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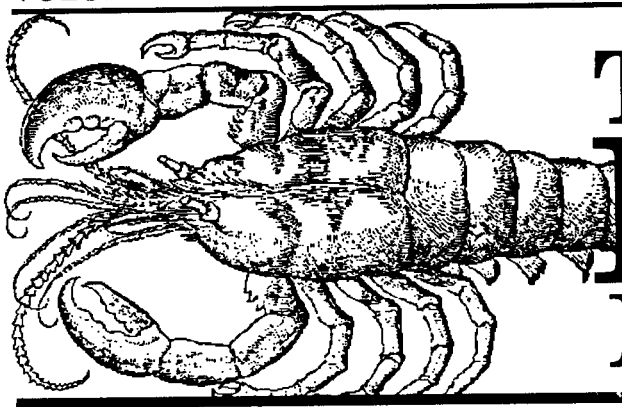

The Lobster NEWSLETTER

RECENT EVENTS

Lobster Workshop in Maine

On November 29 and 30 about sixty people interested in research on *Homarus americanus* gathered in Orono, Maine for a workshop on the "Life History of the American Lobster." The workshop was hosted by the Lobster Institute at the University of Maine. Thirty-nine papers were scheduled to be presented on topics ranging from larval distributions through molt-cycle physiology to population modeling. A wide variety of groups from the United States were represented, including fishermen and scientists from state, federal and university research centers. Unfortunately, a last-minute decision by the Government of Canada prevented lobster scientists from the Department of Fisheries and Oceans from attending. Although that did not delete all the Canadian contributions, only two papers, from non-federal scientists, were presented.

Here some of the presentations are highlighted. For a copy of the proceedings, which contain abstracts of all the papers (whether presented or not) and summaries of each session and accompanying discussions, write to The Lobster Institute, 22 Coburn Hall, University of Maine, Orono ME, 04469, USA.

In the session on larvae, it became apparent that there is more evidence for the effect of wind and hydrographic features on postlarval distributions. The reports reiterated that larvae are patchily distributed. Temporal and spatial patterns are dependent upon the scale of examination. The ratio of RNA to DNA, an indicator of recent growth, can be determined for individual *H. americanus* postlarvae, but variations of the ratio over the molt cycle still need to be documented before field applications can be made.

Two presentations underlined the importance of relating molt cycle changes to behavioral and physiological studies in juvenile or adult lobsters. Not only does blood chemistry change markedly from one part of the molt cycle to the next, but the nature of the tail flip escape response changes from postmolt to premolt.

Several papers presented accumulating evidence from tagging studies that smaller lobsters tend to move relatively short distances, while large animals may move hundreds of kilometers at minimum rates of up to half a kilometer per day. Tracking individuals with acoustic tags complements traditional tagging methods and appears promising. Genetic

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RESEARCH NEWS

Fight or Flight: Neuroethology of the Molt Cycle in Lobsters –A Progress Report

American lobsters are aggressive animals. Food and shelter are frequently fought for. In an aggressive encounter, the winner usually is the larger animal, or the one with larger claws. More interestingly, as Tamm and Cobb (1978) demonstrated, premolt (stage D1) lobsters emerge as victors of a bout more often than their intermolt (stage C) or postmolt (stage A/B) opponents. There were also marked molt stage-related differences in the frequency with which competing lobsters resorted to the meral spread or tail flip in an encounter.

This suggested that inherent physiological changes occuring over the molt cycle caused differences in aggressive behavior. About 10 years ago, Stan Cobb and I began to look for the basis of these behavioral changes.

Our approach has been to specify the components of a particular behavior and then to look for molt-related differences in the underlying physiology. We have been focussing on the meral spread (claws extended and open) and the tail flip (escape response)

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EDITORIAL

Lobster scientists are a diverse and far-flung lot. Only our interests in the animals tie us together since the research topics we choose tend to be extremely broad. Some of us work on lobsters because the animals are easy to manipulate and can be models of invertebrate nervous systems, crustacean endocrine systems, etc. Others do so because they are fascinated by the animal itself. Still others are charged with managing the human exploitation of the species, and for that must know the biology well, as Larkin (1980) advised.

There is not, and cannot be, a common thread to the research carried out by the members of the lobster research community, other than the lobsters themselves. However, we all know that we are interested in animals that, almost without exception, are of considerable commercial value. The commercial value makes our research economically and politically important. All research on lobsters, no matter how basic or without obvious application, helps in the understanding of the animal and thus with its management. This also acts in reverse; the importance of lobsters to the economy of a number of areas means that a considerable amount of the research is driven by management needs.

Political concerns should be the last things that we as scientists worry about as we work to learn more about lobsters. Nevertheless, we must recognize the role they play. This was brought home to a relatively small group of lobster scientists at a workshop held at the University of Maine (USA) in November (see Recent Events.) Several months before the workshop, controversy over minimum legal size became tied together with a trade controversy between the USA and Canada. The controversy started because one group of scientists in the USA disagreed with the science behind a new regulation to increase the minimum legal size and questioned the value of the regulation. Their influence was felt in Canada which prevented Canada's move to increase lobster size in concert with the USA. The history of the rest of the controversy is less important than the outcome: a bill was passed in the US Congress that restricted trade in lobsters between the US and Canada. The Canadian federal government, not wishing the delicate subject of trade to come up at a workshop on lobster biology, denied permission, at the last moment, for their employees to attend the workshop. Conference attendees were very disappointed not to have most of the Canadian contingent there, and their Canadian colleagues were chagrined not to be able to attend. An avenue for scientific communication was closed.

We do not expect something like this to happen again between Canada and the USA, since the circumstances surrounding it were unusual. However, political differences between Cuba and the USA may close another door of communication. Those US scientists hoping to go to the International Lobster Workshop in Cuba in June are facing difficulties, since the US government places severe obstacles in the path of its citizens who wish to travel to Cuba.

Communication is at the heart of science. That is why The Lobster Newsletter exists. Somebody asked recently for whom we edit The Lobster Newsletter. The answer is easy enough. In grandiose terms, the readers of The Lobster Newsletter are members of the international lobster research community. Most of the readers are scientists, but a number are fishermen, writers, or "just interested." This issue of the Newsletter will be mailed to about 350 people in 32 countries. We were surprised to find out, from an analysis of our mailing list, just how large and far flung the community is. As the contributions to this (and we hope, to future issues) show, we are a diverse group. Our ambition is to promote communication within this community, to make a network of information that will both enhance the process of research and stimulate communication. Hitches in the communication process, such as happened at the Maine workshop and might happen for US citizens at the Cuba workshop shouldn't happen, but they do. We hope The Lobster Newsletter will help to enhance communication when these unfortunate hitches occur.

J.S. Cobb
J. Pringle

The Lobster NEWSLETTER

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RESEARCH NEWS

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as characteristic expressions of aggression and avoidance.

Mary Schwanke, then a graduate student in my lab and now at the University of Maine at Farmington, began the search by looking at the effects of blood from different molt stages on the electrical properties of the neuromuscular junction of the opener muscle of the dactyl. The pronounced contraction of this muscle during meral spread is an essential component of this threat behavior and so seemed a likely place to begin looking for the factors underlying aggressive behavior. Figure 1 diagrams the experimental preparation for the experiments on the dactyl opener muscle. As expected, blood from stage D lobsters caused an increase in the excitatory junction

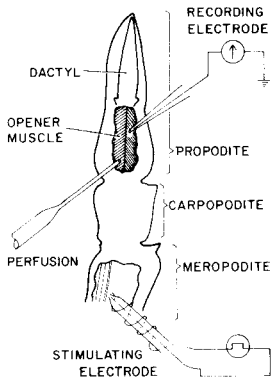

Figure 1. Experimental Preparation

potentials (EJPs) of this muscle. A further look at the properties of the neuromuscular junction itself showed that even in saline, EJPs of hard-shelled lobsters were larger than EJPs of soft-shelled lobsters (stage A/B) while for IJPs (inhibitory junction potentials), just the reverse was true (Schwanke 1989 and ms submitted.). Figure 2 presents the results of this experiment. These findings immediately led to two other questions: What factors were responsible for the effects of blood from aggressive D-stage lobsters? What neuronal differences were responsible for the differences in size of the EJPs?

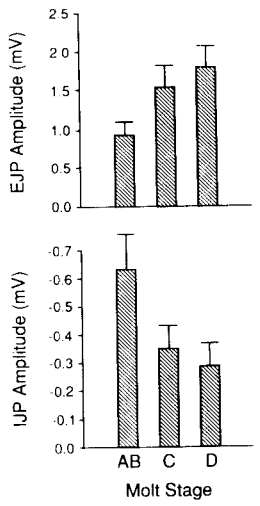

Figure 2. Changes in EJPs and IJPs with molt stage.

We have begun to look for answers to these questions. We started by analyzing the blood for differences in serotonin and octopamine, since the work in Ed Kravitz's lab at Harvard showed that these substances had profound and opposing effects on the postural stances of lobsters that he interpreted by associating octopamine with submission and serotonin with aggression (see Kravitz et al. 1988 for a review). Working with our collaborator, Phyllis Brown of the Chemistry Department at URI, Debra Fadool undertook the chemical analysis of blood from various molt-stage lobsters. Her findings were not what we anticipated: there were no statistically significant differences in the quantities of serotonin or octopamine between premolt and postmolt lobsters. There were differences, however, between males and females; males had higher concentrations of both octopamine and serotonin than did females (Fadool et al. 1989.) Clearly the question of whether there are molt-related blood-borne factors that mediate components of aggressive behavior is still unresolved and so we are continuing our search.

We also are following the other lead.Together with Linda Hufnagel of the Department of Microbiology at URI, we are beginning to look into the possibility of inherent anatomical and ultrastructural differences in the presynaptic terminals of the opener muscle in different stages. Such differences seem likely in view of our findings that there are inherent molt-related differences in EJP amplitudes.

In the mean time, we recently completed a study of the differences in escape behavior over the molt cycle. This is the work of Stuart Cromarty, another graduate student in my laboratory. The escape behavior (tail flip) of juvenile lobsters in various molt stages was videotaped and analyzed frame-by-frame. Although lobsters in postmolt and in premolt travelled about the same distances, they did it in different ways. Premolt lobsters showed a forceful power stroke (the first tail flip in the series) and a few subsequent flips, while postmolt lobsters had a weaker power stroke but more following swims. We expect these differences to be reflected in differences in the neuromuscular physiology of the abdominal muscles, and work on this aspect of the project is underway.

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Spiny Lobster Survey at Tristan da Cunha

A team of research divers from the Sea Fisheries Research Institute in Cape Town visited the Tristan Island group during March and April 1989. The three closely adjacent volcanic islands of Tristan da Cunha, Inaccessible and Nightingale are situated at approximately 37°S in the South Central Atlantic Ocean, slightly north of the subtropical convergence. They are bathed by the relatively warm waters of the South Atlantic gyral circulation which flows persistently east- to north-eastwards at these latitudes.

The spiny lobster, *Jasus tristani*, is endemic to these islands, as well as to Gough Island (at ca. 40°S) and to Vema Seamount, an isolated volcanic pinnacle in the center of the Cape Basin (Figure 1).

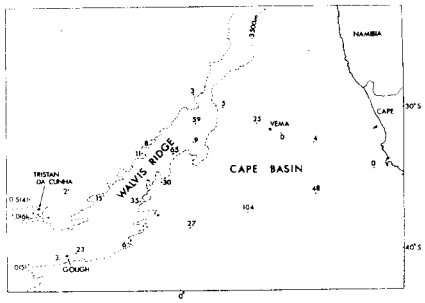

Figure 1. Localities inhabited by Jasus tristani. *The locations of stations and the numbers of phyllosoma larvae captured during one-hour tows are also indicated. (Mean during (n) consecutive tows indicated for three stations in the extreme west).*

The objective of the survey was to investigate possible reasons for the difference in lobster growth rates and size composition observed at Nightingale and Inaccessible, two islands situated just to the south of Tristan da Cunha. The subtidal region was investigated by diving to a maximum depth of 50 m. The region is characterized by a depauperate fauna typical of mid-ocean islands, creating a relatively uncomplicated ecosystem which is fairly easy to describe and understand. The diving team collected lobster samples for maturity and feeding studies, and made notes on the relative abundance of all major benthic organisms, especially those used as food by the lobsters, e.g. sea urchins, kelps and barnacles. Predatory fish were abundant at all the islands visited. We hope to present detailed findings at the lobster workshop in Cuba next June.

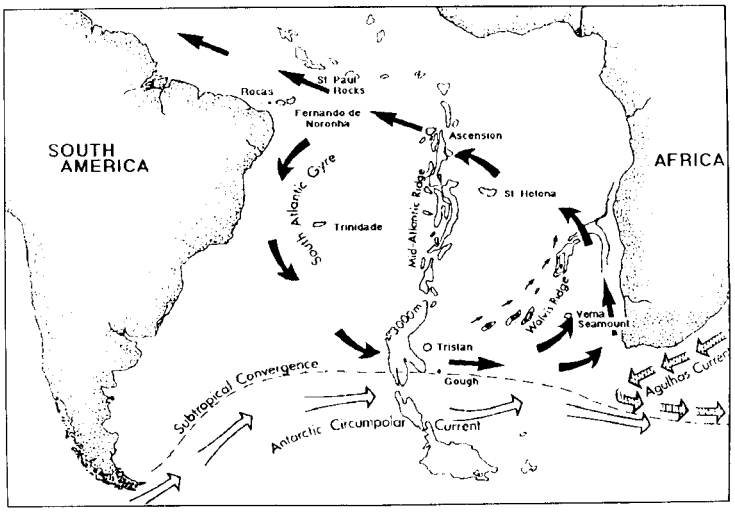

Figure 2. The South Atlantic gyral circulation system. (From Pollock 1989, Spiny Lobsters. in Oceans of Life off Southern Africa, eds I.L. Payne and R.J. Crawford. Cape Town. Vlaeberg. 380 pp.)

Phyllosoma larvae of *Jasus* were caught by the research vessel Africana in the upper 100 m of water at night at all stations shown on Figure 1, proving widespread distribution of larvae in the southern and south-eastern South Atlantic region. Late-stage larvae of *Jasus* caught at the few stations occupied up-current (west) of the islands certainly lends credence to the view that larvae of *Jasus* make use of the South Atlantic gyral circuit to disperse their larvae from and return to home populations (see Fig. 2).

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Panulirus ornatus in Papua New Guinea

At the Department of Fisheries and Marine Resources, we have been working on *Panulirus ornatus* in Papua New Guinea from Torres Strait to the eastern Gulf of Papua. We have gone a long way towards understanding this species. Our research, much of it with CSIRO in Australia (a project now supervised by Bill Dall), has recently focussed on the fate of migratory lobsters that cross the the Gulf of Papua to the area of Yule Island. We have carried out some gross physiological studies that demonstrate severe physiological stress in the emigrants. Readily observed changes were found in the water content of the digestive gland and abdominal musculature. CHN analysis showed marked changes in the ratio of carbon to nitrogen, particularly in the digestive gland, as the carbohydrates and lipids are metabolized for maintaining locomotor and reproductive activity. We feel that we have found a mechanism that explains the mass mortality of breeding lobsters first suggested by Ray Moore and Wallace MacFarlane. Lobsters probably are physiologically incompetent to molt when they finally reach the end of the

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breeding season, after an especially long and stressful intermolt period. I hope to pursue this line of work further with the help of Rick Phleger and his colleagues at San Diego State University during the next breeding season.

I am now engaged in a field study using the DELTA submersible to look for deep water breeding populations, which we believe are distributed along the edge of the continental shelf from the northern end of the Great Barrier Reef to the eastern end of the Gulf of Papua. We hope that if we find these populations we will be able to determine whether the same level of physiological deterioration is experienced in deep water. Basically, we are interested to know if we are dealing with a semelparous population, unknown in other species of lobsters.

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RECENT EVENTS

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studies on DNA found high levels of variability and evidence for historical differences in population structure. Predation clearly is an important factor in determining mortality and perhaps distribution of small lobsters, but much less so in larger lobsters. On both sides of the Atlantic, the size structure of lobster populations seems to be determined in part by the nature of the substrate. Changes in size and in behavior with age cause what appear to be ontogenetic shifts in ecological role and habitat distribution. Differing views on the habitat distribution of juveniles were presented yielding the impression that generalizations from localized studies should be made cautiously.

At the end of the workshop, discussion turned towards subjects more directly tied to management, such as trapping, models of population dynamics and stock enhancement. The influence of trap design and placement on biological inferences was emphasized in two presentations. Assumptions involved in population modeling received attention, particularly model sensitivity to mortality estimates. The topic of changes in minimum legal size, always a hot one in the *H. americanus* fishery, generated spirited discussion, but intentionally, no conclusions were drawn. An excellent summary that tied together stock-recruitment relationships, yield per recruit models and biological data presented at the meeting also had the effect of suggesting that a minimum legal size increase is a conservative way of managing a risk-prone fishery.

LETTERS

We received the following request for information about spiny lobsters:

I am now in the middle of writing a popular book on the lobsters of the Caribbean, Bahamas, and Florida. The book deals primarily with the natural history and fishery, recreational and commercial, of *Panulirus argus*, but also includes a key to the 20 most common species of this region along with an illustration of each species and a synopsis of biological and fishery data for these species. These sections have already been written, but I would like to include any pertinent information that I might have missed.

I will include sections on larval rearing (based largely on work we did in the Florida Keys in rearing *P. argus* to the 5th intermolt), mariculture and "farming" potential, maintaining tropical lobsters in aquaria, the "how to" of recreational lobster fishing, a methods description of the commercial fishery, a discussion of the condition of the resource, and a culinary section. ... The first section (of the book) was completed two years ago. I put this book aside at that time to do a different book on marine aquaria which is now completed. I was working with Bill Lyons and John Hunt to gather correct and recent information and am now resuming contact with them for up-dated information.

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TERMINOLOGICAL TRIBULATIONS

Once more the thorny (or spiny?) problem of names for *Panulirus* has pricked our attention. While prowling through his reprint files, John Pringle rediscovered an article in Crustaceana by Harold Sims (1965) "Let's call the spiny lobster 'Spiny Lobster.'" Sims issued a clarion call to use common names that allow us to distinguish between freshwater crayfish (astacids), clawed lobsters (the Homaridae) and the spiny lobsters (Palinuridae.) That matter seems to have been fairly well agreed to, at least in the scientific literature, and the conventions suggested by Sims 25 years ago are followed (perhaps excepting the occasional "rock lobster" from our colleagues Down Under.) But as Rene Buesa reminded us in a recent letter, the Caribbean is a sticking point.

Buesa wrote that he feels uncomfortable with the common name of the 'Caribbean Spiny Lobster' for *Panulirus argus* "(as happens with almost all common names): for certain it should not be called the 'Florida Spiny Lobster' but should it be called the 'Caribbean Spiny Lobster'? Widening the geographical range of the name does not make it more accurate — what about the Bahamas, Bermuda, and all of the Brazilian populations of the species that are out of the *Caribbean* range of the name? Nor is 'American Spiny Lobster' a good solution because it would "outname" the other *Panulirus* in the area, and 'Western Spiny Lobster' is so broad as to make it meaningless.

"*P. guttatus* earned the common name of 'Dotted Spiny Lobster' because it refers to an anatomical characteristic rather than a geographical distribution. *P. laevicauda* has an overall greenish hue and might be called the 'Green Spiny Lobster.' Unfortunately *P. argus* does not have any distinguishing characteristics warranting a common name, and has a wide variety of colorations. It also inhabits a great range of types of bottom, and has a wide depth distribution!

"Why could we not name *P. argus*, which is the most abundant of all, the 'Common Spiny Lobster' instead of the 'Florida' (too local) or 'Caribbean' (not true!) spiny lobster?

"In any event, as a rule I strongly dislike common names that are unrelated to some anatomical, environmental, or behavioral characteristic of the animal involved!"

As editors, we couldn't agree more with the thoughts expressed in Buesa's last paragraph. In fact, we would go further, and attempt to limit common names to ones that are anatomical (including color) or behavioral descriptors. Unfortunately that does not always work; there really are instances in which a geographic descriptor is appropriate. The worst case is exemplified by *P. argus*, an undistinguished generalist whose wide range encompasses the distribution of other *Panulirus* species. We suspect that *P. argus* will continue to be known as the 'Caribbean Spiny Lobster', with the understanding that its range really is greater than that reflected in its common name.

With regard to this type of terminological tribulation, there now are two reference works to turn to, and we suggest that when in a quandry about common names, you look at either (or both) of the following: "Common and Scientific Names of Aquatic Invertebrates for the United States and Canada: Decapod Crustaceans" American Fisheries Society Publication No. 17, or "Lobsters of the World — an Illustrated Guide", reviewed in this issue of the Lobster Newsletter

J. S. Cobb
J. Pringle

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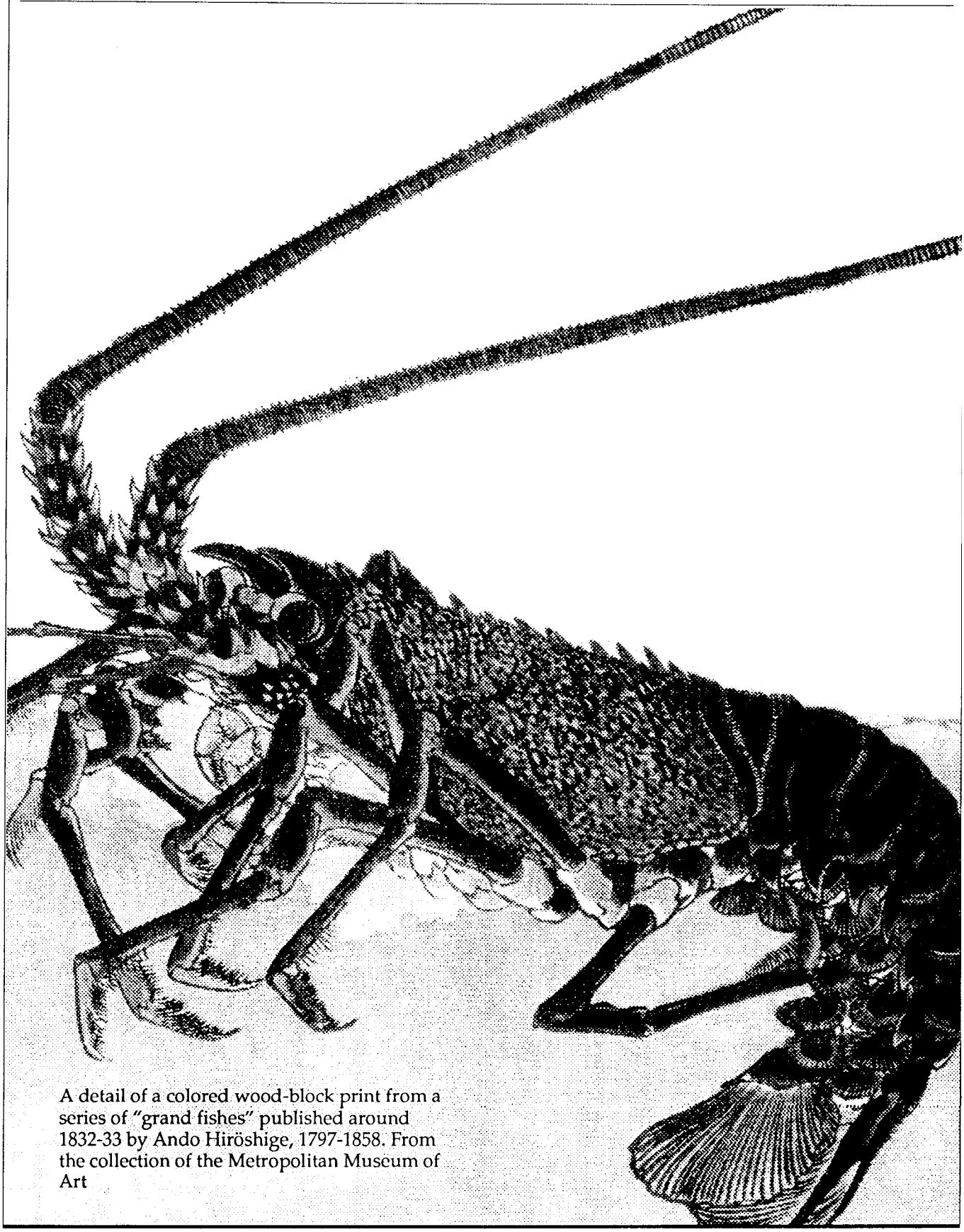

A detail of a colored wood-block print from a series of "grand fishes" published around 1832-33 by Ando Hiröshige, 1797-1858. From the collection of the Metropolitan Museum of Art

FISHERIES UPDATE

The Fishery for Spiny Lobsters in Brazil

The abundance of lobsters in the continental shelf of northeast Brazil appears to be determined by the existence of hydrologically stable waters, which have very little seasonal variation in physical conditions such as temperature and salinity. The low volume of freshwater runoff and the concentration of rock and coral formations on the inner shelf, and calcareous algae on the outer shelf provide suitable conditions for lobster growth and development throughout their life cycle.

Two species of lobster are found in commercial quantities in Brazilian waters: the Caribbean spiny lobster *(Panulirus argus)* and the smoothtail spiny lobster *(P. laevicauda.)* Their distribution overlaps, extending on the shelf as far as the continental slope (to about 100 m.) There is a seaward trend of increased individual size in both species. The population of *P. laevicauda* is concentrated on the inner shelf, while *P. argus*, the numerically dominant species, spreads over a much wider area. Sharing the same habitat may only be possible through the occupation of breeding and nursery sites at different times of the year in order to minimize competition for food and shelter.

Following are data on some biological characteristics from the catchable stock:

	P. argus	*P. laevicauda*
Asymptotic length	43.8 cm	38.0 cm
Asymptotic weight	3.2 kg	1.8 kg
Mean total length	21.6 cm	18.2 cm
Mean total weight	404 g	247 g
Growth coefficient (K)	0.163	0.171
Mean growth rate	2.9 cm/yr	2.7 cm/yr
Mean absolute fecundity	262,819 eggs/female	141,235 eggs/female
Mean relative fecundity	609 eggs/g body weight	579 eggs/g body weight

Molting is seasonal, taking place twice a year in the adult phase, with highest intensity in January and July-August for both species. The molting seasons alternate with breeding seasons in February-April and January-March.

The lobster fishery in Brazil started in 1955, concentrating at first in the northeastern and eastern grounds and in no time at all market demand for lobster tails boosted exploitation to the extent that depletion was noticable in the eastern grounds. In 1974 fishing was extended to the northern grounds, and in 1979 to the southern grounds.

Until the early 1960s fishing was carried out from wooden rafts and sailing canoes, but the fleet has been motorized steadily, so that now about one-third of it is made up of vessels greater than 16 m, with freezer holds. They are capable of making trips of up to 60 days from the main home port of Fortaleza, which receives about 80% of the landings. Sailing boats recently have become common again because of their suitability for the use of gill nets (trap fishing requires motorboats and larger deck space) while keeping operational costs low.

Brazilian fishermen land the world's second largest catch of warmwater lobster species. The average annual landings (in metric tons) for the period 1965 — 1987 are:

	P. argus	*P. laevicauda*
Yield (live weight)	5,280	2,256
Exportation (tail weight)	1,672	714

The commercial catch is maintained by three age groups in *P. argus* (III-V years, 16.0-27.2 cm TL), and two age groups in *P. laevicauda* (III-IV years, 15.2-21.8 cm TL). These account for 88.8% and 90.2% of total production, respectively.

The annual absolute recruitment fluctuates about an average of 50 million individuals in both species, generating a virtual population of 31 million, out of which 18.5 million lobsters are taken by the fishery. The optimum values of the yield (OSY), fishing effort (f_{opt}) and catch per unit effort (U_{opt}) for the period 1965-1987, were estimated as: OSY, 9,130 tons live weight (*P. argus*: 6,414; *P. laevicauda*: 2,716); f_{opt}, 20.1x106 trap-days; and U_{opt}, 0.459 kg/trap-day (*P. argus*: 0.319 kg/trap-day; *P. laevicauda*: 0.135 kg/trap-day). There was considerable variation in yield and CPUE until 1982, but since then there has been a steady decline, reflecting a real reduction in lobster stocks. This decline has occurred despite the discovery of new grounds and a three-fold increase in the size of the area exploited, from 54.4x103 km2 in the 60s, to 157.6x103 km2 in the 80s (see figure). It seems there has been a concentration of effort on the southern grounds, instead of an even distribution over the whole area. Unfortunately, it is impossible to tell from the pooled landing statistics whether the northeastern and eastern grounds have shown signs of recovery. In addition, the need to reach distant grounds from the homeport has brought soaring operational costs to the large, high-powered vessels. High lobster

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prices have helped to maintain the fishery's profitability, but government subsidies also have played an important role in drawing maximum socio-economic benefit from the fishing sector.

Several steps have been taken to protect the lobster stocks of Brazil. It is illegal to land, sell or transport small lobsters with tail length less than 13.0 cm *(P. argus)* and 10.6 cm *(P. laevicauda)*. A four-month closed season has been set up, from December through March, aimed at both reducing fishing effort and preventing the capture of breeding females. Use of gill nets is forbidden, but this has proven difficult to enforce since they are operated from rafts that can land anywhere, avoiding harbor facilities.

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Lobster Resource Science in Massachusetts

American lobster *(Homarus americanus)* research in Massachusetts coastal waters is determined by economic and political concerns, as well as a genuine quest for knowledge. Previous short-term studies, designed to answer specific resource management questions, have provided biological and behavioral information, and descriptive statistics on populations. These have served as "stepping stones" for future endeavors.

Since 1981, we have been monitoring the lobster resource in the six most important lobstering regions of the state of Massachusetts. A comprehensive biological description of the resource, catch rate trends, and regular stock assessments are thereby generated. As well, bottom water temperatures are electronically (analog) monitored at depth throughout the year. These data are used to asses molt patterns and catch rates in relation to molt probability. This coastwide program has augmented our understanding of lobsters by placing formerly fragmented information in perspective.

Our analyses confirm significant seasonal and geographic variations in lobster biological parameters. Estrella and McKiernan (1989) described the areal variation in parameters such as size-at-maturity, percentage of ovigerous females, size frequencies, morphometrics, and weight-to-length relationships. It is well-known that there is an inverse relationship between size-at-maturity and summer water temperatures (Templeman 1936.) As expected, size-at-maturity is smallest south of Cape Cod, particularly in the shoal waters of Buzzards Bay; it is largest in our deeper, "more exposed" coastal environments.

Cape Cod demarcates two biogeographic zones. To the southwest, lobsters in Buzzards Bay are subject to the highest maximum summer water temperatures among the regions sampled. The bay is shallow, with an average depth of 11 m, and maximum bottom temperatures of about 24°C. The shallow waters prevent the development of a thermocline; summer vertical themperature gradients are less than 3°C.

To the northeast, in the southern Gulf of Maine, and east of Cape Cod, conditions are quite different. The waters are substantially deeper, summer thermoclines exist, and bottom water temperatures are inversely proportional to depth. The waters off Cape Ann and east of Cape Cod are considerably deeper and colder than inshore. They are characterized by steeply sloping gradients which lead to a much greater depth than other areas. Cape Cod Bay temperatures are higher, due to shoal water and partial enclosure created by the peninsula of Cape Cod. Boston Harbor waters, which are relativley shallow and sheltered by several islands, experience similar warming.

The effects of geographical and hydrographical characteristics of the Massachusetts coast on lobster reproductive ecology and recruitment represent important areas of research. Scientists have expended considerable research effort on this subject in recent years. However, size-at-maturity is but one facet of the complex (seemingly mystifying) recruitment process. There are numerous factors, each with inherent variability, which act in concert to determine recruitment strength. It is therefore necessary to ensure, when modelling lobster population dynamics, that the important parameters are measured accurately.

Fecundity is an integral part of the recruitment mechanism. Its relationship to environmental influences is not known. Squires (1970) suggested the possibility of geographic variation in fecundity estimates, but the suggestion has never been satisfactorily tested. Small sample sizes with large variability in egg counts at size lead to imprecise regression analysis results. Acquiring adequate samples of ovigerous females is difficult given the current high exploitation rates.

Only one formal lobster fecundity study has been conducted in Massachusetts coastal waters. This was reported by Herrick (1911) from Buzzards Bay and Vineyard Sound. His estimates are based on the largest sample size of any fecundity study, 4,645 individuals; however, the validity of his data has been questioned. It was clear that the available size-fecundity relationships could not be considered as representative of Massachu-

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setts' lobsters without further study. Consequently, in concert with our desire to describe comprehensively the local lobster resource, we currently are attempting to accomplish the following: 1) provide fecundity estimates for Massachusetts' coastal lobsters based on adequate sample sizes; and 2) investigate geographic variation in fecundity within Massachusetts coastal waters relative to regional diffeences in size-at-maturity. These studies should permit us to determine if Herrick's estimates were realistic. If we are successful, we hope that our results will help to explain the large variability of fecundity estimates observed throughout the range of the American lobster.

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_____. 1936. J. Biol. Board Can. 2: 41-88.

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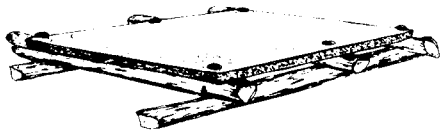
Stock Enhancement of Caribbean Spiny Lobster

Fishermen in Bahia de la Ascension, Mexico have been harvesting the Caribbean spiny lobster, *Panulirus argus*, from artificial shelters ("casitas", see figure) that simulate lobster dens, since 1976. Casitas are positioned in shallow (2-7 m depth) back-reef and inner-bay nursery habitats and spaced some 20 to 30 m apart. Fishermen free-dive to the shelter and remove lobsters with a gaff or net. Using a net we have captured up to 109 lobsters (18-89 mm carapace length) from a single casita.



The spiny lobster fishing grounds in Bahia de la Ascension are divided among 110 fishermen into approximately 150 "campos" or parcels of water. Currently, fishermen use over 10,000 casitas positioned throughout 160 km2 of Bahia de la Ascension. The fishery has been quite productive with annual landings ranging from 40 to 65 metric tons over the past 8 years.

Due to the intense fishing effort and high production of the fishery, we initiated experimental field tests in 1987 on the utility of artificial shelters in enhancing spiny lobster catch. The key issue concerns whether the artificial shelters actually increase spiny lobster production or merely concentrate lobsters for the fishermen. More than likely, the final answer will involve a mix of concentration and increased production.

Our field experiments have emphasized the role of complexity and shelter scaling in regulating predator-induced mortality rates of the juvenile spiny lobster. We hypothesized that predation intensity would vary as a consequence of different habitat features (e.g., seagrass density.) Habitats with limited refuge from predation but adequate food might support increases in lobster abundance if artificial shelters placed there reduce predator-induced mortality. Furthermore, the protective capacity of shelters may vary according to the relationship between shelter size and lobster size. We recently tested these hypotheses with field experiments in Bahia de la Ascension. Lobsters were tethered on short leads in several habitats. We found that juvenile spiny lobster survival was:

- Low in natural seagrass habitats with adequate food but limited shelter;
- Higher in an algal mat habitat within dense turtle grass than in dense or intermediate density turtle grass;
- Higher in casitas than in seagrass, although survival varied with distance from the casita;
- Generally higher in smaller than in larger casitas, although the effect depended upon the relationship between lobster size and shelter size; and
- Independent of site (inner-bay sand grass flat versus outer-bay seagrass bed) adjacent to coral reefs.

In addition, our observations of predators indicated that the size range, maximum size and species diversity of predators increased with casita size, thus imposing higher predation pressure upon spiny lobsters residing in larger casitas. Thus, scaling of artificial shelters according to lobster size appears to reduce lobster mortality due to predation.

The collective evidence from field observations and experiments suggests that shelter is limiting spiny lobster abundance in certain habitats such as reefs (*Panulirus cygnus*: Ford et al. 1988) and seagrass beds (*P. argus*: Eggleston et al. in press), with a dynamic interplay between shelter and food availability (Herrnkind 1980.)

The casitas are inexpensive (about US$30 each) and extremely durable, as evidenced by our low loss rate (8%) of structures in the direct path of Hurricane Gilbert. The use of appropriately scaled casitas may be an economical and effective approach for increasing spiny lobster fisheries production in the Caribbean by reducing

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mortality from predation in areas with sufficient food. However, final conclusions regarding the impact of artificial shelters on spiny lobster predator-prey dynamics and production in nursery habitats require field manipulations that test our hypotheses (mentioned above.) In addition, the impact of recruitment limitation (Herrnkind and Butler 1986) must also be addressed in any comprehensive study of population regulation.

We recently have expanded our efforts to the Bahamas in a program of cooperative research with the Caribbean Marine Research Center (at Lee Stocking Island in the Exuma Cays). After extensive descriptive studies of spiny lobster population structure (Herrnkind and Lipscius in press), we have initiated manipulative field experiments that (1) assess postlarval recruitment in relation to habitat features, meteorological events and water transport, and (2) test the impact of postlarval recruitment, juvenile movements and shelter availability upon the survival and abundance of juvenile and adult spiny lobster. We expect these experiments to provide novel information regarding the efficacy of artificial habitats in stock enhancement of spiny lobster populations throughout the Caribbean.

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Stock Enhancement of *Homarus gammarus*

Exciting results are emerging from experiments to test the potential for enhancing stocks of *Homarus gammarus* in Europe. So far about 120,000 hatchery-reared juveniles have been released at four major sites in the United Kingdom and France, involving numerous individual releases onto lobster habitat of cobble and rocky reef between 1983 and 1989. Most hatchery lobsters are released at about 12 mm carapace length, and all contain an inert microtag batch-coded to facilitate identification of release site and year, at subsequent recapture.

Since 1985 recapture trials have been made by diver, trap fishing and bulk testing of landings at the quayside. A total of at least 233 tags has been recovered, mainly in the United Kingdom. Early recaptures taken by divers in Scotland in 1985 were about 20 mm carapace length (CL) but the remaining recaptures have ranged from 46 to 96 mm CL. Results from the English west coast have been particularly good, with 26 recaptures in 1988 and 110 recaptures in 1989. In the latter case, recaptures came from three sources, 1260 shorts tested at known fishing locations in the release area (giving 60 recaptures); 2429 legal-sized animals from unspecified fishing locations in the release area (giving 20 recaptures), and 9631 legal-sized lobsters tested at the quayside landing place (giving a further 20 recaptures.)

Recaptured lobsters generally were clustered close to the release position, and the tag decoding showed they belonged to the 1983, 1984 and 1985 cohorts, with approximately a third having passed the minimum legal size of 85 mm CL. There is some suggestion of variability in growth rate between cohorts.

It is too early to comment on these results from the commercial standpoint but they show that some hatchery stock has survived for 6 years in the wild, has grown well, and has remained in the release area where the lobsters can be caught commercially. I am indebted to many colleagues for help in compiling this report, especially Julian Addison, Craig Burton, Bill Cook, Alan Howard, Daniel LaTrouite and Steve Lovewell.

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NEW METHODS AND APPLICATIONS

Briny Dip for Lobster Traps

Fishermen who use wooden traps long have been plagued by "trap worms" which destroy the wood by burrowing in it. The trap worms, or shipworms as they are called more commonly, in fact are wood-boring bivalve mollusks in the genera *Teredo* and *Xylophaga*. The burrow provides shelter to the tiny clams and the wood particles resulting from the boring process seem to be food . At least in the deep-water fishery of the northeast USA, trap worms of the species *Xylophaga atlantica* can be a major source of trap loss and fishermen are continually looking for a better way to prevent infestation. Protected traps may last as long as five years, while unprotected ones could be destroyed in as little as a year.

An effective preservative for wooden traps was introduced several years ago, whose active ingredient is tributyltin (TBT.) This substance now is incorporated in antifouling paints in many parts of the world. It is effective, of course, because of its toxicity. In the United States, TBT has been banned by the Environmental Protection Agency (EPA) for use on the bottoms of small boats because of its effects on estuarine organisms. Additional health concerns to humans have been raised.

Joe DeAlteris, Bob Bullock and Bill Romey (1988) reported their efforts to discover an effective but environmentally safe method of reducing fouling by *Xylophaga atlantica*. Instead of a preservative, they looked for short term biocides, and on the suggestion of Mimi Johnson of the EPA, tried a saturated salt solution. They found that a 30-second dip in saturated brine repeated at 60 day intervals was effective in destroying the trap worms. Since the treatment is effective only against animals present in the trap and not against settling animals the dip must be repaeted at regular intervals.

If you want more information about the treatment, write to Joe DeAlteris, University of Rhode Island Fisheries Laboratory, 35 Steamboat Ave., Wickford RI 02852 USA.

REFERENCE:
DeAlteris, J., R. Bullock and W. Romey 1988. J. Shellfish Res. 7, 445-451.

Lobster Movement-Ultrasonic Transmitters/Receivers

The nearshore Scotian Shelf waters have been hypothesized as marginal habitat for lobster larvae (Harding et al 1983). They further hypothesized that the nearshore warm water bays were important for larval survival. Duggan and Pringle (1988) supported this hypothesis with empirical data on the distribution of late stage berried females in and near these bays. A followup study was conducted in the summer of 1988 to discern the movement of late stage berried females in relation to one of these bays, Jeddore Harbor. Specifically I was interested in discerning whether these lobsters actually moved into the Harbor to brood and hatch their eggs. The fishery on this coast extends between April 20 and June 20. The fishermen were keen on the study, thus it was decided to incorporate them into the study as much as possible.

To demarcate animals, two types of tags were employed; the ancient carapace tag and the modern transmitter tag, the subject of this article. Ten berried females were obtained from the fishery just prior to season close. Egg samples were remove from each to determine proximity to hatching. A Vemco V3-4H expendable pinger was then attached and the animals were replaced on the bottom, at point of capture, by SCUBA equipped divers.

The transmitters employed were about the size and weight of a penlight battery. Their half life was rated at about 32 days; their cost was $275. Cdn(1988). The signal was transmitted on one of five frequencies (50-77 khz) at one of two repetition rates (60 or 65 pulses/minute). Hence, each of the ten transmitters had a unique combination of frequency and pulse repetition rates. A transmitter was attached to the lobsters carapace using five minute epoxy. As well, a plastic cable-tie was placed around the carapace as a backup.

Once the animals were replaced on the bottom they were tracked or relocated from the surface using a Vemco directional hydrophone (Model CS 40) linked to a CAI receiver. Specific location of the tagged animal was determined using Loran-C coorodinates. Underwater, the animals were intercepted by divers using a handheld receiver (Vemco Model VUR-455). The underwater receiver is equipped with five channels, has three gain levels and an LED bar, similar to those found on many stereo receivers, which displays signal strength. The latter feature is most important when the lobster is hunkered down in kelp or rubble.

The system worked extremely well. Animals were easily followed on a hourly and daily basis. A number of lobsters were followed for up to three months More difficult was the relocation of an animal after a week , when it had moved some distance from it's last position. Nevertheless, the latter relocation was commonly carried out. In many cases animals were found despite, being well camouflaged in thick sea-

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weed beds, under rock piles, or in caves. The somewhat conspicuous tag appeared not to impede mating or larval hatching. Females, having hatched their clutch, were spotted with large males in cryptic locations. Later the molted carapace, with transmitter attached, were recovered.

This study was carried out, and sponsored by personnel of the Benthic Fisheries and Aquaculture Division , D.F.O. Canada, P.O. Box 550, Halifax, N..S., Canada. Dr. R. O'Dor, Dalhousie University, Halifax, was an advisor. Information on the equipment referred to can be obtained from Vemco Ltd., 3895 Shad Bay, R.R.# 4,Armdale, N.S., B3L 4J4 or by calling Fred Voegeli at (902) 852-3047.

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BOOK REVIEW

Lobsters of the World — an Illustrated Guide

A. B. Williams (with additional material by Ian Dore). 1988. Van Nostrand Reinhold, 115 Fifth Ave., New York City NY 10003, USA. ISBN 0-943738-23-7. 186 pp, numerous colored and black and white illustrations. US$79.95

This very handsomely produced book actually is an extended version of A.B. Williams' (1986) article "Lobsters — Identification, World Distribution, and U.S. Trade." In this new form it is made available to a much wider public.

The book is divided into four parts. Part 1 provides an introduction discussing the various vernacular names used for lobsters in general, the different types of lobsters recognized in commerce, and their economic importance. There is also a synopsis of the general classification of lobsters and a concise account of their anatomy. The lobsters treated here belong to the families Nephropidae, Palinuridae, Scyllaridae and Galatheidae.

Part 2 is the revised edition of Williams' article. In it due attention is given to the economic aspects of lobster fisheries, with statistics of their world wide catches (landings) and of the importation of lobsters into the United States. These statistics were taken verbatim from the 1986 paper and not further updated. Two charts show various areas of the world where lobsters are fished. A special small chapter is devoted to the problem of the difference between lobsters and shrimps, tricky especially if only tails are available. Then follows the *piece de resistance* of the book, namely the key to the commercially important species of lobsters. This very useful key is made even more practical by the numerous illustrations, in both color and in black and white. Most impressive and helpful are the colored photographs of the lobster tails taken from the 1986 publication, but reproduced twice as large. Also, the photographs are not crowded together on three plates as in the original publication, but placed individually near the relevant part of the text. The black and white illustrations are of different quality, but usually clear and quite instructive. New distribution maps show the range of the various species; considering our incomplete knowledge of the occurrence of most species, the maps on the whole give a fair picture. The least satisfactory of the illustrations are the colored sketches of the whole animals; many of the colors and color patterns are not very natural and most likely based not on direct observation, but on second-hand information.

Part 3 is a rather peculiar mish-mash, it starts with six species of freshwater crayfish, figured in black and white, with a list of their vernacular names, indications of size and some general remarks. This is followed by a number of miscellaneous clawed lobsters, spiny lobsters, slipper lobsters and Anomura treated in the same fashion. Several of these already had been treated in Part 2, and the figures are the black and white versions of the color sketches provided earlier in the book. A few of the species (e.g. *Metanephrops challengeri* and *Scyllarus arctus*) not mentioned in Part 2 are dealt with here, and the figures of the Scyllaridae and Galatheidae provided here have no counterparts in in Part 2.

Part 4 contains the bibliography and a selective list of the lobsters of the world; it would have been preferable if this list had been made complete, like the one published on pp. 65-71 in Vol. 1 of Cobb and Phillips (1980) "The Biology and Management of Lobsters". Several indices end the book.

The book, although somewhat unbalanced in its presentation, will be found quite useful, especially because of the good key and copious illustrations. It will be of great help for the identification of lobsters (and lobster tails) found in commerce.

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ANNOUNCEMENTS

Crustacean Society Seeks New Members

Dr. Dorothy Skinner, Governor for North America of the Crustacean Society, has invited all interested members of the lobster community to become members of the Crustacean Society. She writes:

Greetings from the Crustacean Society.

One of my pleasant duties as a member of the governing board of the Crustacean Society is to invite crustacean biologists to join the society. Given your area of research, I do hope you will consider joining. Let me give you a few reasons.

One of the most important perks that members enjoy is the privilege of submitting articles for publication in the Society's JOURNAL OF CRUSTACEAN BIOLOGY. At present, it takes only six to eight months from the time a manuscript is submitted until it appears in print, far shorter than the turnaround time of a number of other journals in which we crustacean biologists publish.

Membership in the Society also permits presentation of papers at the annual meeting of the American Society of Zoologists, with which the Crustacean Society meets. Along with the annual meeting comes the annual social, an event that gives us the opportunity to talk with old friends and make new ones. The meetings are held in various locations of the United States and always are informative and fun.

THE ECDYSIAST, the Society's informal newsletter, appears twice a year. Periodically, a list of members of the Society with their addresses is included, invaluable for contacting others in our field. New publications in crustacean biology also are listed in The Ecdysiast. This information is particularly useful for publications from other countries, which may not be advertised in your part of the world. Information is also given about international symposia.

There are three classes of membership: Regular (including journal subscription), US$40; Sustaining, $100; and Associate (with no journal subscription), $15.

To join, contact Dr. Denton Belk, The Crustacean Society, 840 E. Mulberry, San Antonio, TX 78212-3194, USA. You may write for a membership blank or simply send the annual dues for the appropriate class of membership. Please limit your mailing address to 4 lines, 34 characters per line, maximum. Be with us for the celebration of our TENTH ANNIVERSARY in 1990!

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Workshop Proceedings Available

A workshop on Rock Lobster Ecology and Management was held in Perth, Western Australia in November 1986. From the Introduction to the proceedings: "Participants at the workshop were encouraged to present on-going research, rather than reviews of published material. Because of this, only abstracts of the presentations are published here ... Included in this volume are reviews of the history of rock lobster research in Australia and New Zealand, together with selected bibliographies."

Copies of the proceedings, which comprise 40 abstracts, 2 historical reviews and a list of participants, cost A$25.00 (Checks should be made out to: Collector of Public Monies.) If you would like a copy, write to:

Dr. Bruce Phillips
CSIRO Division of Fisheries
P.O. Box 20
North Beach
Western Australia 6020
Australia

Cuban Workshop Update

The International Workshop on Lobster Ecology and Fisheries, to be held 12 - 16 June, 1990, recently sent out a second mailing. If you have not received it, or wish more information about the workshop, write to either:

Dr. Julio Baisre, Chairman
Workshop Planning Committee
Ministry of Fisheries
Barlovento, Santa Fe
Havana, Cuba
Telex: 0511396 - 0511309 - 0511345

or:

Sra. Georgina Luis
Workshop on Lobster Ecology and Fisheries
International Conference Center
Apartado 16045
Havana, Cuba
Phone: 20-4653
Telex: 511609 palco cu
Fax: 22-8382

The workshop is expected to attract about 100 participants from all over the world. Titles and abstracts of papers to be presented at the workshop must be sent to Dr. Baisre by March 15, 1990 (note the revised date.) The conference center will provide simultaneous translation in English and Spanish for all participants.

ANNUAL FISHERIES YIELD

Listed below are the landings per species, for those countries from which information was received.

Country	Species	Location	Seasons	Landings (t)
Brazil	*Panulirus argus*	Northeastern	Jan.-Nov., 1986	3869
	Panulirus laevicauda	Northeastern	Mar.-Nov., 1987	5356
Denmark	*Nephrops norvegicus*	North Sea	1986	233
			1987	478
			1988	200
		Skagerrak & Kattegat	1986	2647
			1987	2840
			1988	2395
	Homarus gammarus		1986-88	~10
New Zealand	*Jasus edwardsii*		1987	5000
	J. verreauxi		1987	10
Scotland	*H. gammarus*		1987	604
			1988	681
	N. norvegicus		1987	16536
			1988	19178
	Palinurus elephas		1987	13
			1988	11
USA	*Scyllaries nodifer*	Florida	1988	10
	Panulirus argus		1988/89 (Jul.-Mar.)	2904
	H. americanus	New Jersey	1988	708
		New York	1988	995
		Connecticut	1988	906
		Rhode Island	1988	2245
		Massachusetts	1988	6483
		New Hampshire	1988	418
		Maine	1988	9847
		USA Total		21602
Canada	*H. americanus*	Nova Scotia	1988	18230
		New Bruns.	1988	7027
		Prince Ed. Isl.	1988	9998
		Quebec	1988	2532
		Newfoundland	1988	2504
		Canadian Tot.		40291

MAILING LIST

As you remember, we enclosed a postcard in the last issue, asking everyone who wanted to stay on the mailing list please to return it. Many people did — more than 300 of you, in 32 countries. The results were a bit confusing however, since a number of our colleagues, who we know well and some of whom have contributed to the Newsletter, were not among those who responded. Cards do continue to come in; some have taken as long as 4 months in transit. We have kept a few names on the list despite the lack of answer. If you want to receive The Lobster Newsletter, and are not now on the mailing list, please write to me! And, if you know of someone who would like to receive a copy of the Lobster Newsleter, but does not, please have them write to me. There will be back issues of this number available. Sorry, but earlier issues are all gone.

In earlier newsletters we announced three other meetings for 1990, here we simply reiterate their titles, locations and dates:

Coloquio Sobre Macrocrustaceos Bentonicos del Pacifico Este Tropical
Estacion Mazatlan
UNAM, Mexico
February or March 1990

Shellfish Life Histories and Shell Fishery Models
Moncton, New Brunswick, Canada
June 25 - 29 1990

Third International Crustacean Conference
University of Queensland, Brisbane, Qld, Australia
July 2 - 7,1990

PUBLICATION SCHEDULE

We hope that the Lobster Newsletter is now on a regular publication schedule. There will be two issues a year, mailed in January and in July. We get together to edit the correspondence (and to cajole more from you) six to eight weeks before it is mailed. The important message to you, all our potential correspondents, regards deadlines: In order to be included in the JANUARY issue, letters, news items, articles, etc., must be received by mid-NOVEMBER. If you want to put something into the JULY issue, it must get to one of us by mid-MAY. We look forward to receiving contributions from all of you!

January 1990

The Lobster NEWSLETTER

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