and the environment, i.e. nature and nuture, in the genesis of an organism.

REFERENCES

Cobb, J.S., D. Wang and D.B. Campbell. 1989. J. Crust. Biol. 9: 60-66.

Emmel, V.E. 1908. J. Exp. Zool. 5: 471-484.

Govind, C.K. 1984. Biol. Bull. 167: 94-119.

Govind, C.K. 1989. American Scientist. 77: 468-474.

Govind, C.K. and K.S. Kent. 1987. Nature 198: 755-757.

Govind, C.K. and F. Lang. 1979. J. Exp. Zool. 207: 27-32.

Govind, C.K. and J. Pearce. !986. Science.233 354-356.

Herrick, F.H. 1895. Fish. Res. Bull. U.S. 15: 1-252.

Lang F., C.K. Govind and W.J. Costello. 1978. Science 201: 1037-1039.

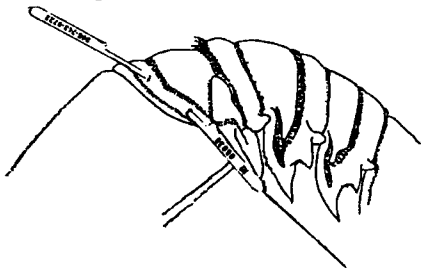
C. K. Govind
Life Sciences Division
Scarborough Campus,
University of Toronto
1265 Military Trail
Scarborough, Ontario,
CANADA M1C 1A4

NEW METHODS AND APPLICATIONS

A Better Lobster Tag?

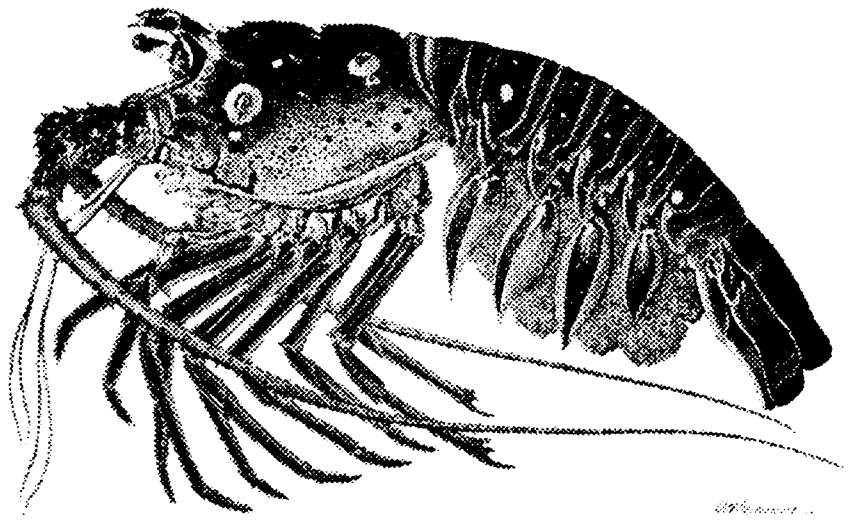
Streamer tags used primarily with shrimp may prove to be useful with lobsters. Preliminary laboratory tests indicate that streamer tags have higher retention and induce lower mortality than sphyrion anchor and toggle anchor spaghetti tags.

Streamer tags are made of thin pliable plastic and have a needle attached for inserting the tag. The needle is threaded under the lateral membrane between the carapace and abdomen with minimal penetration of the abdominal muscle, and then pulled through so a portion of the narrow mid-section of the tag remains underneath (Figure 1). The needle is then broken off leaving the wider ends of the tag protruding from the dorsal and ventral portions of the membrane.



Because streamer tags used this way do not penetrate muscle nor rely on an invasive anchor, infection, mortality and tag loss may be reduced. The Florida Marine Research Institute is planning to conduct further trials on this and other tags.

David Forcucci
Florida Institute of Oceanography
P.O. Box 968
Long Key, Fl 93001 USA



LETTERS

One of the real pleasures of editing The Lobster Newsletter is correspondence with people such as Rene Buesa who, although no longer active directly in lobster research, has a grand storehouse of information and many revealing stories to tell. Dr. Buesa emigrated from Cuba to the United States in 1982, and brought with him the illustration above. His letter explaining the history of the original watercolor is fascinating:

"In Vol. 2 No. 1 of the "Lobster Newsletter" you requested old and occasional illustrations of lobsters; I am sending you one from Cuba. It is not so old, but has a very interesting history:

"When on December 11, 1941 the United States declared war on Germany (and Italy) the first Latin American country to follow the USA in such a declaration of war was Cuba. In those days, in Cuba, there was a quite large German colony (mostly skilled workers and merchants) and they were sent to sort of a concentration camp (similar to the Pacific coast of the USA with the Japanese immigrants and residents in the USA).

"Among the German nationals living in Cuba was a painter called Otto Siepermann, and he had been painting and drawing for the Zoology (called Natural Sciences) Department of the University of Havana, at that moment headed by a well-known and politically well-connected Cuban naturalist and malacologist, Dr. Carlos de la Torre.

"Dr. de la Torre, by using his political influence, managed to prevent Otto Siepermann from being sent to confinement or concentration camp as long as Siepermann agreed to spend the duration of WWII painting and drawing for the University. It turned out that Dr. de la Torre kept most of Siepermann's drawings in his personal files, where they remained for more than 15 years.

"Otto Siepermann painted line drawings with extremely beautiful water colors. You must see his paintings personally to fully appreciate the quality, which is superb. He painted almost all the fishes known at that moment for Cuban waters; he painted a wide array of crustaceans, a most beautiful collection of Cuban lizards, he painted flowers, the most beautiful molluscs (including all of Don Carlos' *P. picta* collection) and almost every animal or plant known for Cuba at that time.

"Unfortunately his *Panulirus argus* drawing is not one of his best: this egg carrying spiny lobster has been drawn in a very unnatural way (the antennae and antennulae hanging as it was above some object). Probably the animals came from a port in the southern part of Havana Province known as Batabano, because in those years most of the lobsters in that port were caught in the Ensenada de la Broa, a place where most of the large lobsters presented barnacles, like the 4 that Siepermann painted over this female's cephalothorax. If you look carefully you will be able to recognize many anatomical details in the drawing, and those details are the ones that make Siepermann's drawings so scientifically remarkable.

"While I was director of the Centro de Investigaciones Pesqueras I was able to recover many of Siepermann's drawings, and used some of them in our scientific publications.
"This illustration became almost the "official drawing" for *P. argus* when I included it in my first comprehensive summary of my research on this spiny lobster. I hope that the illustration, and the history may prove to be of interest to you (and I hope you may use it in one of the issues of the "Newsletter").

Rene J. Buesa
4171 West 9th Lane
Hialeah, FL 33012 USA

ANNOUNCEMENTS

Crustacean Nutrition Workshop

The International Working Group on Crustacean Nutrition has announced its third workshop, to be held June 16-17, 1991, immediately following the World Aquaculture '91 meeting in Puerto Rico. Objectives include a review of nutritional requirements of penaeid shrimp, to develop tables of nutrient requirements by species of crustacean, and to establish tables of recommended nutrient levels for feed formulation. For further information, write to:

The International Working Group on Crustacean Nutrition
c/o World Aquaculture Society
Home Office
16 Fraternity Lane
Louisiana State University
Baton Rouge LA 70803 USA

National Shellfish Association

The annual meeting of the National (USA) Shellfish Association will include a full day session on lobster biology and ecology, including all life history stages. Both oral presentations and posters are encouraged. The meeting will be held 23-27 June, 1991, at the Sonesta Hotel, Portland, Maine. For further information, contact the workshop organizers:

Dr. L. Incze
Bigelow Laboratory for Ocean Sciences
McKown Point, West Boothbay Harbor
Maine 04575 USA

Dr. J. D. Pringle
Halifax Fisheries Research Laboratory
P.O. Box 550
Halifax, N.S. CANADA B3J 2S7

Publication Available

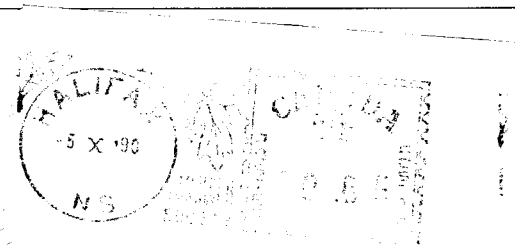
Special publication #17, entitled "Common and Scientific names of Aquatic Invertebrates from the United States and Canada: DECAPOD CRUSTACEANS" is offered by The American Fisheries Society. The price is US $17.00 (or $14.00 if you are a member of the society.) Add US $3.00 for postage if you are outside the USA. For further information, or to order, write:

American Fisheries Society
5410 Grosvenor Lane
Suite 110
Bethesda MD 20814 USA.

July 1990

The Lobster NEWSLETTER

P.O. Box 550
Halifax, NS B3J 2S7
Canada



Mark J. Butler
Dept. Biol. Sciences
Old Dominion Univ.

Norfolk VA 23529-0226 **USA**

ADDRESS CORRECTION REQUESTED