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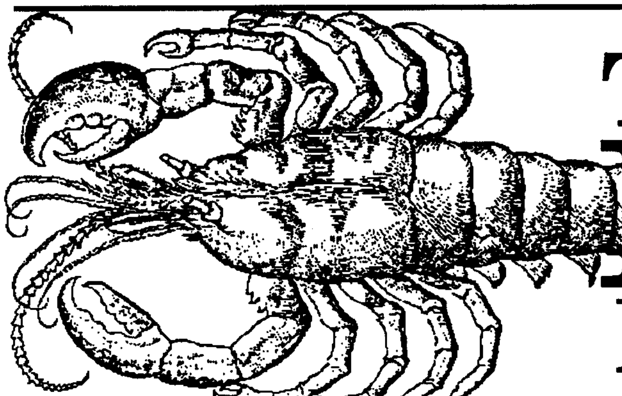

The Lobster NEWSLETTER

RECENT EVENTS

Catastrophic Mortality of Sponges Affects Juvenile Spiny Lobster Populations

In the Florida Keys early this year (1992), Mark Butler, John Hunt, Bill Herrnkind and their research team followed the mass mortality of nearly all species of sponges in their study area at Lower Arsnicker Key, and report, in a manuscript submitted to Ecology, that it was accompanied by a marked decline in abundance of juvenile spiny lobsters.

Nearly all species of sponges were affected. Butler at al. suspect a cascade effect, starting with a die-off of seagrass during October 1991, which released large quantities of nutrients from sediments and decomposing grass. The nutrients may have fed a massive diatom bloom which was so dense that it prevented the normal census of lobsters the research team performs each month, in December 1991 and January 1992. After the bloom cleared, dead and dying sponges were everywhere in their study area. Up to 90% of some species were killed.

The loggerhead sponge is a preferred habitat for juvenile *Panulirus argus.* After the die-off, lobsters moved into previously

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RESEARCH NEWS

Eyestalk Ablation and Growth, Molting and Gonadal Development in Spiny Lobsters

FROM: E.V. RADHAKRISHNAN AND M. VIJAYAKUMARAN

The physiological and biochemical processes that govern molting and reproduction in spiny lobsters are not yet well understood. Published accounts from different species are somewhat contradictory. Travis (1954), Dall (1977) and Aiken (1980) concluded that molt inhibiting substances were lacking whereas Quackenbush and Herrnkind (1981) and Radhakrishnan and Vijayakumaran (1982, 1984) found evidence of its presence. The

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FISHERIES AND AQUACULTURE UPDATE

Recreational Fishing for Lobsters in Florida: A Mail Survey

FROM: R. BERTELSEN

During the fall of 1991, the Florida Marine Research Institute conducted its first mail survey of the recreational fishery for the Caribbean spiny lobster, *Panulirus argus.* We wished to estimate the recreational harvest on a regional and on a statewide basis, to determine the movement patterns of the fishermen (where do they travel from and where do they fish), and to determine fishing methods. The survey was a pilot study and did not include a telephone follow-up, so conclusions must be taken with caution. Nevertheless, there were some surprises and some confirmation of our ideas that may be of interest to the readers of The Lobster Newsletter.

Our survey was divided into two separate questionnaires reflecting the two time periods when recreational fishermen can take lobsters. The first is a two-day special, recreational

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RECENT EVENTS

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underutilized shelters such as octocorals, coral heads, clumps of macroalgae, and experimental block shelters. By March, a month after the sponge mortality, the resident population of juvenile spiny lobsters had declined by more than 30% in their study area. Evidence concerning the mechanism of the decline in lobster abundance (emigration or mortality) does not exist, but Butler et al. fear that with the loss of primary habitat, mortality may well have increased dramatically on a local level.

The phytoplankton bloom in southwestern Florida Bay had catastrophic, and unexpected, results. It was not, unfortunately, a one-time event. Butler indicated in a recent telephone conversation that the phytoplankton bloom has returned this year at the same time, and covers a wider area of Florida Bay. Sponges have been killed again, sometimes in as little as 10 days.

It was fortunate that a research team was working in the area so the effects on the commercially valuable population of spiny lobsters could be documented. It is not clear yet whether the effects will be long-term, or reversed quickly. It is clear, however, that the knowledge of this (and most other) ecosystems is not sufficient to predict the consequences of even catastrophic events. This event points out the importance of long-term observations by dedicated field scientists.

Roundtable on Lobster Ecology Seeks More Communication Between Behaviorists and Population Modellers

FROM: RICK WAHLE

At the 1985 International Workshop on Lobster Recruitment, Dr. Bill Herrnkind, of spiny lobster fame, made this plea:"... behavioral ecologists must attempt to extend their insight from the level of the individual organism to that of the population". His plea may well apply not just to behaviorists, but all those working at the organismal level. With that challenge in mind, Rick Wahle (Brown University, Providence, RI, USA) and Ehud Spanier (University of Haifa, Israel) organized a roundtable discussion on the issue during the 20th annual Marine Benthic Ecology Meetings held March 26-29 in Newport, Rhode Island.

Participants included about thirty colleagues and students representing several lobster taxa and a breadth of disciplines from fisheries science to neuroethology. Four colleagues among the group had been asked in advance to give their own views on the integration of organismal and population level questions. Each brought a valuable perspective from his own area of expertise. Appropriately, Bill Herrnkind (Florida State University, Talahassee, FL, USA) started off with remarks on issues emerging in spiny lobster research. Stan Cobb (University of Rhode Island, Kingston, RI, USA) followed with parallel comments on clawed lobsters. Dick Zimmer-Faust (University of South Carolina), a specialist in sensory biology, focused on the environmental regulation of behavior and its population-level effects. Finally, Rom Lipcius (Virginia Institute of Marine Science, Gloucester Point, VA, USA) emphasized that understanding behavioral mechanisms helps refine stock-recruitment models. Following are some highlights of the discussion.

Perhaps the unifying theme of the discussion was that the ontogenetic shifts in behavior seen in many lobster taxa have important implications to the population. Certain similarities in the life history of clawed and spiny lobsters seem to be leading to a convergence in thought among those working on the different taxa. For example, Herrnkind's description of the behavioral transitions from cryptic to wide ranging behavior that occur during the life of *Panulirus argus* strike a familiar chord to those working on clawed lobsters. But intriguing differences also exist: spiny and slipper lobsters become gregarious as they grow, whereas *Homarus* becomes increasingly solitary and aggres-

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The Lobster NEWSLETTER

Editors:
J. Stanley Cobb
Department of Zoology
University of Rhode Island
Kingston RI 02881 USA
FAX: (401) 792 4256

John Pringle
Fisheries and Oceans
PO Box 550
Halifax B3J 2S7
CANADA
FAX: (902) 426 3479

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Coordination: Ron Duggan

Please send change of address to John Pringle.

sive. The emerging question is what ecological settings favor these divergent modes of behavior? On a different note, Cobb pointed out the importance of understanding the morphological and physiological events that set the stage for behavioral shifts. For example, the pelagic larva of *Homarus* undergoes a physical metamorphosis to the post-larva, having all characteristics for a benthic existence, several days before it undergoes its behavioral "metamorphosis" and settles. But as Spanier noted, as we fine-tune our understanding of the ecological ontogeny of some lobster taxa, we have yet to even locate the nursery habitat for others such as his research subject, the slipper lobster *(Scyllarus)*.

Much of the discussion addressed how ontogeny applies to questions of stock-recruitment relationships. Spanier posed the question of whether we can define bottlenecks, critical segments of the life history where density-dependent processes can ultimately place limits on recruitment to the adult population (as in Beverton-Holt or Ricker recruitment models). Lipcius urged behaviorists to be sensitive in designing experiments to the kinds of behavioral mechanisms, for example shelter competition or cannibalism, that might affect recruitment. The exchange reinforced the notion that the first few months or years of benthic life are likely to be critical, and that while some data sets suggest a bottleneck, they are too limited to make generalities about particular species. *(Editors' note: an article in the "Perspectives" section of this Newsletter addresses the bottleneck issue.)*

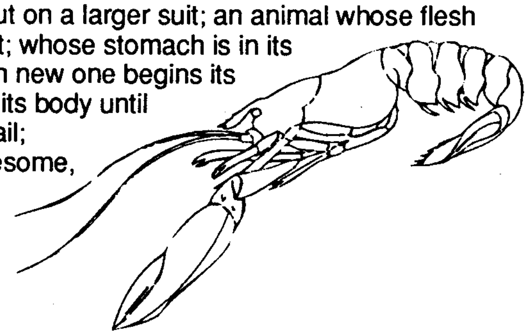
On the "supply-side" of the issue, we can't lose sight of the fact that the degree to which density-dependent processes are important to a population depend on larval supply, and the availability of suitable benthic nursery habitat. Herrnkind (with collaborator, Mark Butler, Old Dominion University, Norfolk, VA, USA) speaking for spiny lobsters, and Wahle who studies the American lobster, observe large local differences in densities of newly settled lobsters that appear to be partly dependent on larval supply and partly on habitat quality. The inference is that some local populations may be limited by larval supply while others may be saturated with settlers that become subject to density-dependent controls as they grow. To date, however, local populations have not been tracked long enough to know what processes generally affect recruitment to the adult population. In short, there appears to be a clear need for long time-series of data at a number of sites on larval supply and the fate of cohorts through time.

Dick Zimmer-Faust focused his comments on the need to delineate causal linkages between environmental conditions and behavior. He noted that lobster scientists are becoming increasingly aware that water-borne chemical stimuli, from food and predators, for example, mediate behaviors that influence habitat use. Because the chemical environment is influenced by hydrodynamical factors at a number of spatial scales, he argued that our power to predict distributions will become better if we understand how these physical and chemical elements of the habitat mediate behavior.

All this is to say that it is critical that population models have strong underpinnings in descriptive and experimental biology. And if population-level predictions are the goal, the message seemed to be that workers at both the organismal and population level should be sensitive not only to the intrinsic and extrinsic factors that influence a species' distribution and abundance, but also to the spatial scale at which they work.

About Lobsters

"I once heard a clergyman at a lecture describe a lobster as a standing romance of the sea; an animal whose clothing is a shell, which it casts away once a year, that it may put on a larger suit; an animal whose flesh is in its tail and legs, and whose hair is on the inside of its breast; whose stomach is in its head, and which is changed every year for a new one, and which new one begins its life by devouring the old. An animal which carries its eggs within its body until they become fruitful, and then carries them outwardly under its tail; an animal which can throw off its legs when they become troublesome, and can in a brief time replace them. Lastly, an animal with very sharp eyes placed in movable horns."



From: "The Water World"
by Prof. J.W. Van DerVoort, 1883.

FISHERIES AND AQUACULTURE UPDATE...

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fishing only, season scheduled for the last weekend in July. Second is the regular season, open to commercial and recreational fishing, from August 6 to March 31. The largest part of the recreational harvest is taken during the first month of the regular season. We mailed two survey forms to 5000 registered recreational fishermen. The first covered the two-day season, and the second covered the first month of the regular season. We received about 2000 responses to the first, and about 1500 responses to the second, survey.

Our harvest estimates were much higher than Zuboy's (1980) prediction. We estimated that about 400,000 lobsters (approximately 197,000 kg) were caught throughout the state during the special two-day season. About 78% of the total (316,000 lobsters; 154,000kg) were captured in the Florida Keys. We estimated the recreational catch during the first month of the regular season to be about 1.19x106 lobsters (0.59x106kg), of which 80% came from the Keys.

In both seasons, two thirds of the recreational fishermen fished in the Keys. Those who did most of the travelling came from out of state, lived in northern and north-western Florida, or along the west coast of the state, and 90% of these people went to the Keys. The fishermen residing along Florida's east coast and the Orlando area divided their efforts: roughly half travelled to the Keys, the remainder fished in the central and southeastern coastal waters. All 400 respondents who are residents of the Keys reported fishing only in the Keys.

The preferred fishing method of recreational fishermen varies considerably between the Keys and the east Florida coast. Of the primary methods, snorkling, diving (using SCUBA), and bully netting, nearly 80% of all fishermen use snorkling in the Keys and about 45% dive. Along the east coast, approximately 15% snorkel and 90% dive (the percentages add to more than 100 because some fishermen use more than one method). Bully netting, which requires shallow, clear water and is done at night, is used by just over 5% of Keys fishermen and less than 2% elsewhere.

We asked how long our respondents have been pursuing recreational fishing for lobsters, and found that many have been doing so for a long time. Over 40% of the respondents from the Keys and the southeast coast have been fishing for more than 10 years. In the rest of the state, about 30% have been fishing recreationally for 10 years or more; the figure drops to about 15% for those residing outside of Florida.

In future surveys, we plan to continue to estimate the harvest and to track movement patterns. By asking the same specific harvest questions over a period of time we expect to be able to see trends in the recreational lobster fishery and to determine the impacts of any changes in the management regulations. We also plan to add general questions (not specific to any year) that will allow us to develop a profile of the recreational lobster fisherman. In addition to asking how long they have been fishing, we will ask where they have fished, where they prefer to fish, and why they fish.

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R. D. Bertelsen
Florida Department of Natural Resources
13365 Overseas Highway #103
Marathon, FL 33050 USA

Harvesting Juvenile Spiny Lobster for Aquaculture

FROM: J. BOOTH

New Zealand's Minister of Fisheries has recently approved small scale, experimental farming of the spiny lobster *Jasus edwardsii* in Port Underwood on the northeast coast of New Zealand's South Island. Here, large numbers of pueruli and young juveniles occur on suspended mussel *(Perna canaliculus)* culture ropes. Some of these are to be ongrown and marketed.

Newly-settled spiny lobsters are commonly found on man-made structures in New Zealand; on marine farms, among growth on the hulls of boats, under floating objects, in crevices in wharf piles, on lobster pot lines, and in the cooling water intake of boats and a thermal power station. They are also taken, often in large numbers, on 'crevice' collectors, in a research monitoring program off the east coast of the North Island.

Jasus edwardsii is a tolerant and hardy communal animal. Juveniles grow best at 18-20°C; feed well on a wide range of marine foods, especially mussels; and are rarely afflicted with serious disease. One obvious market for the lobsters is Japan, where there is high demand and price premium for live animals 200-

300 g in weight. This size is much smaller than the minimum legal size for lobster caught in New Zealand's commercial fishery. In nature, it takes at least 3 years to reach 200 g, but pueruli can probably be cultured to this size in 2 years. Small scale harvests of pueruli and juveniles are to go ahead in Port Underwood because, during normal mussel harvesting procedures, most lobsters are crushed and otherwise killed. Up to 50 pueruli and young juveniles occur on the 9 to 12 m long mussel culture ropes. The lobsters shelter between mussel, within dead shells, and in enclosed spaces on the buoys which support the culture ropes.

Thirty percent of animals collected for aquaculture are to be made available for research and for enhancement of wild fisheries.

Late in September 1992, I watched 9 culture ropes being hauied. Lobsters were evenly distributed in the upper 8 m, with an average density of just under 1 animal per metre of rope. Other lobsters probably escaped from the rope during hauling. Two size modes were present, one centred at 13-15 mm CL (a few weeks old) and the other at 33-37 mm CL (one-year old). Pueruli had been present on ropes a few months earlier. The inferred season of settlement is consistent with pueruli collector catches nearby. The nearby collectors also point to 1991 and 1992 having had the highest settlement in this area since observations began in 1980.

An aquaculture industry will require large numbers of small lobsters, but more widespread collections for commercial ongrowing are not planned at present. A conservative approach is being taken and harvesting of pueruli and young juveniles restricted. Puerulus harvest is seen as a stock management issue crucial to New Zealand quota holders, Maori and recreational people alike. The spiny lobster stock is much smaller than optimal, and the impact on it of any large-scale puerulus collections is unknown.

Nowhere in the world, to my knowledge, are large commercial collections of young juveniles allowed. According to Lee and Wickins (1992), the only instances where removal of pueruli or juveniles from the wild for commercial ongrowing takes place is in Taiwan, Singapore, and India. In these countries, small numbers of *Panulirus spp.* are ongrown in ponds or cages; New Zealand joins these countries in allowing small scale harvests of pueruli and young juveniles for aquaculture.

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John Booth
MAF Fisheries, Greta Point
P.O. Box 297
Wellington
NEW ZEALAND

Possibility of Lobster Culture in India

FROM: M.O. RAHMAN AND B. SRIKRISHNADHAS

One benefit of marine biotechnology is the growth of India's aquaculture industry. At present the industry is by and large shrimp farming. However, shrimps may not rule the industry for ever. There are many other marine organisms which could be farmed as would be expected from the great biological diversity of tropical waters. There are six commercially important species of spiny lobsters in India, of which four form the bulk of the landings. The total lobster catch amounted to 2,556 t in 1990. The export of lobsters earned 22.22 crores of rupees of foreign exchange in 1988.

The climatic conditions, biological diversity, and the availability of equipment and inexpensive labour are reasons for attempting the mariculture of species not economically successful elsewhere. Spiny lobsters found in Indian seas are suggested as candidates for aquaculture. Culture of *Panulirus polyphagus* has been practiced in Gujarat by local fishermen for years. Two species, *Panulirus homarus* and *Panulirus ornatus*, are common in the Gulf of Mannar. They grow to a maximum size of 1.5 kg and 3.0 kg, respectively. They produce 300,000 to 500,000, eggs per clutch. The females carry the eggs in their abdomen and then incubate them for about one month when they hatch out into phyllosoma larvae. The spiny lobster species of Indian waters possess some interesting features which make them suitable candidates for aquaculture: They are hardy, have high growth rate, feed on a variety of food organisms and should be easily adopted to controlled conditions. Furthermore, lobsters fetch the highest unit value (Rs 450-500 per kg) among India's marine food products. The biggest constraint for lobster culture is larval production, currently under investigation.

The study conducted suggests that *P. homarus* and *P. ornatus* might be cultured in the many places where peuruli (juvenile lobsters) occur naturally. The

FISHERIES AND AQUACULTURE UPDATE...

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ideal regions for lobster culture are the Gulf of Mannar (Tuticorin to Kanyakumari), Ramanathapuram district, south of Madras and southern Andhra Pradesh. After several years of intensive research, scientists of Fisheries College and Research Institute, Tuticorin, have developed an aquaculture system for spiny lobsters. The culture technique is very simple compared to that followed in other mariculture systems.

Juvenile *P. homarus* and *P. ornatus* of 80-100 g size could be grown to 250 g (marketable size of high unit value fetching maximum price) in five months. There will be a return of over 50 paise for every rupee of operational cost, in foreign exchange. There is little pressure on the land, as the system consists of mainly 5-10 ton capacity tanks. Lobster culture could be adopted by large marine farmers (shrimp farmers who draw water directly from the sea) to diversify their products. The system could be developed on a shrimp farm site with a relatively small additional investment.

The scientists of Fisheries College and Research Institute, Tuticorin are of the view that these lobsters could be grown in culture pond established along sea shores where sandy soil and clear seawater are available.

M.O. Rahman
B. Srikrishnadhas
Fisheries College and ResearchInstitute
Tuticorin 628 008
INDIA

RESEARCH NEWS

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latter workers reported accelerated weight gain and molting in prepubertal spiny lobsters. We extended this work to *Panulirus ornatus* and *Panulirus homarus.* Below is a summary of our findings.

P. homarus and *P. ornatus* were grown indoor under ambient light in fibreglass tanks and polythene pools respectively; 75% of the water was changed daily. Temperature (23 to 28 C), salinity (32 to 35 %) and dissolved oxygen (3.5 to 4.2 ml/l) were monitored.

Growth and Molting

Wild, immature *P. homarus* lobsters in intermolt were bilaterally eyestalk-ablated and reared on clam *(Meretrix casta)* for 23 weeks. The ablated and control lobsters respectively, molted five times (mean intermolt period of 34 days, excluding the first molt after ablation) and three times (mean intermolt period of 55 days). The respective mean weight gains were 347g and 57g. Another experiment on sexually mature *P. homarus* yielded similar results.

Similar experiments using immature and mature *P. ornatus* were conducted except that the animals were fed green mussel *(Perna viridis)*. The ablated and controlled groups molted four times (mean intermolt period of 35 days) and three times (mean intermolt period of 52 days) respectively. The respective weight gains were 530g and 67g. The sexually mature ablated and control lobsters molted four times (mean intermolt period of 65 days) and two times (mean intermolt period of 96 days) respectively. The respective mean weight gains were 1,379g and 62g.

Gonadal development

We also have evidence that eyestalk ablation accelerates gonadal development in sexually mature lobsters. Two sexually mature female *P. ornatus* lobsters, ablated 10 to 13 days following molt, oviposited unfertilized (though two males were in the tank) eggs on their pleopods 17 to 20 days after ablation. They exhibited typical egg-combing behaviour during incubation. The ova were shed 14 to 23 days after oviposition and they molted 58 to 68 days after their previous molt. During subsequent intermolt periods (68, 64 and 72 days) the lobsters exhibited no reproductive activity. The ovaries, at the end of the experiment, resembled spent ovaries. In contrast, one of the control females mated and oviposited fertilized eggs during the first intermolt period, which lasted 141 days. During the second intermolt period this female did not mate but mated in the third intermolt period. Ablated *P. homarus* females mated and ovipositioned fertilized eggs, but then molted, shedding exoskeleton with attached eggs in the naupliosoma stage.

We conclude that bilateral eyestalk ablation accelerates molting and gonadal development in *P. homarus* and *P. ornatus.* When lobsters in late intermolt stage were ablated they immediately entered premolt stage with an accelerated ovary. However, within a few days the hemolymph turned a deep orange until molt; the new exoskeleton was an unusual black in color. This was likely due to the resorption of the energy-rich carotenolipoprotein complex of the ovary being used in cuticle synthesis. This occurred only in lobsters maintained on green mussel. Lobsters main-

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tained on clam resembled albinos after two to three molts. Additionally this work supports the conclusions that first, the gonadotropic factor does not interfere in the molting process and secondly, that bilateral eyestalk ablation accelerates molting and gonadal development simultaneously. Earlier work suggests these two processes are regulated antagonistically.

Our work also suggests the response to eye stalk ablation in the taxa studied depends on the animals physiological state, in particular the period of time in intermolt, which occupies 40% to 50% of the molt cycle.

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E.V. Radhakrishnan
Regional Centre of CMFRI
Marine Fisheries P.O. 623 520
Mandapam Camp, Tamil Nadu
India.

M. Vijayakumaran,
MRC of CMFRI
141 Marshalls Road
Madras-600 008
India

A Large Scyllarid Phyllosoma Larva from Sri Lanka

FROM: D. S. JAYAKODY

During research on the spiny lobsters of Sri Lanka, I came across an unusual specimen of a phyllosoma larva, captured in a surface deployed drift net 115km off the west coast of Sri Lanka. It was identified as a stage X or XI phyllosoma of *Parribacus antarcticus* by the Rijksmuseum van Natuurlijke Historie in the Netherlands (Figure 1.) *Parribacus antarcticus* is circumtropical, with only one living species. I do not know of other records of the phyllosoma of *P.antarcticus* from Sri Lankan waters.

The cephalic shield has a width almost equal to its length, and tapers gradually towards the posterior end. The thorax is subcircular in shape. The eyestalk is 1.3 times longer than the antennulae. The pereiopods are the following lengths:
1ts perieopod - 52mm;
2nd - 68mm; 3rd - 84mm;
4th - 125mm; 5th - 135mm. All five pereiopods have well-developed projections (Figure 1.) This phyllosoma is unique in possessing well developed 4th and 5th pereiopods. In particular, the 5th pereiopod is well developed and differs greatly from the genus *Scyllarus* and from the unidentified phyllosomas described by Robertson (1972).

The larva measures 64mm from the anterior end of the cephalic shield to the tip of the telson. In most cases, scyllarid phyllosomas measure up to 20mm total length. According to Johnson (1971), the largest recorded phyllosoma of *Parribacus antarcticus* was captured in the Hawaiian Islands and measured 57.2mm. In considering the size and hyaline nature of the Sri Lanka specimen, I think that it is possibly the nisto stage.

Little can be deduced about the ecology of these larvae. However, since this specimen was captured at night in a surface drift net, it clearly is planktonic, and may be nocturnally active or come to the surface at night.

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D.S. Jayakody
National Aquatic Resources Agency
Crow Island, Mattakkuuliya
Colombo 15
SRI LANKA

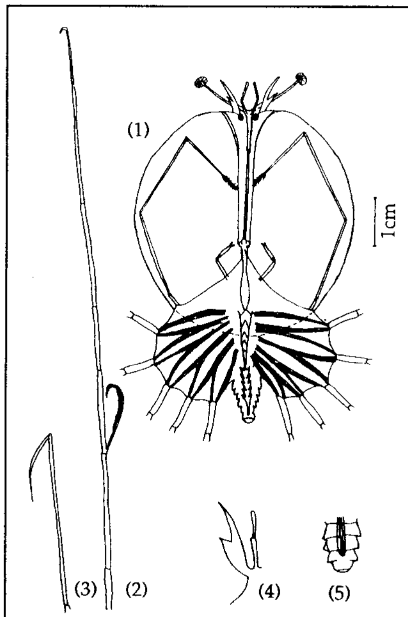

Fig. (1) Parribacus antarcticus (Land) stage X or XI (64.0mm); (2) Leg 4 or 5; (3) terminal segments of legs 3 or 4; (4) first and second antennae; (5) Telson

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Jasus Phyllosomas in Southern Oceans

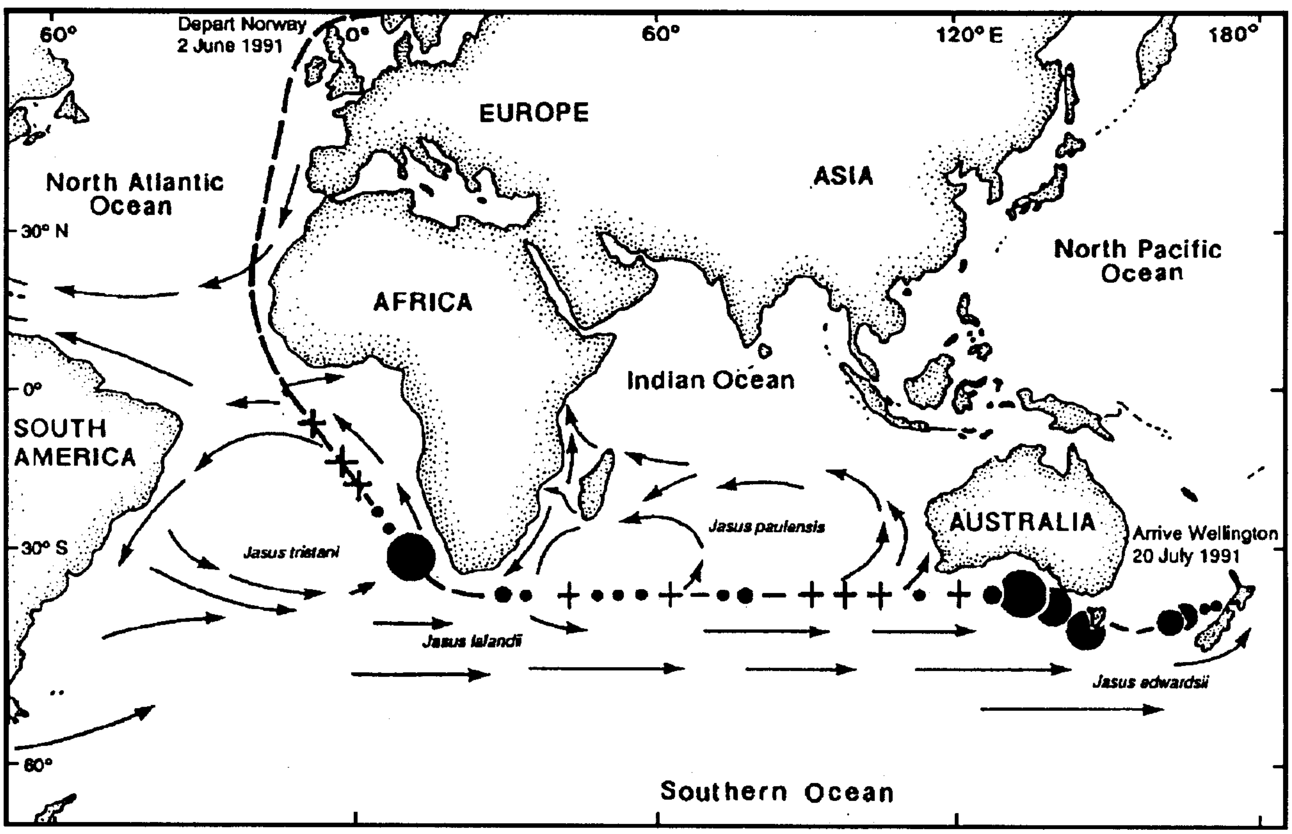
FROM: JOHN BOOTH

Last June we sampled for *Jasus* phyllosomas in the southern oceans during the delivery voyage from Norway to New Zealand of our new 70m research vessel Tangaroa. The main aim of the survey was to collect biological material and data which would increase our understanding of the larval recruitment processes which support Jasus fisheries in New Zealand and other countries. Our main net was a large, finemeshed midwater trawl, 60 sq.m at the mouth and with a mesh of 12mm.

Our preliminary findings are that *Jasus* phyllosoma larvae in southern oceans occur in greatest abundance in the general vicinity of adults, and the Australia is the only likely foreign larval source for New Zealand stock.

Adult *Jasus* spiny lobsters occur in the central and eastern South Atlantic Ocean, around southern Africa, in the south Indian Ocean, in Australasia, and in the eastern South Pacific Ocean (see figure). *Jasus edwardsii* from New Zealand and *J. novahollandiae* from Australia cannot be distinguished (Booth et al. 1990, Ovenden et al. 1992), and now are considered to be one species, *J. edwardsii*. Genetic data support the specific differences among *J. lalandii, J. tristani* and *J. edwardsii* (Brasher et al. in press); mtDNA analyses of *J. paulensis* and *J. frontalis* are yet to be made.

Larval development in *Jasus* takes at least 10 months, Most of the phyllosoma growth takes place in offshore, oceanic waters. There have been several hypotheses of larval recruitment in *Jasus* species. These include, from the one hand, that phyllosomas are widely transported in southern waters by currents to the other, that larvae remain near the adults because of particular behaviours which they have evolved. We recently found that *Jasus* phyllosoma are widespread in the south Tasman Sea, suggesting that larvae are transported to New Zealand from Australia (Booth et al. 1990). But the strength of the eastwardly di-



Distribution of Jasus species, major currents (arrows), and results of phyllosoma larval sampling on the delivery voyage to New Zealand of the Research Vessel Tangaroa. Dashed line gives vessel track. For phyllosomas, area of the circle is proportional to the size of the catch of Jasus larvae; a cross indicates zero catch.

rected flows in southern parts of the temperate oceans and in the Southern Ocean, together with the duration of the larval stage, suggest that *Jasus* larvae could reach new Zealand not just from Australia, but perhaps from as far west as southern Africa.

Are phyllosomas widely dispersed through southern waters? What are the likely foreign sources of larvae for New Zealand? On its passage out from Europe, Tangaroa passed near areas occupied by four species of *Jasus*. The voyage provided a splendid (and rare) opportunity to investigate larval distributions.

One station was sampled every night that weather permitted once Tangaroa reached 10° S in the Atlantic Ocean. Some 400 phyllosomas were caught, of which about 250 were *Jasus* at mid and late stages of development. The rest were *Panulirus* and scyllarid lobsters.

All *Jasus* phyllosoma larvae were caught quite close to adults (see figure). Greatest concentrations were near the coast of South Africa and off the south coast of Australia. Phyllosomas were taken also in the west Indian Ocean off the coast of South Africa where *J. lalandii* occurs, and near seamounts which contain *J. paulensis;* further east near Amsterdam Island; and in the south central Tasman Sea. Unfortunately, heavy sea conditions caused strategic stations to be missed off the Cape of Good Hope, east of Amsterdam Island, and east of Tasmania.

Distribution of *Jasus* larvae by species has yet to be described. Separation of the larvae presently is being attempted through mtDNA analyses at the University of Tasmania.

But the results so far suggest that many larvae could be using behavioural strategies that cause them to avoid being carried too far from shore. Another explanation of the results is that the larvae disperse widely, but that those close to the adults have much higher survival. A surprising result was the number of *Jasus* and *Panulirus* larvae captured together in samples taken near southern Africa. Could the recruitment mechanisms of these two very different genera overlap?

In conclusion, the preliminary results suggest that many *Jasus* phyllosomas remain in the general vicinity of adults, and that Australia is the only likely foreign source of larvae for New Zealand. Austalia appears to receive little or no larval recruitment from the Indian Ocean.

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John Booth
MAF Fisheries, Greta Point
Wellington
NEW ZEALAND

ANNOUNCEMENTS

International Lobster Workshop

Dr. Jiro Kittaka, the chair of the Organizing Committee of the next International Lobster Workshop, reports that more than 100 people have returned preliminary registration forms. The workshop is scheduled to take place July 25-31, 1993, in Sanriku, Japan (the location of the School of Fisheries Science of Kitasato University. Dr. Kittaka is Dean of the School of Fisheries Science.)

The sessions planned are: Early Life History; Distribution and Ecology of Larval Stages Recruitment; Settlement and Early Juvenile Ecology Physiology; Sensory systems, Feeding, Reproduction Biochemistry; Nutrition, Composition, Color Aquaculture; Larval Culture, Grow-out, Water Quality, Feeds Restocking; Present Situation and Prospects Population Dynamics and Stock/Recruitment; Fisheries Issues

The workshop will address both basic and applied research on spiny, slipper and clawed lobsters. A poster session also will be presented.

A post conference tour of the Sanriku coast and to inland mountains and hot springs will be organized.

For further information, contact:

Dr. Jiro Kittaka
School of Fisheries Science
Kitasato University
Sanriku-Cho, Kesen-Gun
Iwate 022-01
JAPAN
Phone: 81-192-44-2121
Fax: 81-192-44-2125

PERSPECTIVE

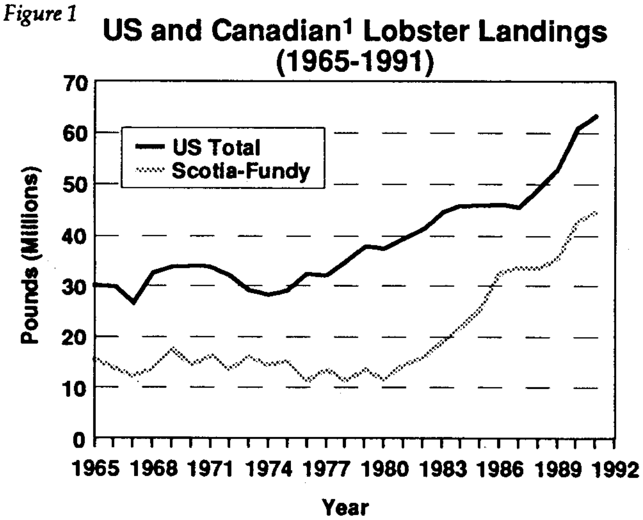
Juvenile Lobster Habitat Limitation: What Can Landings Tell Us?

FROM: J. ADDISON AND M. FOGARTY

Are American lobster populations limited by habitat availability? This issue is currently the topic of intense debate by lobster biologists in North America following the suggestion by Wahle and Steneck (1991) that habitat limitation results in a demographic 'bottleneck' for juvenile *Homarus americanus.* In our view, much of this debate is subsumed within the more general question of why *Homarus* stocks have been so resilient to high levels of exploitation. Although it is possible that fishing mortality rates have been overestimated to some degree, the observed resilience of the stocks suggests that there is some compensatory mechanism in the life cycle (Fogarty 1989). Fogarty and Idoine's (1986) re-analysis of Scarratt's (1973) data suggested that the compensatory response may occur early during the period between the fourth larval stage and recruitment to the fishery (i.e. in the juvenile stages). It is not clear what form the regulatory mechanism takes but habitat limitation is a reasonable hypothesis — hence the interest in Wahle and Steneck's work. This issue is of broad significance because most clawed and spiny lobster species exhibit well defined habitat requirements and are potentially habitat-limited.

In the last decade, there has been a sustained increase in landings of *Homarus,* which in some areas have now reached unprecedented levels (Elner and Campbell 1991; Figure 1). The apparently high abundance of lobsters would seem to refute the habitat limitation hypothesis. Attempts to equate increases in landings with increases in abundance, however, have the potential of being extremely misleading. Clearly there has been a massive increase in landings over a broad scale, but in many areas there has also been a concurrent and dramatic increase in effort. An example is provided in Figure 2 for the Maine lobster fishery. Landings in Maine are now slightly higher than those of a century ago, but the number of traps fished to attain this level has increased by a factor of twenty. Increases in effective effort may also have occurred in Canadian lobster fisheries which have limited entry and trap limits [see Morgan (1980) for an example of effort increases in the limited entry western rock lobster fishery]. We therefore need to be cautious in interpreting the increase in landings as an increase in abundance. We need also to be careful to take into consideration any expansion in fishing grounds that may have occurred as effort levels increased.

Figure 1



[1] Canadian Landings for Scotia-Fundy Region

Although the landings have reached record levels, the current position contrasts starkly with that of the virgin fishery. Catch per trap is very much lower, fishing mortality is very much higher and the average size range of animals caught now is much smaller than that caught in the virgin fishery. The notion that the current population abundance and size structure is comparable to the virgin population is clearly fallacious. Both the biomass and the mean size of females (and hence levels of egg and larval production) are presumably much lower than historical levels.

Despite the above caveats, there may indeed have been a recent increase in American lobster recruitment. If so, it has occurred over a broad scale, suggesting the influence of a common environmental factor. Interestingly, increases in landings of European lobster *(H. gammarus)* have also recently

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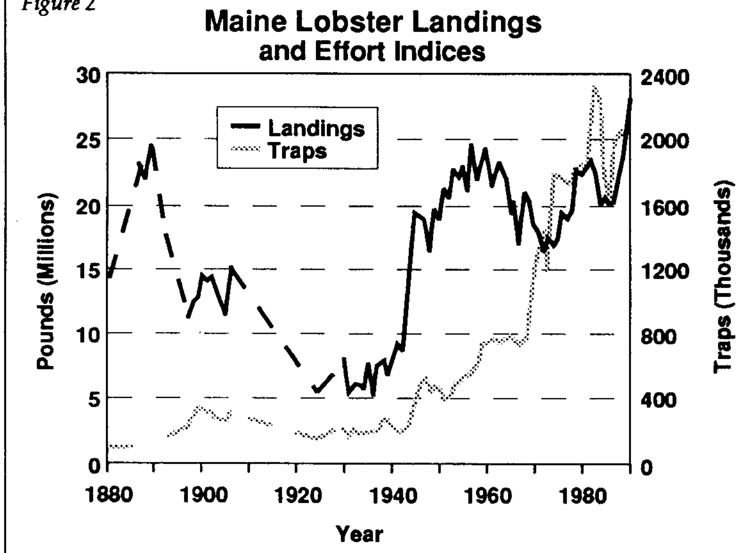
been observed, possibly indicating the effect of a large-scale climatological variable. Sea water temperature is an obvious possibility that could underly changes in landings on a pan-Atlantic scale. An increase in temperature could generate increased survival of larvae and juvenile lobsters by increasing growth rates thereby decreasing the time spent in vulnerable life history stages. However, time series analyses of the effect of temperature on catch (Fogarty, 1988; Campbell et al., 1991) have not demonstrated consistent lagged effects that could be biologically interpreted. Immediate temperature effects on catchability are more probable (or at least detectable). Lobster activity levels (and hence vulnerability to capture) increase with increasing temperature (McLeese and Wilder, 1958). Fogarty (1988) demonstrated an immediate (lag 0) effect of water temperature on catch. The observed increases in landings over the last decade is most likely due, in part, to an increase in catchability with increased water temperatures. This in turn has apparently stimulated an increase in effort in response to increased catches. More recently, water temperatures declined in 1992 relative to previous years and preliminary catch estimates are also lower, further suggesting the importance of immediate temperature effects.

An alternative explanation is that the increase in lobster landings is linked to the recent decline in groundfish stocks. It is argued that the decrease of groundfish predators has significantly increased survival rates of juvenile lobsters. Although many groundfish stocks have declined, other lightly exploited species, including known predators of lobsters such as small elasmobranchs have increased markedly in some areas. It is difficult therefore to attribute increases in lobster abundance primarily to declines in predator biomass, although it may play some role.

Whatever the underlying explanation for the apparent high abundance of lobsters, it has polarised opinion in the debate surrounding the Wahle and Steneck (1991) hypothesis of habitat limitation in the juvenile stages. Wahle and Steneck found that early benthic phase lobsters were restricted to shelter-providing (cobble substratum) habitats in the Gulf of Maine, and postulated that this requirement may limit benthic recruitment because a census showed that the necessary cobble habitat comprised only 11% of coastal Gulf of Maine habitats. The debate has been fueled by the fishing industry picking up on the "bottleneck" theory to justify rejecting proposals for an increase in minimum landing size. Wahle and Steneck's hypothesis is challenged by Miller et al. (1991) who conducted extensive diver studies of the Nova Scotia coastline. They took the recent high lobster landings as a proxy for recruitment and concluded that there is an abundance of suitable habitat for juvenile lobsters in that region. Similarly Peter Lawton (pers. comm.) conducted diver surveys in the Bay of Fundy and concluded that it was unlikely that habitat is limiting there either. Their observations support the view that if juvenile lobster abundance is at its highest level in the recent past, it seems highly unlikely that there is any limitation on suitable habitat. How can there be a "bottleneck" in the system if such apparently large "year-classes" of juveniles are now present on the grounds and if habitat availability has not changed over the recent past? The only reliable measure of true changes in abundance, however, would be direct census estimates of juvenile abundance over many years at the same site. Because we cannot retrospectively collect this information, we must be sure that our indirect (fishery-dependent) estimates of abundance are not biased by changes in the area exploited by the fishery and increases in effort. A shift in the fishing grounds to encompass previously unfished areas could also misleadingly suggest increases in abundance.

Figure 2



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PERSPECTIVE

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Direct estimation of the amount of suitable habitat will not be easy. The obvious test would be to conduct habitat deletion and addition experiments to determine if these result in long-term changes in abundance of juvenile lobsters. Although cobble substrate may be the preferred habitat for juvenile lobsters, they have been found in a variety of other habitats such as eelgrass, bedrock and mud. A simple estimate of the proportion of cobble habitat therefore may not provide an adequate estimate of potential juvenile lobster habitat. Defining suitable habitat, let alone quantifying it, seems to be fraught with difficulties, not least because what a diver perceives as suitable lobster habitat may not be seen as such by the lobster. The relevant features of the habitat include not only shelter sites but prey abundance and availability. Lobster distribution and abundance in different environments may also vary with the distribution, species composition and abundance of predators — the enforcers in the habitat selection game. Under low predator levels, the risks associated with occupying sub-optimal habitats are less and the range of habitat types occupied can expand. The abundance of competitors for space in the preferred substrates must also be considered in assessing habitat suitability and availability.

The question of whether habitat is limiting now for lobster populations is important but whether habitat has been limiting in the past or may be at some time in the future is equally as important. The population(s) may be currently operating on the steeply ascending portion of a stock-recruitment curve at relatively low egg production levels and therefore not under severe density-dependent contraints. This view underscores both a possible reason for the resilience of lobster populations to exploitation — strong compensation — and the potential for recruitment overfishing if effort levels continue to increase. Management strategies that increase overall levels of egg production and yield per recruit (e.g. decreasing fishing mortality, increasing minimum legal size limits, etc) provide, in our opinion, the most effective approach to increasing productivity and maintaining a viable fishery. Even if habitat is currently limiting, these measures would be beneficial in increasing yield per recruit and in providing a buffer in egg production against the vagaries of the environment.

If we are to understand why American lobster stocks have been so resilient to persistently high exploitation rates, we have to identify the stage of the life cycle, if any, at which compensation occurs and/or to identify alternative mechanisms that promote resilience. The ability to sample quantitatively for early benthic phase and juvenile lobsters as pioneered by Hudon (1987) and Wahle and Steneck (1991) is an important starting point. Habitat may or may not be limiting for American lobster populations but the recent increase in landings cannot be taken as prima facie evidence that it is not. We need instead to directly sample all life history stages to determine the factors controlling the dynamics of lobster populations. The broad similarity in habitat requirements, particularly with respect to shelter, for many clawed and spiny lobster species suggests that this issue is of general importance and that comparative studies across taxa could yield valuable insights into factors governing the stability and resilience of these populations.

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Julian Addison
MAFF
Lowestoft, UK

Michael Fogarty
NOAA, NMFS
Woods Hole MA USA

NEW METHODS AND APPLICATIONS

Visible Implant Microtags

FROM: M. EDMUNDS

The advent of coded micro-wire tags has enabled the markings of individual lobsters as small as 9-10 mm CL, increasing the precision of growth and movement data compared to other batchmarking techniques. Coded micro-wire tags must be excised from the animal to be read, thereby limiting use to single, capture-mark-recapture studies. This limitation may be overcome by either implanting a second tag in distal segments of periopods, which can be excised without killing the specimen, or by using x-ray readable micro-tags. A third alternative is the use of externally visible, implanted micro-tags (VI tags). We began an investigation on the use of VI tags in early benthic phases of the spiny lobster, *Jasus edwardsii.*

The microtag VI study used tags developed by Northwest Marine Technology. The tag measures 1.0x2.5x0.1 mm inscribed with a three digit, alphanumeric code. The VI tag was designed for and is used successfully in the clear tissues of fish, particularly the adipose eyelid of salmonids and adipose fins, mandibles and fin membranes of other fish species. In this study, VI tags were applied with a syringe style injector directly beneath the lobster's intersternal membranes of the ventral abdomen.

The first trial, which employed 13 pueruli (10.4-11.4 mm CL) and 7 post-pueruli (11.23-13.3 mm CL), was unsuccessful with all animals dying within 18 days of tag placement. The main causes of mortality were reopening of the wound during moulting from the puerulus to post-puerulus stage (the puerulus stage is short-lived, limiting the time available for healing before ecdysis), projection of the tag into the wound scar such that it could not heal properly, and infection of the haemocoel by facultative protozoan parasites. Other problems included air embolisms during injection, and movement of the tag into the thorax when injected between the sternum and abdominal sternum 1. These problems were largely overcome in subsequent trials with an increased competency in the injection method and with a strict attention of hygiene.

Effects of the VI tag on growth and survival of ten post-puerulus lobsters (10.3-12.6 mm CL) were tested in the laboratory against ten abdominal spine clipped controls (post-puerulus 11.3-12.5 mm CL). After 60 days, only two deaths had occurred; one control and one experimental. All surviving lobsters moulted successfully with no significant difference in the time to moulting between the VI tagged group and the control group. A further 191 post puerulus and juvenile lobsters have been tagged for release into artificial dens on a natural reef. The lobsters were tagged in batches of 30-50, held in the laboratory for a week and then released. During this holding period only 6 (3%) of the lobsters died while six moulted successful (four to seven days after tagging).

The artificial dens are monitored regularly and 12 lobsters have been encountered since their release, 3 of which have been encountered more than once. The VI tags are easily read underwater and growth and movement data can be taken with minimum disturbance to the lobsters. The use of the VI tags is continuing as part of a larger study of the growth and habitat utilization of juvenile *Jasus edwardsii.*

Matthew Edmunds
Department of Zoology
University of Tasmania
GPO Box 252c
Hobart, Tasmania
AUSTRALIA 7001

BOOK REVIEWS

FAO Species Catalog. Marine Lobsters of the World. An Annotated and Ilustrated Catalog of Species of Interest Known to Date. L.B. Holthius 1991. FAO Fisheries Synopsis No. 125, vol 13: 292p. Rome.

REVIEWED BY: AUSTIN B. WILLIAMS

FAO continues its excellent annotated and handsomely illustrated world-wide catalogues of major groups that enter marine fisheries, a series that was initiated by Dr. Holthuis' "Shrimps and Prawns of the World" (1980). The present work "intends to include all of the species of marine lobsters that are of interest to fisheries," those known to be used for food, bait or subproducts, and species not exploited at present but considered by experts to be of potential commercial value. This adds up to the most comprehensive work of its kind, including accounts for 149 species in 3 infraorders, 10 families, and 33 genera, representing the results of the author's years of painstaking research on systematics and review of fisheries biology.

Nomenclature for each systematic category includes: the valid scientific name; reference to the original description with its citation; all synonyms of the valid name, and in the case of new combinations, the valid name and synonyms; type species of genera; illustrated keys to, or lists of, systematic categories; FAO names that are English, French, or Spanish for each species, with rationale for this choice and the same for names of generic categories, e.g. lobster (all nephropids), rock lobster *(Jasus)*, spiny lobster *(Panulirus and Palinurus)*, etc.

Beyond the basic framework of nomenclature is a set of informative remarks for each family and genus. For each species there is a set of variously detailed paragraphs supplying biological information that should satisfy almost any inquirer using the reference: type locality of species and its synonyms, with depository of primary types, or if unknown, depository indicated at the time of original description, all of this filled with fascinating historical lore; diagnostic features of species accompanied by handsome line and toned drawings of body and/or body parts, often supplemented by labelled insets; geographic distribution summarized, mapped, and listed by major marine areas for statistical purposes; habitat and biology summarized; size given in length-width proportions and maxima; interest to fisheries including catch statistics or potential for development to the extent this can be determined from market of exploratory reports; local names often more descriptive than standardized FAO names; and literature giving significant information pertaining to fisheries biology, with bibliography of 231 entries.

Following an introductory section on morphology, general habitat and biology of lobsters and their interest in fisheries, and illustrated glossary of morphological terms precedes the systematic accounts. There is a table of contents and an index of scientific and vernacular names. The author has perhaps given more weight to nomenclature than would a non-systematist, but the pithy text in a generous format illuminated by large, mostly well-reproduced illustrations makes this a thoroughly satisfactory reference. The volume (21 x 29.5 cm) may be ordered from UNIPUB, 4611 F Assembly Drive, Lanham, MD 20706-4391 (US$55).

Austin B. Williams
NMFS Systematic Laboratory
National Museum of Natural History
Washington, DC 20560 USA

Techniques of Lobster Stock Enhancement. Craig Burton 1992. Seafish Report No. 396 SeaFish Industry Authority, Marine Farming Unit. Ardtoe, Acharcle

Argyle, United Kingdom PH36 4LD

REVIEWED BY: SUSAN WADDY

This report describes the operation of a pilot-scale lobster *(Homarus gammarus)* hatchery in Ardtoe (Scotland) established in 1983 as one of several hatcheries operating at that time in the United Kingdom, part of a larger programme being conducted by the Ministry of Agriculture, Fisheries and Food (MAFF) to assess the success of lobster hatcheries for stock enhancement. This report describes the Ardtoe operation in detail and was intended as a manual of hatchery and release techniques for other groups contemplating hatchery operations in Scotland. The Ardtoe hatchery was modelled after the MAFF unit at Conwy and many of the techniques are similar to those described earlier in various reports by Beard, Wickins and colleagues.

This report was only intended as a manual and a record of activities at this particular hatchery and so does not attempt to compare the techniques and strategies used in various laboratories in Europe and North America for broodstock man-

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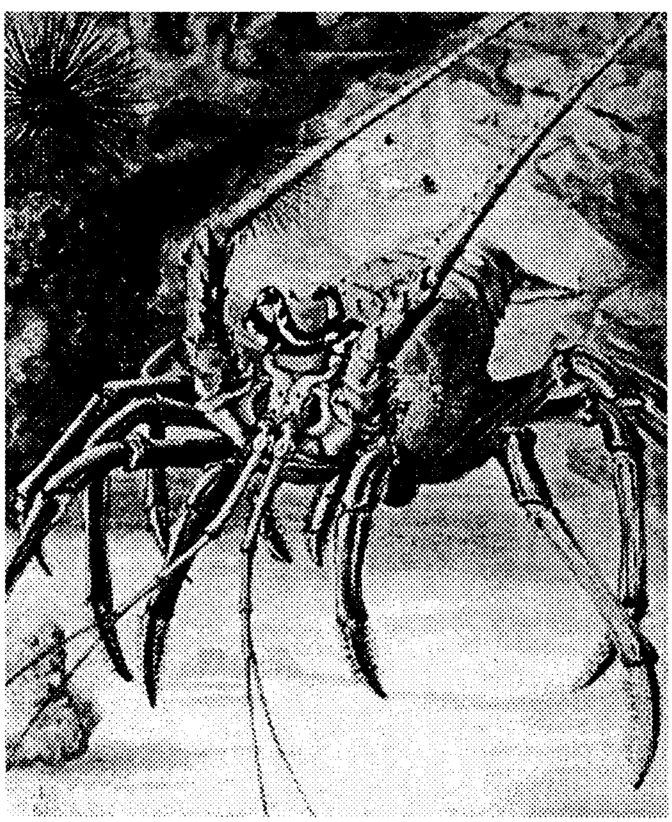
agement, hatching and larval rearing. It is interesting to note that techniques and strategies for lobster culture vary considerably among operations. For example, temperatures used at other locations proved to be unsuitable for ovigerous females from Scottish waters. causing excessive egg loss and reduced larval survival,

The Ardtoe hatchery uses berried females from the wild fishery, rears the larvae and releases them into the wild as postlarvae or small juveniles (stages VI and XII). Production at the hatchery is managed so that release to the wild occurs twice a year, in the spring and again in the autumn. Prior to release the juveniles are microtagged with a stainless steel wire encoded with information such as larval batch and date of release. Market-size animals hatched and reared in the various hatcheries in the UK have been recovered from sites throughout Scotland, England and Wales. There is still insufficient data on recaptures to determine whether populations are being significantly enhanced.

However, the capture of microtagged mature adult lobsters from the wild fishery demonstrates that hatchery reared lobsters can survive and grow to reproduce in the wild. The results (although preliminary) also suggest a high level of retention of the seeded stock at the release sites. Meat flavor and texture in the cultured lobsters was no different from that of wild stock.

This report is relatively expensive (£ 15) considering that most of the information is available from a variety of other sources. There were some annoying grammatical and typographical errors and I would have preferred to see the figures incorporated into the text instead of grouped at the end. But the results of the project are interesting and one of the most significant contributions from such hatchery projects may be the information they will provide on growth rates and recruitment dynamics.

S. L. Waddy
Fisheries and Oceans
Biological Station
St. Andrews, N.B. E0G 2X0
CANADA



From an original painting by Else Bostelmann under direction Roy W. Miner. ©National Geographic Society

ANNOUNCEMENTS

CONTINUED FROM PAGE 9

American Lobster Market Study

Want to learn just about everything there is to know about the U. S. live-lobster market? A new, 176 page, report from E. J. Richardson Associates, Lobster Market Study with Analysis for Management comes in an easy-to-read format with over 140 figures. The comprehensive report examines U.S. and Canadian landings and sales from storage pounds, American lobster distribution and consumption by U.S. region and retail market segment, the growth of processed lobster products, the factors that determine U.S. live-lobster prices, and the effects of the U.S. increases in minimum legal size. The report concludes with an analysis of issues important to the future management of the American lobster fishery and includes evaluations of altenate harvesting regulations from a global seafood marketing perspective. Copies may be obtained by sending a check or money order for US$40 to:

E.J. Richardson Associates
P.O. Box 236
Sandown, NH 03873, USA.

LETTERS

Dear Colleagues,

I am working with a project called "The potential for farming the Sculptured Shrimp *Sclerocrangon boreas*." *Sclerocrangon* resembles lobsters in many ways and there is not much information available in the literature. Could I ask for your help? If you have information about the species, from distribution to taxonomy, to physiology, could you let me know about it? Thank you very much..

Ilona J. Miglavs
Norwegian College of Fisheries Science
Dramsveien 201
9000 Tromsø
Norway

Formation of an International Forum of Lobster Scientists

Four years have passed since the appearance of the first volume of The Lobster Newsletter. Today, the Newsletter is reaching almost 450 professionals in 43 countries involved in lobster research and management. The purpose of The Lobster Newsletter is to enhance research communication. It has achieved its objectives to a great extent, thanks to the perseverance and ingenious efforts of Dr. Stan Cobb and Dr. John Pringle. Now the time is appropriate for us to think of a Society or an International Lobster Science Forum, the main objective of which would be, regular interaction among the lobster scientists around the world. This will also encourage information exchange and strengthen lobster re search. The most effective and customary method of transfer of information between scientists and technologists is through conferences, seminars, workshops, personal contacts, visits and other informal modes of communication. The forum would provide a formal mechanism through which lobster scientists could regularly share information and address issues of common concern.

A questionnaire seeking international opinion can be circulated through the Lobster Newsletter. The formation of the official body and other matters can be discussed at The Fourth International Workshop on Lobster Biology and Management to be held at Sanriku, Japan in 1993.

E. V. Radhakrishnan
Central Marine Fishery Research Institute
Marine Fisheries P.O. 6Z3 5Z0
Mandapam Camp
Tamil Nadu, India

December 1992

The Lobster NEWSLETTER

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

ADDRESS CORRECTION REQUESTED