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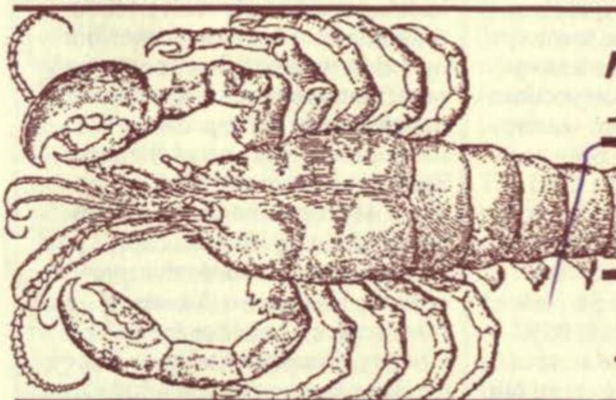

The Lobster NEWSLETTER

RECENT EVENTS

A note from Dave Pollock about mass mortalities of lobsters in South Africa reminded us of the ecological disaster in Florida Bay, USA (The Lobster Newsletter 5(2)) and a mass mortality of lobsters in Canada several years ago. We asked Bill Herrnkind to bring us up to date on what is happening in Florida and Don Maynard to write a short piece about his experience with a catastrophic mortality event of Homarus. *As Pollock points out, these catastrophes are not new, nor are they necessarily linked to human activity. However, the increasing prevalance of coastal eutrophication around the world suggests that low oxygen events may become more frequent. The lobster, with its relatively low mobility (compared to fishes) and low tolerance for reduced O_2 (many species will not tolerate much below 2 ml/l) as well as its conspicuous size and value, may emerge as a key species for characterizing and drawing attention to these events. We urge the readers of The Lobster Newsletter to let us know if similar mortalities happen in their regions.*

Catastrophic Lobster Mortalities in the Benguela Upwelling System

FROM: DAVE POLLOCK

Catastrophic mortalities of marine organisms have been recorded irregularly for centuries in many places. There is evidence that toxic algal blooms and related fish kills have become more frequent in the Northern Hemisphere (especially within enclosed seas) during the past two or

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RESEARCH NEWS

On the "Over Size" Puerulus of *Projasus parkeri*

FROM: PAULETTE McWILLIAM

The editors' comment on Richard Webber's splendid drawing of the puerulus of *Projasus parkeri* reproduced in The Lobster Newsletter Vol. 6 (2) invited response about the possible size of the final phyllosoma. My guess is its total length (TL) was around 54 mm, but it may have been as small as 40 mm.

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FISHERIES AND AQUACULTURE UPDATE

The Helgoland Lobster: a Disappearing Island Population

FROM: KLAUS ANGER AND JOACHIM HARMS

For its tiny size, the Island of Helgoland is extraordinarily well-known. Historians know it for its interesting past (it had been ruled by pirate captains, the German Duke of Schleswig, and by Danish and British governors, before Germany traded it for Zanzibar, in 1890); marine biologists know it for its 100 year old research station (Biologische Anstalt Helgoland, BAH); paleontologists collect its unique triassic and tertiary fossils; and millions of tourists (tourism has become the major economy on the island) have visited and enjoyed this spectacular, lonesome red rock in the North Sea. Perhaps it is less known among lobster specialists, although the island does have an old tradition in lobster fisheries. The nearest neighbouring *Homarus gammarus* populations are found some distance away in northern Denmark, Norway, and around the British Isles. Hence, our lobsters are likely a true island population in the biogeographic sense (Fig. 1).

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three decades due to eutrophication. But eutrophication is not caused just by human activity.

Eutrophic conditions in eastern boundary upwellings are largely the result of natural processes in that enhanced nutrient supply from deep waters provides the basis for high rates of phytoplankton production in shallow waters. On the west coast of southern Africa, the Benguela upwelling system is one region where major fish kills have occurred as a result of eutrophication caused purely by natural phenomena.

In the Benguela, high diatom production is often replaced by dinoflagellate blooms (including red tides) during late summer and autumn, when southerly winds which induce upwelling abate. The phytoplankton dies and decays in dense accumulations, using up oxygen in the cold, subthermocline waters. Oxygen-depleted waters near the seabed are thus common during autumn.

West coast rock lobsters (*Jasus lalandii*) are sensitive to low oxygen levels, and often mass inshore in an attempt to avoid oxygen-depleted conditions. They appear to avoid dissolved oxygen levels of about 2 ml/l or less (about 33% saturation). Since the late 1960's there have been four catastrophic mortalities, each associated with oxygen depletion during autumn. In March 1968, thousands of rock lobsters were stranded and died at Elands Bay on the Cape west coast following a calm period coinciding with spring tides. The subtidal and intertidal zones where the lobsters accumulate are gently sloping rock. Eighteen years later, in March 1986, again after a calm period coinciding with spring tides, about 90,000 moribund lobsters were washed ashore at Elands Bay. A similar occurrence, involving 120,000 lobsters, took place in March 1989 at the same locality. These events were associated with the shoreward advection of oxygen-depleted bottom water, but none seemed to have been associated with red tides.

However, in February and March 1994, a massive mortality of fish and lobsters took place at St. Helena Bay just south of Elands Bay. This involved hundreds of tons of fish and sharks, as well as about 60t (over 300,000 individuals) of lobsters. Detailed results and descriptions await publication. It appears that severe oxygen-depletion of bay waters was associated with dense accumulations of red tide comprised of a mixture of non-toxic and toxic dinoflagellates. Mortalities were primarily caused by asphyxiation, rather than by the toxicity itself. The catastrophic mortality is likely to have severe repercussions for certain isolated lobster fishing grounds in the vicinity of the bay (which itself is a lobster sanctuary), and may also impact adversely on several local finfish and shark fisheries. Recovery rates of affected populations will be monitored.

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Impact of Sponge-Shelter Loss on Juvenile Spiny Lobster, *Panulirus argus*, in Florida Bay: An Update

FROM: W. HERRNKIND

Florida Bay contains the essential nursery habitat for the region's spiny lobster population. It is a shallow, subtropical lagoon lying between the southern tip of Florida and the Pleistocene reef ridge of the Florida Keys. Hard-bottom areas (calcium carbonate rock pocked with solution holes and overlain by a thin veneer of carbonate sediment) interspersed with seagrass meadows are most prominent in the southern portion of the bay. Sponges, octocorals, and macroalgal patches, particularly red algae (e.g., *Laurencia* spp.), are characteristic features that provide the settlement substrate, food resources, and shelter for spiny lobsters. Despite extremely heavy fishing pressure on the adults over the last two decades, continued postlarval recruitment and postsettlement growth and survival have provided a relatively stable catch. Between 1991 and 1993, however, we documented widespread mortality of sponges following repeated cyanobacterial blooms encompassing > 1000 km^2 in central Florida Bay. The loss of large sponges that typically shelter juvenile lobsters was nearly 100% at many sites we sampled

The Lobster NEWSLETTER

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before and after the blooms. Juvenile lobster abundances declined by an average of 49% over that time in this productive nursery area of > 200 km². We therefore expect a decrease in that area's contribution to the fishable lobster population. Lobsters take 2-3 years to enter the fishery after settlement, so the full impact of habitat loss will occur over the next few years. Moreover, these impacts may be long lasting because the blooms have not abated, preventing recovery of the sponges.

In 1994, our goal was to estimate the potential impact of these recent, widespread disturbances on the total juvenile spiny-lobster population. One way we approached this problem was in initiate a computer-simulation model of spiny-lobster recruitment in Florida Bay to generate predictions of potential changes in juvenile lobster abundance under various scenarios of habitat disturbance. Under Mark Butler's leadership and guidance from Kenneth Rose (Oak Ridge National Labs), we developed a first-generation, individual-based, spatially explicit biological model in collaboration with John Hunt for the Florida Marine Research Institute and Florida Department of Environmental Protection. Individual-based models literally track each individual within a population and incorporate biological, spatial, and temporal interactions in a realistic, often probabilistic fashion, in order to construct projected populations and pinpoint life stages, habitats, geographic locations, dates, or processes crucial to the model outcome. The information we have obtained over the past decade on lobster recruitment processes made it possible for us to develop this type of model. We also conducted a large-scale quantitative field survey of juvenile spiny-lobster numbers and nursery habitat structures throughout the Florida Keys. They survey data provide an important, empirically based estimate of the impact of sponge loss on the region's spiny-lobster population.

The field survey revealed that the sponge die-off region provided about 20% of the total nursery production of juvenile lobsters. On the basis of our comparison sampling in 1990-1993, indicating a 49% lobster decline in that area, the total impact is about a 10% reduction. The model results predict that the total decline would range from about 1% to 20% depending on the availability of intact alternative, underutilized shelter such as solution holes, sea whips, coral heads, etc. That is, the larger decline is expected where nonsponge shelter is scarce because the small, predator-vulnerable juveniles would be exposed more and, consequently, suffer high mortality rates. The field surveys in the sponge die-off region showed a definite shift in sheltering potential lies somewhere between the modelled extremes. We plan to refine the model further but are encouraged by the approximate correspondence between its initial predictions and the empirical estimate. Regarding the fishery impact, a 10% loss may not be easily detected against interannual variation in catch but potentially constitutes a yearly loss of over half a million lobsters until sponges grow back to sheltering size.

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Storm Generated Lobster *(Homarus americanus)* Mortalities off Prince Edward Island, Canada

FROM: DON MAYNARD
& WADE LANDSBURG

On November 12th 1986, three days of storm-force northerly winds in the Gulf of St. Lawrence abated, and in their wake lobsters were stranded on exposed beaches of Prince Edward Island (PEI) in eastern Canada. Early reports of lobster mortality came from the Brackley Beach National Park area the same afternoon. Lobsters are a most valuable commercial species, thus a survey team was assembled consisting of scientific staff from the Gulf Fisheries Centre, the morning of November 13th, to quantify lobster mortalities between Cove Head Harbour and Tracadie Bay.

Distance along the shoreline was measured with a vehicular odometer. Team members, walking in front of the vehicle , collected whole lobsters or pieces thereof found between waters edge and the high water mark. All piles of flotsam were sorted for lobster remains. A total of 5 kilometres of beach were surveyed in this manner. At the time of the survey, air temperature was 0°C and the bottom water temperature from the closest available station, at approximately 10 metres depth was 5°C. Ice forming in the surf zone indicated the cold air temperatures combined with the mixing effect of waves resulted in much lower near shore temperature than that measured at 10 metres. As lobster activity is directly related to temperature, we suggested the sudden drop in water temperature reduced lobster activity. If this occurred quickly, the lobsters may have been unable to take shelter or move to deeper waters away from the wave affected substrate.

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The survey revealed the greatest density of lobsters to be located within the piles of storm cast seaweed dislodged from the substrate by the storm. The marine plants consisted primarily of *Laminaria saccharina*, *Fucus vesiculosus* and *Zostera marina*. The substrate within one kilometre of the coast is a patchwork of sand, sandstone cobble and sandstone reefs and ledges. Abundant seabird tracks in the sand provided evidence of scavenging and predation. This bird predation resulted in an under estimation of the storm induced lobster mortality as we did not attempt to assess the loss to the birds. Intact lobsters and lobster pieces were later examined and measured in the laboratory.

A conservative estimate of lobster mortality in the survey area was calculated, using the principle of mutual exclusion. If a 10 metre transect yielded 10 lobster claws, three carapaces and four abdomens, the confirmed mortalities for this area was noted as four, based on the abdomens. The loss of a claw is not fatal, while separation of the carapace from the abdomen by, say a seabird, is. This technique is another source of under estimation.

The number of confirmed mortalities was 39 per linear kilometre of shoreline. The carapace size of individual lobsters and separated carapaces collected ranged from 22 mm to 135 mm.

The commercial lobster catch composition along the 200 kilometre coast of northern Prince Edward Island is predominately in the range of 64 to 81 mm CL. Considering lobsters within the commercial size range only, the estimated storm mortality was 5800 lobsters for the entire 200 kilometre coastline. To put this level of mortality in perspective, approximately 95 million commercial lobsters are landed during an average nine week season along this coast.

Anecdotal record of the occurrence of storm related mortalities of lobsters in the Gulf of St. Lawrence have appeared through out history. In 1811, Bishop Msgr. Plessis, reported in his journals that lobsters covered beaches for several kilometres after a storm in Caraquet, New Brunswick. In 1873, Shippagan, New Brunswick experienced an August storm which deposited drifts of lobsters one to five feet deep on the beach. Recent reports of storm-cast lobsters have been noted, but quantitative data were not collected until this survey, which is the only quantitative study of storm-induced lobster mortality in the Gulf of St. Lawrence.

Storm related mortality of lobsters in a nearshore stock should be included in estimates of natural mortality. Repeated storm events over a short time period could cause considerable cumulative mortality.

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A distinct color variety of *Panulirus penicillatus*

FROM: D.S. JAYAKODY

Panulirus penicillatus is a commonly occurring spiny lobster species found along the south coast of Sri Lanka. Normally, it is dark brown in color. It occurs in shallow rocky bottom areas to a maximum depth of 12m. On 20th December 1993, a 122mm carapace length female *P. penicillatus* with a sperm packet (tar spot) was caught entangled in a bottom set net. It was entirely blue in color. Stripes along the pereiopods were similar in color to the normal *P. penicillatus*. This is the first time the color pattern has been recorded from Sri Lankan waters.

The blue lobster is being kept at the Crow Island laboratory of the National Aquatic Resources Agency in Sri Lanka.

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Editors note: Dr. Jayakody's letter was accompanied by two photographs of the blue specimen. Strikingly bright blue specimens are rare but not unknown in *Homarus* populations. Is unusual blue coloration found in other species?

LETTERS

To the editors:

We work with the red lobster fisheries (*Panulirus interruptus*) in the middle portion of the peninsula of Baja California, at Cedros Island. Presently, we are in the process of reviewing the minimum legal length for capture (now 82.5 mm cephalothorax length) in cooperation with the Ministry of Fisheries. We would like to know of papers or programs that review the minimum length of capture in other species of lobsters around the world.

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RESEARCH NEWS

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Is it possible that the puerulus phase in *Projasus* lasts much longer than that estimated for other palinurid genera such as *Jasus* or *Panulirus* ? Could it extend from 3-6 months and perhaps involve one or more ecdyses, with a concomitant size increase? And if lasting longer, is it possible the puerulus in *Projasus* is also a feeding stage and able to manipulate and ingest soft food? Comments are welcome.

The duration of the puerulus of *Jasus edwardsii* in nature is possibly up to 70 days (Booth, 1989). But *Projasus* is is a deep-living, more 'primitive', palinurid. When erected by George and Grindley (1964) it was regarded as intermediate between *Palinurellis* (Synaxidae) and *Jasus.*

Scattered data in the literature (too numerous to cite) indicate the TL of the final phyllosoma larva of *Projasus* tends to be greater (by some 4 - 10 mm) than that of the puerulus in species of *Jasus* and *Panulirus* . This is explicable because the anterior margin of the larval cephalic sheild (from which measurements are always taken) is actually that of the optic lobe, which is not equivalent to the anterior margin of the puerulus carapace (repositioning occurs in metamorphosis). The primordium of the true carapace margin and supraorbital spines become visible as a "rostral elevation", or dorsal flange, posterior to the anteriomedial margin of the larval shield in the final phyllosomata of both genera (M^cWilliam and Phillips, 1987,1992).

Only in the synaxid, *Palinurellus wieneckii*, is the puerulus about the same length as it's final phyllosoma - actually a few millimeters longer (see Michel, 1971). This is because, throughout later larval development in this genus, the larval shield is more equivalent to a true carapace (covering most of the thorax) and has a true rostrum proturding from it. The carapace covers the optic lobe and the anteriomedial margin of the larval carapace (from which measurements are taken) is clearly demarcated by the base of the rostrum.

In relative terms, a TL of 54 mm is not oversize for a final phyllosoma larva. The TL of the final stages of *J. edwardsii* and *Palinustus* sp. were reported to be approximately 48 mm (Lesser, 1978; M^cWilliam and Phillips, 1987) and 50 mm (Gurney, 1936 see Fig. 15) respectively. The so-called 'giant' phyllosomata of the early literature were mainly late larval stages of the genera *Scyllarides* and *Parribacus* (which,P with *Arctides*, are the more 'primitive' of the scyllarid genera). Those of *P. antarcticus* have ranged from a TL of 65 - 80 mm. Michel (1971) reported the TL for the final stage of *Parribacus* sp. as 83 mm (Holthus, 1985). Whether such larvae ever metamorphose is another matter (Gore, 1985).

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Importance of the Cleaning Pereiopods in Preventing Embryo Mortalities in *Homarus gammurus* (L.)

FROM: INGEBRIGT UGLEM

Embryo mortality, caused by microbial fouling of the egg surface, has been a problem in culturing externally brooding decapods (Fisher, 1976; Fisher *et al.* 1978; Fisher, 1986). Fouling occurs with both filamentous and non-filiamentous forms; one common filamentous bacterial pathogen is *Leuchothrix mucor* (Johnson *et al.* 1971). The non-filamentous forms normally accompanying the filamentous forms (Nilson *et al.*, 1975), are shown (Fisher, 1976) to be responsible for mass mortalities of eggs from the Dungeness crab (*Cancer magister*).

Most decapods exhibit parental care in aeration and grooming of embyros, by picking and brushing the egg mass with specially adapted pereiopods (Bauer, 1979). It has been shown that these legs are essential in the defence against microbial fouling in the shrimps, *Heptacarpus pictus* (Bauer, 1979) and *Palaemon macrodactylus* (Fisher, 1986). Nephropid lobsters use the fifth pair of pereiopods in grooming.

In Norway lobster juveniles are cultured large scale at the Institute of Marine Research Lobster Hatchery, as part of a government sponsored sea ranching program. Egg mortalities caused by microbial fouling has been a frequent problem. This note summarizes observations on the importance of the cleaning pereiopods as an anti-fouling mechanism in the European lobster (*Hommarus gammarus*).

RESEARCH NEWS

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Culture of juvenile lobsters usually takes place twice yearly, June to August and January to March. To induce winter embryo hatching, wild caught egg bearing females are held in water with elevated temperatue (14°C to 18°C) from early October till hatching starts. Broodstock are housed in an open, single pass, culture system (Grimsen *et al.*, 1987). The observations presented below were recorded in early December 1991 and 1992. Unfortunately, in 1991, it was not possible to investigate animals with both fifth pereiopods in place; one was removed from each lobster for genetic studies prior to the current observations. Dead eggs, collected from heavily infested lobsters, were examined under high magnification for the presence of filamentous fouling.

The number of lobsters with embryo mortalities was higher in 1991 than in 1992 (Table 1), probably because of the one missing fifth pereiopod. There was a significant ($p<0.001$, Fisher-Irwin exact test) decrease in number of lobsters with egg mortality when cleaning cheliped number increased . The examination of dead eggs revealed the presence of massive fouling, probably by *L. mucor.* It is therefore reasonable to suggest that microbial fouling could be responsible for the embryo mortalities. Hence, the observations carried out on *H. gammarus*, support the general assumption that the cleaning pereiopods are important in the defence against microbial fouling on eggs.

The findings imply that egg mortalities caused by fouling of egg surfaces can be significantly reduced if a loss of cleaning pereiopods is prevented. The loss of legs in the hatchery is normally a result of intraspecific aggression in the collective containers. Addition of shelters in these containers may reduce the intraspecific aggression. An optimal feeding regime may also minimize aggression by reducing hunger as motivation for conflicts. However, individual storage of the lobsters would eliminate this problem completely. More careful handling during sampling of the broodstock will also be important for reducing loss of legs.

Table 1. Number of lobsters with and without embryo mortality in relation to presence/ absence of pereiopods.

	No. cleaning periopods		
	None	One	Both
1991 (n-92)			
No. Mortalities	2	60	-
No. Mortalities	20	10	-
1992 (n=102)			
No. Mortalities	0	17	77
No. Mortalities	3	5	0

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Recent Advances in the Biology of Japanese Palinurid Lobsters

FROM: HIDEO SEKIGUCHI

The Japanese archipelago extends over subarctic (Hokkaido Island), temperate (Honshu Island), and tropical/subtropical (Ryukyu Island) zones of the northwest North Pacific (Figure), so the marine fauna is remarkably varied. A total of 27 palinurid an scyllarid lobster species are known and others (eg., *Scyllarus* spp.) may still be found (Sekiguchi, 1988).

Panulirus spp. form the most important fisheries, so most biological and ecological studies of lobsters in Japan have been directed at these, particularly *P. japonicus.* Catches of *P. japonicus* have fluctuated between 970 and 1850 t per year since 1951 (Nonaka, 1986); *P. longipes femoristriga, P. penicillatus,* and *P. versicolor* catches are much lower, with annual yields of *P. longipes femoristriga* up to 50 t (Sekiguchi, 1988).

P. japonicus occurs along the Pacific coast open to the Kuroshio Current - central and southern Japan, around Kyushu (but not Ryukyu) Is., Cheju Is. (Korea), and northern Taiwan (Sekiguchi, 1988, 1989). The southern boundary for *P. japonicus* is the northern one for *P. longipes femoristriga* and also coincides with the northern limit of coral reefs in the northwest Pacific, *P. longipes femoristriga* has been reported from Ryukyu and Ogasawara Is. and northern Taiwan; *P. longipes longipes* is found only in northern Taiwan (Huang et al., 1988). None of these species has been reported from mainland China or the Yellow and Japan Seas.

Generally, fishing grounds are on rocky coasts. Mie, Wakayama, and Nagasaki Prefectures (including Goto Is.) in western Kyushu have highest *P. japonicus* catches

(Nonaka, 1986). Berried females are common during spring to early summer throughout the fishing grounds and are protected. Seasonal migrations include movement inshore from deeper shelf waters in winter and early spring, and migration alongshore in shallow shelf areas in other seasons. Most movements have been less than 10 km, but some have taken place over tens of kilometers (e.g., Ishida and Tanaka, 1985).

Details of early life history and larval recruitment in *P. japonicus* are scattered. Larvae have been cultured from egg to settlement in 307-391 days using *Mytilus* gonad as food (Kittaka and Kimura, 1989; Yamakawa et al., 1989). In nature, phyllosomas have been found associated with medusae (Shojima, 1963; Herrnkind et al., 1976); nematocysts have been detected in the gut of phyllosomas, and medusae are ingested by larvae in the laboratory (Sims, 1968; Cobb and Wang, 1985), but experiments indicate that medusae are not sufficient alone as food (Kittaka, pers. comm.). First-stage phyllosomes are often collected over fishing grounds (Harada, 1956; Murano, 1967), but mid- and late-stage phyllosomas have rarely been taken in coastal waters (Sekiguchi, 1988). Pueruli are collected with artificial traps set close to rocky shores, mainly in summer (Fushimi, 1976; Ichirai et al., 1967, Kanamori, 1982).

The Kuroshio Current flows north between Taiwan and Ryukyu Island. Recent oceanographic studies suggest that the Kuroshio-Counter Current forms a sub-gyre within the subtropical gyre (Hasunuma and Yoshida, 1978). Trajectories of satellite-traced buoys released into the Kuroshio Current west of Ryukyu Island. (Ishii, 1981; McNally et al., 1983) were a) generally to the northeast, but often with clockwise and/or anticlockwise circulation south of Shikoku and Honshu, and b) east toward the Hawaiian archipelago or into the counter current south of the Kuroshio and then south or southwest.

Floating volcanic pumice from Iwo Island south of Ogasawara (and south of the Kuroshio Current) sometimes reach Okinawa Island. From these, and from the movement of satellite-traced buoys, I infer that it takes it takes nearly one year for full circulation in subgyres of the Kuroshio-Counter Current (Sekiguchi, 1988). The larval period of *P. japonicus* in the laboratory is also around one year, as described above.

A hypothesis for larval recruitment of *P. japonicus* follows. Phyllosomas hatched in shallow, rocky reefs in summer are entrained and transported in the Kuroshio Current and then in the Kuroshio Counter Current. Subfinal- and final-stage phyllosomas enter the Kuroshio from waters east of Ryukyu Island, and pueruli are transported and dispersed along the Pacific coast of central to southern Japan and western Kyushu (Sekiguchi, 1985, 1988).

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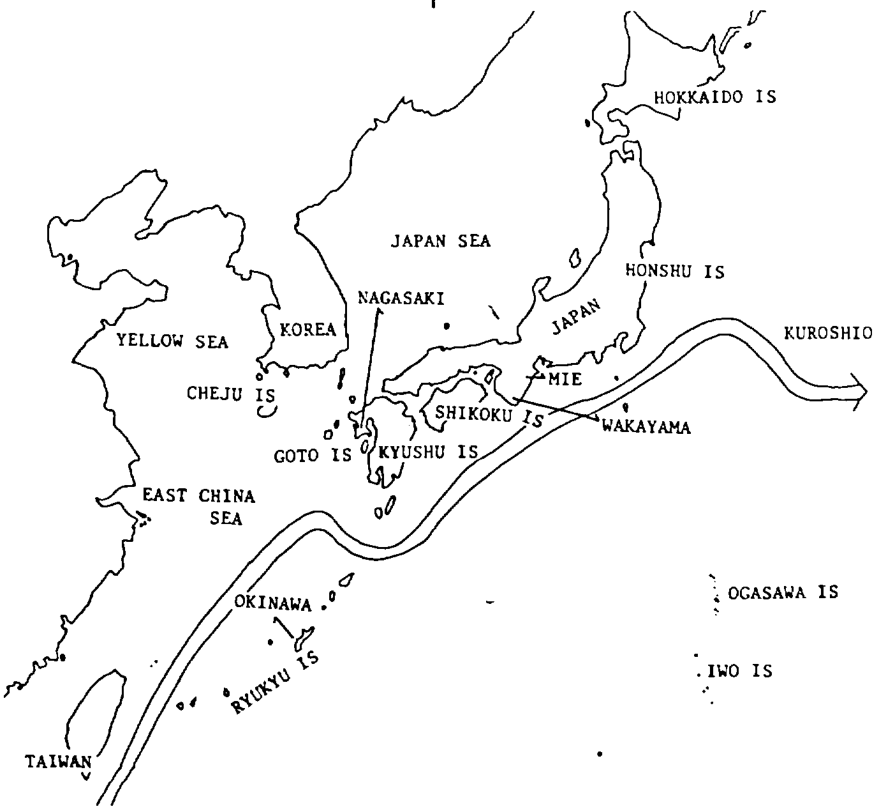

The Shocking Truth About American Lobsters

FROM: PETER KOELLER

The Early Benthic Stage (EBS) of the American lobster leads a cryptic existence immediately after settling on the bottom as "Stage IV" postlarvae (about 8mm cara-

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pace length). They remain well hidden under small rocks before emerging for increasingly longer periods of time, beginning when they are 35-45mm CL. EBP research is an expensive and cumbersome proposition. It is also destructive to habitat. Divers must turn over rocks in a corralled sampling area, or "vacuum" rocks, sediment and the young lobsters from quadrats with an air-lift sampler. When exposed, small lobsters are extremely agile and often escape a pursuing diver.

There are good reasons to continue research on techniques to enhance fishery scientist's ability to enumerate and/or capture EBP. An EBP abundance survey could be used to predict recruitment 4-6 years in advance of the fishery. Information on distribution, especially location of important "nursery" areas, would be invaluable in habitat management and environmental reviews.

An effective sampling device could put EBP research and surveys within reach of more investigators despite dwindling budgets. This spring we conducted initial experiments with a prototype device that may meet this objective. The device, developed by Technical University of Nova Scotia (TUNS) electrical engineering student Greg Crowell, is based on the electrofishing method used, since the turn of the century, by freshwater fishery researchers.

Electrofishing in the marine environment presents special challenges. Salt water is highly conductive and effectively "shorts out" an ordinary current. Lobsters lack a spinal cord, which in fish facilitates the involuntary orientation and movement in the electric field (electrotaxis). However, U.S. researchers (Saila and Williams,1972) showed that adult American lobsters are more vulnerable to trawls when an electric current precedes the net. Michel Comeau from our Moncton, N.B. laboratory, recently conducted experiments (unpublished data) to determine the best voltages and pulse lengths for stimulating lobster to move from their shelters. Phillips (1980) described a device which caused the spiny lobster, *Panulirus cygnus* to move from shelters toward an electrode, but to our knowledge no one has demonstrated electrotaxis in *Homarus americanus.*

We used the TUNS device to successfully demonstrate that American lobsters as small as 30mm CL, do have an electrotactic response. Under certain frequencies and voltages they move backwards, towards the positive electrode, similar to their well known "escape" response.

This behaviour could form the basis of a combination electrofishing/low velocity water flow sampler that reduces bottom time for divers and permits surveys of juveniles with minimal habitat destruction.

Alternatively, an electric quadrat could bring lobsters into the open and temporarily stun them for collection by divers. Another possible application is an electric " prod" to coax larger animals from their shelters. However, much work needs to be done before practical field samplers can be designed. In particular, we would want to know if the electrotactic response is exhibited by the newly settled postlarvae. Also, we noticed that animals beneath rocks attempt to head straight for the anode, becomming jammed between rocks. This suggests the sampling process will have to consist of two steps involving two types of electric stimulation - a non-directional phase which brings the animals out of shelters, and a second "tractor beam" which uses the electrotactic response to herd them toward the collector We also found the lobster's movement controllable during the initial agitation, during the vacating of the shelter, and especially during the movement toward the anode. This control would be particularly useful, but the diver must be able to observe the animal and vary the electric stimulus in response to behaviour. To do this requires the immediate presence of a diver during sampling, which poses safety related problems (Stewart and Cameron, 1974). UW video may be helpful in this regard.

Additional laboratory experiments are planned this fall using animals supplied by the St. Andrews Biological Station.

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Lobster Phylogeny Project Update- Summer 1994

Many thanks to those of you who responded to our request for information on lobster DNA research. We appreciate the reprints and suggested laboratory techniques. As of this summer we have legs of following species of lobsters:

Panulirus argus
Panulirus gattatus
Panulirus versicolor
Panulirus penicillatus
Scyllarus americanus
Scyllarides nodifer
Parribacus antarcticus

For those of you that missed our original letter in December 1993, *The Lobster Newsletter* Vol. 6(2):13, here is a brief description of the Lobster Phylogeny Project. We are gathering the legs of lobsters to construct a lobster molecule phylogeny using both mtDNA and nuclear DNA sequences. Our goal is construct a series of nested phylogenies of lobsters, superfamilies within the family Palinuridae, and species within the genus Panulirus. At each taxonomic level the amount of accumulated variation the mtDNA and non-coding regions of nuclear DNA require us to use more or less conservative regions. We have found a region of the mtDNA which shows approximately 2-4% sequence divergence between members of the genus *Panulirus*. The region is approximately 550 base pairs in length of the Cytochrome Oxidase I gene. Our first phylogeny we plan to tackle is the genus *Panulirus* with inclusion of all species and sub-species.

We are limited by two factors. First, we are still in need of lobster legs. We are primarily interested in lobsters of the genus *Panulirus* but since we are planning to construct broader phylogenies in the future we would be happy to receive legs of any species of lobster. Ray George has made the following suggestions for how the collection of legs can be standardized. Since there exists a remarkable amount of variation within each species we request two legs from the same individual while it is still alive and the following additional information:

1. a good color photograph of the specimen after the two legs have been removed,
2. the two legs should be from walking legs 2, 3 or 4 (since walking legs 1 & 5 are sometimes valuable taxonomic characters) and only fresh legs should be sent,
3. label the legs carefully (using only pencil), species, subspecies if applicable, sex, carapace length, date and location of collection (be specific, the more information the better),
4. use a different container, preferably plastic with a screw-top lid, for each pair of legs sent,
5. fill the container with absolute (95-100% ethanol (indicate if only able to obtain 70% ethanol) at least twice the volume of the legs; the greater the ratio of ethanol to tissue the easier the DNA extraction,
6. place container in a 20°C freezer for a day or longer before sending,
7. wrap the containers with plenty of packing materials.

We are also limited by our budget. We would like to be able to send complete collection kits to all interested lobster biologists, however at this time that is not possible. We are not yet to the point of passing the hat among our fellow lobsterologists, but we would appreciate your legs, ethanol, and postage. In addition, if you think your fishery organization would be interested in funding a small proportion of the laboratory costs, or if you know of any international fishery agencies that fund such research we would appreciate your comments and recommendations. As always we look forward to hearing from you. If you have additional questions, recommendations or lobster legs, send them to:

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Michael Childress
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Bill Herrnkind
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Tethering experiments with lobster *(Panulirus argus)* in Cuban reefs

FROM: A. HERRERA AND D. IBARZÁBAL

A tethering experiment to evaluate relative mortality rate of lobsters, *Panulirus argus*, in the reef environment was carried out as part of the ecological investigations on lobster populations in the Cuban southwestern reefs (ULISES Project).

Lobsters measuring between 79 and 158 mm CL were collected from the reef and transferred to shipboard for acclimation in a continuous flowing water tank. Tethers were constructed by locking a flattened plastic cable-tie around the cephalothorax between the second and third pereiopods, and tying it firmly upon it; leaving a free portion of approximately 30 or 40 cm to be tied to a stake or any hard bottom structure.

Lobsters were tethered in the reef between 17 and 30 m depth (from the spur and groves zone to the reef slope) at 72 selected points: 18 in optimum shelters (height = 30 cm and depth > 45 cm, in which lobsters could be totally concealed); 17 in suboptimum shelters (height > 30 cm and/or depth < 20 cm, with some part or the whole animal visible) and 37 in open areas (27) lobsters bearing all its appendages and 10 lacking their antennae). The criteria for shelter optimality were obtained from measurements of the height, width and depth of 356 natural unoccupied shelters (natural offering), 305 shelters occupied by solitary lobsters (selected shelters) as well as measurements of the length, width and height of the carapace of the lobster in the shelters.

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Observations were made at 8:00 and 16:00 h, over seven days, to record mortalities and to observe the interaction between lobsters and different fish species, making a qualitative census of potential predators.

Optimum shelters displayed no mortality, while in the suboptimum shelters predation occurred in the third to fifth day accounting for a cumulative mortality of 23.1%. In open areas, when lobsters were intact, mortality was recorded from the first day and increased cumulatively to 52.6% at day seven. It was even higher for lobster without antennae reaching 100% cumulative mortality in the third day (Fig. 1).

In terms of daily mortality, lobsters in suboptimal shelters reached 3.1%; intact lobsters in open areas, 7.1%; and lobsters without antennae in open areas, 33.3%. Eggleston (1991) found 88 and 24% daily mortality for lobsters in open areas of the reef, for sizes between 46-55 and 56-65 mm LC, respectively (values extrapolated from his Figure 11), and our data complement those results with a 7.1% of mortality/day for a higher size range (79-158 mm CL) exposed to similar conditions. This is a strong experimental evidence that natural mortality in spiny lobster is size-dependent

Several species of groupers *(Epinephelus striatus, E. morio* and *E. cruentatus)* and snappers *(Lutjanus jocu, L. analis* and *L. cianopterus)* interacted with tethered lobsters in the vicinity of the experiment. However, the massive attack of five great triggerfishes *(Canthidermis sufflamen)* of 30 to 50 cm FL, on a 138 mm CL lobster tethered to a suboptimum shelter, was the most relevant event observed. This fish species had been observed daily in the sites of the experimental area, swimming near the bottom.

During a manoeuver of circular movements, characterized by rapid approach and retreat, the biggest triggerfish bit the base of the left antennae removing it. The attack was immediately directed to the left eyestalk, until it was destroyed. With only one antennae and one eyestalk, the lobster unsuccessfully tried to avoid the predators which began to bite the left pereiopods breaking all of them one by one. Then it was even easier for the triggerfishes to destroy the right pereiopods while biting the right eyestalk and the top of the right antennae.

The attack of the triggerfish *Balistes vetula* on a lobster, beginning by the eyestalks have been reported by Kanciruk (1980), but this species is solitary while *C. sufflamen* is always in schools. The attack by *C. sufflamen* appears to be a very well-developed collective strategy, that reminded us an attack of wolves, although tether may facilitate in some extent the action of predators. Due to their rapid movements, flattened body, very strong mouth and schooling behavior these triggerfishes seem to be more dangerous predators than was thought. As far as we know this fact has not been reported before and it is surprising since these triggerfish are commonly seen swimming near the surface as plankton eaters.

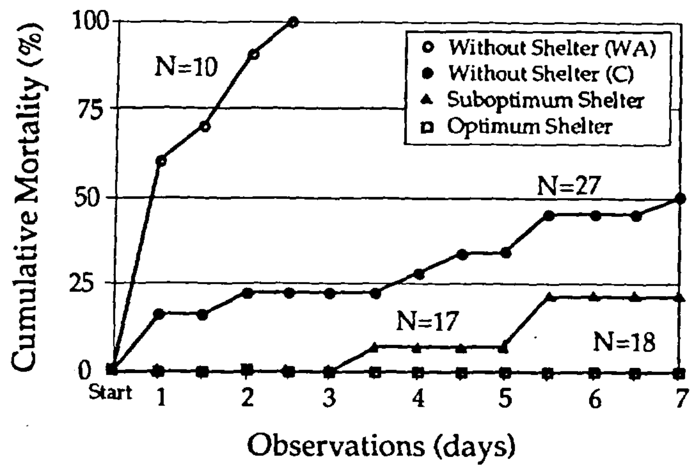

Figure 1. Variation of cumulative lobster mortality at different protection alternatives. C: intact lobsters; WA: lobsters without antennae; N: sample size.

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FISHERIES AND AQUACULTURE UPDATE

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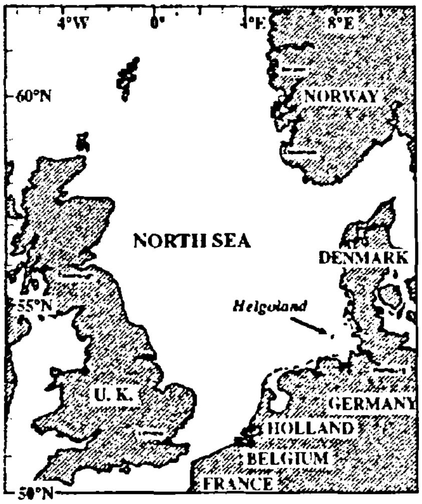

Fig. 1. Geographical position of the Island of Helgoland.

For centuries, about 30,000-45,000 lobsters per year were caught here (Fig. 2), and the denomination "Echt Helgoländer Hummer" ("genuine Helgoland lobster") used to be a guarantee of high quality. Increased fishing efforts led to peak landings around 1900 and in the 1930's (about 87,000 animals were landed in 1937).

However, in spite of a paucity of fishing activity for at least seven years during 1945 - 1952 (the island was used as training target for Royal British bombing pilots), lobster catches have since decreased dramatically (Fig. 2): Only about 10,000 landed per year in the 1950's, about 1,000 in the 1970's, and consistently <600 per year since 1980; the 1992 catch officially amounted to 102 lobsters. Interestingly, this decline coincides with decreased landings in the Scandinavian countries, while those of the British Isles remain rather stable (Dow, 1980).

A number of potential causes or combination of causes of this substantial decline in the Helgoland lobster population have been suggested, e.g. commercial over-exploitation, seawater pollution, harbour construction, natural causes, man-made calamity (in 1947 the British military attempted to remove the island from the seascape by blowing up 6,000 metric tons of ammunition), and effects of other environmental destruction and noise from years of bombing.

We can only speculate what might have initiated the dramatic decline in the Island's *H. gammarus* population since world war II; we do, however, have a testable hypothesis of why the decline continues today, despite little commercial fishing activity . Combined laboratory experiments and field studies have started at the BAH marine station to nullify the hypothesis that decline in lobster is due to competition with and predation by the crab, *Cancer pagurus*. According to fishermen the crab abundance has increased substantially.

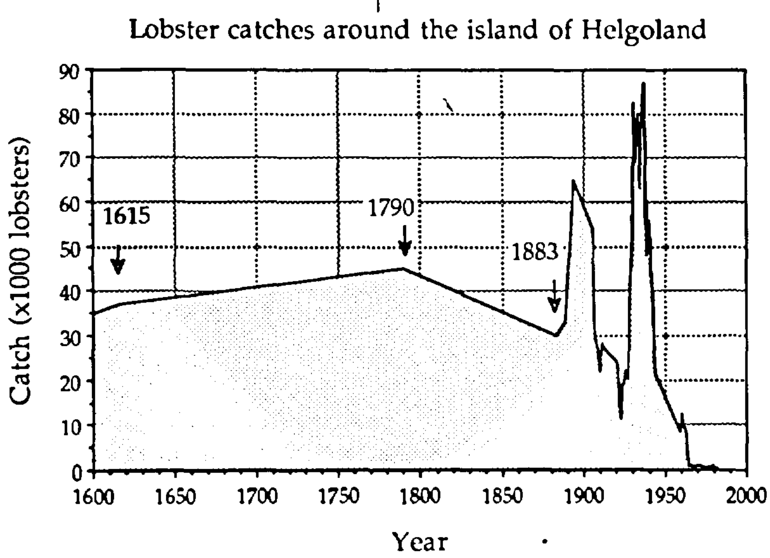

Fig. 2. Lobster landings at Helgoland (source: Goemann, 1990).

Both species are reared in the laboratory, and mutual predation and competition for habitat and food resources are studied in relation to body size and environmental variables. Much basic information is lacking, so we need to further study recruitment, growth, and other life-cycle parameters in both *H. gammarus* and *C. pagurus* at Helgoland. For example, Fig. 3 shows the moulting frequency of lobster at ambient temperatures in flow-through culture. In Helgoland lobster may grow to the tenth post-embryonic instar (including the larval stages), before overwintering (similar to *H. americanus*). There was no significant moulting activity at temperatures below 10°C.

A part of this program is a doctoral thesis, just now started, on population genetics of *H. gammarus*. This species does not migrate over wide distances, unlike some populations of the American lobster (Howard, 1988; Jensen et al., 1993). Also, the duration of pelagic larval development in our warm temperate waters is relatively short. In consequence, limited exchange with other European populations might have contributed to the continued decline of the Helgoland lobster.

Last but not least, our studies include larval bioenergetics. Comparison of biochemical and CHN data suggests *H. gammarus* larvae hatch with a larger body size and a higher dry weight compared with those of *H. americanus*, but apparently with lower relative (% of weight) C, N, lipid, and protein reserves (Fig. 4; c.f. also biochemical data given by Sasaki et al., 1986, and Anger and Harms, 1990). This may indicate a higher

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dependence on food resources in European lobster larvae. However, we observed a substantial variability among different hatches of both the European (Fig. 4) and the American lobster (Anger et al., 1985, observed that some *H. americanus* larvae are able to develop successfully from hatching to the second stage even in complete absence of food). Thus, more comparative research of intra- and inter-specific variability in bioenergetic traits of lobster larvae is required.

Our working group has some experience with the investigation of crab life cycles, but very little with lobsters. So any advice from or cooperation with lobster specialists would be most welcome. Let's hope it is not too late to save our little island lobster population!

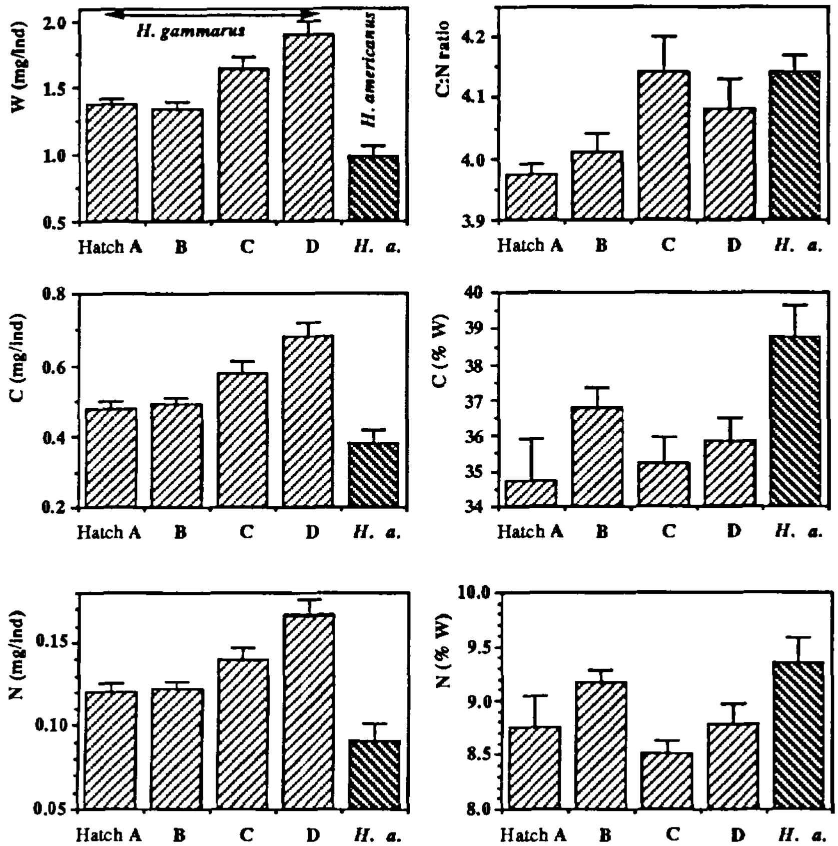

Fig. 4. Dry weight (W) and elemental composition (carbon, C; nitrogen, N) of freshly hatched stage I lobster larvae, in 4 different hatches (A-D) of H. gammarus *and one of* H. americanus *(H.a.).*

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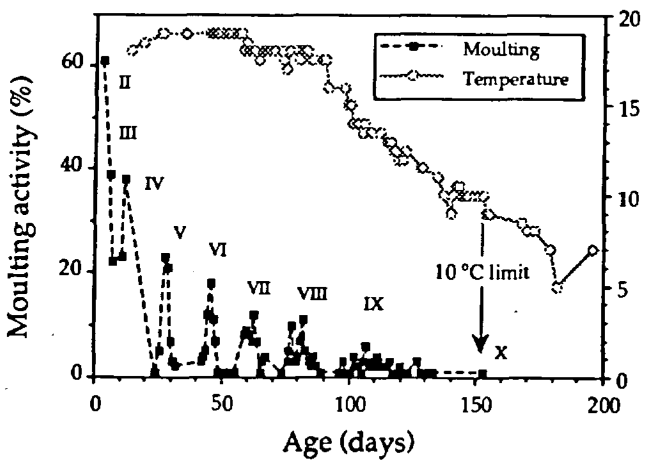

Fig. 3. Moulting frequency in a laboratory population reared under ambient temperature conditions.

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A New Lobster Culture Facility on the French Mediterranean Coast

FROM: GUY CHARMANTIER AND CHRISTOPHE HAOND

Our laboratory has been conducting studies on the ecophysiological ontogeny of lobster juveniles for several years. Larvae were produced in a small facility in Montpellier, using filtered recirculated sea water.

In Sete, 25 km west of Montpellier on the Mediterranean coast, the university owns a biological station founded in 1879. As part of a 1993 station renovation program, we built a lobster culture facility consisting of tanks for holding berried *Homarus gammarus* females; ten, 40 l plankton-kreisels for larval culture; and a compartmented raceway for 100 postlarvae and juveniles. Running sea water used in the system is pumped from a canal linking a large salt pond to the sea; the water is filtered and degassed. Annual salinity and temperature variations range from 33ppt to 38ppt and from 5°C to 26°C. The facility has been operating since May, 1993 with satisfactory results in terms of survival, rate of development and growth. In particular, juvenile survival has been 95% despite high summer temperatures. The raceway capacity will soon be increased.

Researchers interested in lobster larval studies are welcome to contact us about possible work in Sete and/or Montpellier.

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Research on Artificial Reefs in Poole Bay, UK

FROM: KEN COLLINS, EMMA FREE AND ANTONY JENSEN

In 1989 the first experimental artificial reef made of waste material in the UK was deployed in Poole Bay, on the central south coast of England (Collins et al. 1991.) The reef is composed of 50 tonnes of concrete, and cement stabilized coal ash blocks coal ash blocks formed into 8 conical units, each 1m high by 5m across. It was deliberately sited on flat open seabed approximately 3km away from the nearest rocky habitat. Lobsters (*Homarus gammarus*) moved in within three weeks, leading to questions about the movements of these species. Since 1990 an extensive study of the lobster population on the artificial reef and in Poole Bay has been undertaken (supported by the Ministry of Agriculture, Fisheries and Food.) Claw, streamer and T-bar tags have been used to mark 140 animals on the reef and 3500 in the commercial fishery in and around Poole Bay. Recapture rates have been high (>30%). The majority of lobsters were recaptured within 1.5km of their capture location (Jensen et al. 1993).

Lobsters have now been resident for up to 4 years on the artificial reef. The movement of lobsters on the reef has been studied with acoustic telemetry and more recently with electromagnetic telemetry. In this latter system (Collins et al. 1994) a tag attached to the animal emits 3ms pulses at 32.7kHz through a 4cm diameter coil. The pulses are received by 5m diameter loop aerials laid on the seabed around each reef unit and joined to a central receiver and data logger on the seabed. Tagged animals within the loop and 3-4m outside of it can be monitored continuously. Aerials are sequentially connected to a 3 stage TRF receiver tuned to 32.7kHz with a BFO to convert to base band output. The output bursts are converted to unipolar pulses which are recorded on a data logger. Animals are identified by the individual tag pulse rate (1 - 0.5 Hz). The data logger is removed and replaced by divers.

While the range of the electromagnetic system is limited (<4m away from the seabed aerials) it transmits through rock and concrete. Four lobsters have been tracked continuously for two months, showing extensive movement around and away from the reef units. The electromagnetic system also is being used in the lab, in a 12 x 5m seawater tank, in order to study shelter size selection and animal interaction. Further development is planned to allow simultaneous tracking of many more animals and to transmit physiological data such as heartbeat. We also hope to produce a combined electromagnetic and acoustic tag which will allow tracking within reefs and at a distance over open seabed.

We have demonstrated the potential value of artificial reefs in providing additional habitat for lobsters. Further research is needed to understand behavior and shelter size requirements of the different stages in order to design purpose-built reefs. Juvenile lobster restocking experiments around the UK by MAFF have yielded large numbers of hatchery-reared animals in commercial catches (Bannister et al. 1994). The two studies suggest the feasibility of constructing commercial lobster reefs stocked from hatcheries.

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BOOK REVIEW

Spiny Lobster Management

Bruce F. Phillips, J. Stanley Cobb, and Jiro Kittaka, Editors. 1994. Fishing News Books, Oxford. ISBN 0-85238-186-7. 550 pages. Indexed. Illustrated with line drawings and a few black and white photos. Cost: £ 69.50

REVIEWED BY: MICHAEL FOGARTY

Lucrative fisheries for spiny lobsters occur throughout temperate, subtropical, and tropical seas, supplying a rapidly expanding worldwide market for luxury seafoods. These fisheries, supported by over 30 lobster species, range from small-scale artisanal operations to highly sophisticated and heavily capitalized industries in developed countries. Spiny Lobster Management provides a comprehensive overview of fisheries, management, aquaculture potential, and markets for spiny lobsters. The 36 chapters in this volume focus on various aspects of utilization of wild stocks, research in support of management, and artificial enhancement of spiny lobster populations. The global perspective afforded by this treatment provides valuable insights into the efficacy of different management strategies and the role of applied ecology in resource management. In addition, important recent advances in rearing of the early life stages and related basic biological studies are described which have opened new avenues for supplementing production of overexploited natural populations and meeting market demands.

The opening chapter provides a solid grounding in essential aspects of the basic biology and ecology of this diverse group, serving as a valuable background for the more applied orientation of the subsequent chapters. The first section of the book (12 chapters) describes the current status and management of spiny lobster populations in Australia, New Zealand, the Indo-West Pacific, Hawaii, South Africa, Kenya, Brazil, Cuba, Central America, Mexico, Florida, and Europe (particularly France). It provides a timely review of trends in landings, methods of capture, management practices, and levels of exploitation. These chapters have been coordinated to permit ready comparisons across taxa and geographical areas.

Management regimes for spiny lobster fisheries encapsulate the full spectrum of systems employed in fisheries throughout the world. These range from open-access fisheries to individual transferable quota and effort systems. The latter are among the vanguard of new approaches to management in fisheries. With few exceptions, the spiny lobster fisheries described are heavily exploited and landings in many have declined. In general, the open access fisheries have fared the worst and suffered the greatest declines. Even in fisheries with intensive input controls such as that for the Western Australian rock lobster, declines in spawning stock biomass have been documented and linked to continuing increases in efficiency brought about by technological innovations — an important object lesson for anyone involved in fishery management. Other innovative approaches applied to management of spiny lobsters that deserve broader attention include the use of marine reserves in Florida, South Africa, New Zealand, and Hawaii. Given international concerns regarding the ecosystem effects of fishing and on maintenance of biodiversity, this approach merits careful scrutiny.

Minimum legal size (MLS) limits and protection of ovigerous females are broadly applied as regulatory measures in many lobster fisheries, although in most areas, the MLS is below the size of maturity. This issue, coupled with high exploitation rates raises fundamental questions about the factors which control the resilience of these populations to sustained perturbations such as harvesting. As with clawed lobsters, spiny lobsters appear to exhibit high resilience to heavy exploitation. Comparative life history studies within the Palinuridae and between this group and the Nephropidae would provide valuable clues to understanding the response of lobster populations to harvesting.

The second section of the book deals in 10 chapters with topics ranging from reproductive dynamics, ecology of the early life stages, stock structure, catch predictions based on environmental measures and pre-recruit indices, population and bioeconomic modeling, and the role of artificial shelters as capture devices. In keeping with the focus of the book as a whole, these chapters maintain a practical orientation, emphasizing important aspect of biology, behavior and ecology with direct implications for management. There can be little question that understanding the reproductive ecology (including dispersal mechanisms) of spiny lobsters holds the key to predicting how these populations will respond to exploitation and the levels of natural variability to be expected in the fishery. This section provides extremely valuable insights into the linkage between reproductive biology and fishery dynamics (and in stock-recruitment relationships for one species). It is shown how basic demographic characteristics (notably the size at sexual maturity) have changed under exploitation; again, observations of this type are critical to understanding the stability and resilience of these populations. Careful investigation of larval dispersal, settlement patterns, habitat requirements, and sources of mortality, has both enriched our knowledge of fundamental ecological processes and led to the development of fishery forecastis. It is demonstrated that predictions of year class strength can be effectively made for several species based on measures of hydrographic conditions (as indexed by sea level). Considerable advances have been made understanding the ways in which the teleplanic larvae utilize current systems. Measures of pre-recruit abundance (at the puerulus and later juvenile stages) have also been used directly to predict events in the fishery for some species (notably *Panulirus cygnus*). It is particularly satisfying that studies of physical oceanography and ecology have permitted prediction and led to successful management programs.

Application of biotechnological tools has provided new avenues of research on the essential question of stock structure. In particular, the analysis of mitochondrial DNA has enhanced our view of levels of genetic variability in the genus *Jasus* . The importance of development of reliable data collection systems monitor catch and fishing effort over time is carefully established; these data are the basic building blocks of stock assessment. The role of modeling in synthesizing results is also nicely showcased and essential lessons for biological and economic aspects of management are extracted. Finally, this section describes the use of artificial shelters in Cuba and Mexico (where they are known as pesqueros and casitas respectively). These structures provide shelter for communally-dwelling lobsters and act as an aggregating device for capture fisheries. A vital question is whether these structures also enhance the long-term productivity of the stocks.

The third section of the book describes important new developments in the culture of spiny lobster through the extended larval phase and in grow-out techniques for postlarvae and juveniles. The biological underpinnings of this achievement are rooted in detailed studies of the maturation process, mating behavior, feeding and nutritional requirements, as well as disease and its control in aquaculture systems. These topics are treated very effectively in the final section of the book. The daunting complexity of the physiological systems involved has been neatly unraveled to make aquaculture ventures a possibility. Intermediate steps to circumvent the still problematical larval period include the grow-out of pueruli and/or older juveniles. Potential interactive effects on the wild stocks would have to be carefully considered although the opportunity to use these newly developed tools to provide experimental approaches to basic ecological problems should also be recognized. For example, much could be learned about density-dependent responses in growth, maturation and survival.

Finally, issues of product quality, shipping of live lobsters, market structures and marketing strategies are described. This completes the overview of the many pragmatic concerns treated in this volume — all of which lead to the end product which graces the epicure's plate. While science has served spiny lobster management well, we are well advised to recall that the impetus (and funding) for study is due to the commercial importance of the product.

Nearly a decade and a half has now passed since the publication of the landmark volumes, Biology and Management of Lobsters; many advances have been made in lobster biology in the intervening years. Spiny Lobster Management fills a different niche but it does offer important updates to many critical topics for one of the two major families treated in the earlier work. Spiny Lobster Management belongs on the bookshelf of any student of crustacean fisheries biology.

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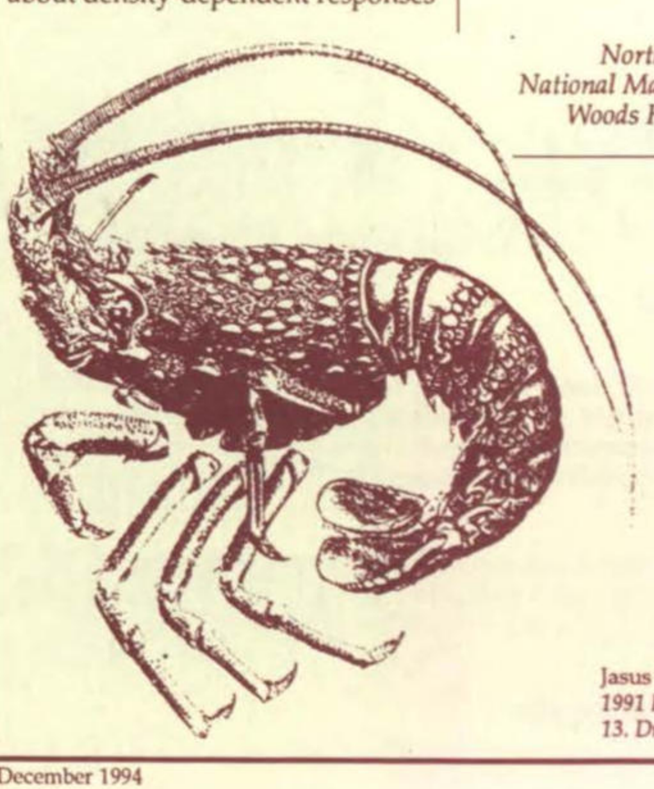
Woods Hole, MA 02543 USA



Jasus tristani. *From Holthuis 1991 F.A.O. Species catalog No. 13. Drawing after Bate 1888*

ANNOUNCEMENTS

Fifth International Lobster Workshop

The Fifth International Conference on Lobster Biology and Management will be held in New Zealand in mid-February 1997. This meeting follows on from the ones held in Australia, Canada, Cuba, and, last year, in Japan.

Contributions on all lobsters — spiny, slipper, clawed and scampi — will be considered.

There will be sessions for formal papers and posters as well as workshops in which researchers, managers and industry will take part. Workshops will focus on topics of wide interest and in which you will be encouraged to contribute preliminary results from ongoing work.

The formal papers and the conclusions from the workshops will be published after normal refereeing.

We want your help in deciding workshop topics. Please send your suggestions (and enquiries) about the 1997 Workshop and Conference to:

John Booth, Convenor
Fifth International
Conference and Workshop on
Lobster Biology and Management
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