PROCEEDINGS OF A WORKSHOP ON FLORIDA SPINY LOBSTER RESEARCH AND MANAGEMENT

24 AUGUST 1984

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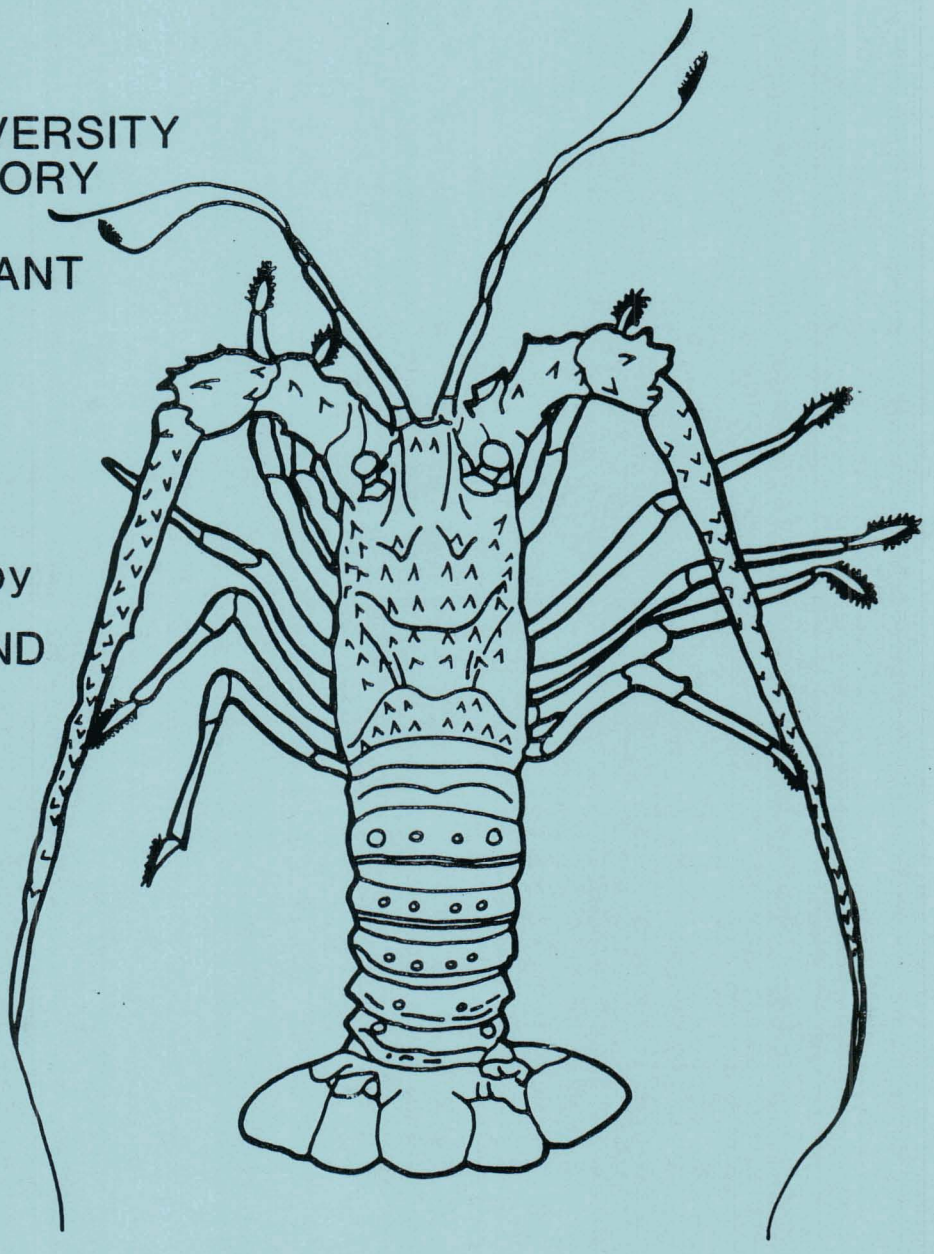

Compiled and Edited by

WILLIAM F. HERRNKIND

SEA GRANT

TECHNICAL PAPER NO. 32

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Sponsored by Florida State University
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FOREWORD

Spiny lobster researchers and resource managers have held workshops every 2-3 years since 1974 to discuss research and information needs pertinent to the organism and its very important fishery. These meetings have resulted in sustained cooperation and coordination among the various individuals, and their respective agencies, and therefore have contributed materially to both the improved state of spiny lobster knowledge and high level of interdisciplinary awareness. The following information emerged from a workshop held on 24 August 1984 at the Florida State University Marine Laboratory co-sponsored by Florida Sea Grant, James Cato, Director, and FSUML, William Herrnkind, Director. Thirteen formal reports were presented to the 20 workshop attendees in addition to a roundtable discussion involving all participants.

The workshop proceedings include: 1) an agenda; 2) abstract/summaries of reports; 3) bibliography of selected recent spiny lobster references; 4) addresses of workshop attendees and other contributors.

Discussion of recent and preliminary findings, or promising leads, is a principal function of the workshop. Users of the proceedings are cautioned not to use the information in the abstracts beyond this intended purpose.

William F. Herrnkind
Workshop Coordinator
November 1984

ACKNOWLEDGEMENTS

I especially thank William Lyons, Florida Department of Natural Resources, who both prompted, and assisted in planning, this conference. The financial contributions of Florida Sea Grant and the facilities provided by Department of Biological Science and the Marine Laboratory of Florida State University are much appreciated. Efficient and capable assistance in preparing and operating the conference was provided by Kath Gauss, Joseph Lusczkovich, Mark Butler, William Greening, Mary Westberg and the rest of the FSUML staff. Their efforts, as well as those of Linda Mathews, Alice Jackson and Cindy Dodson in preparing these proceedings, are commended.

SCHEDULE FOR
SPINY LOBSTER WORKSHOP
FSU MARINE LAB, 24 AUG 1984

Thursday, August 23rd Evening check-in at FSUML

Friday, August 24th

8:00-9:00 AM	Coffee and rolls in FSUML library	
9:00-9:15	Welcoming comments	W. Herrnkind
9:15-9:55	Research for management in the Florida spiny lobster fishery.	W. Lyons
9:55-10:35	Effects of exposure and confinement on spiny lobsters used to bait traps in the Florida fishery.	J. Hunt
10:35-11:00	Coffee break	
11:00-11:20	Effect of air-exposure on spiny lobster blood chemistry and desiccation rate.	G. Vermeer
11:20-11:40	Movement dynamics of spiny lobster in the Florida Keys	J. Marx
11:40-12:00 PM	Spiny lobster movements in the lower Keys and size frequency analysis of lobsters caught by shrimp trawlers.	D. Gregory
12:00-1:15	Catered lunch at FSUML classroom	
1:15-1:35	Macroalgae as habitat for young juvenile spiny lobsters.	J. Marx
1:35-2:05	Growth and survival of post settlement spiny lobsters in artificial nurseries and the potential application of artificial nursery habitats to the Florida fishery.	M. Calinski
2:05-2:25	Status of chemo-reception research on spiny lobster (and other marine crustaceans) at the C.V. Whitney Lab.	R. Gleeson
2:25-3:00	Coffee break	
3:00-3:20	Isoenzyme analysis of slipper lobsters from the Gulf of Mexico and Caribbean: I.	G. Cline

3:20-3:40	Isoenzyme analysis of slipper lobsters from the Gulf of Mexico: II.	C. Hardwick
3:40-4:00	Demand and consumption analysis of spiny lobsters.	F. Prochaska
4:00-4:20	Gulf of Mexico and South Atlantic Fishery Management Plan	D. Gregory
(Abstract only)	Major management issues in the spiny lobster fishery.	G. Waugh

Friday, August 24th

4:20-8:00 PM	Social hour at FSUML Residence House followed by dinner at restaurant of choice.
8:00-9:00	Round table discussion and films.

Saturday, August 25th

8:00-9:00 AM	Coffee and rolls in FSUML library.
9:00-10:00	Tour of FSUML facilities.

WORKSHOP REPORT ABSTRACTS

1. SETTLEMENT, GROWTH, AND SURVIVAL OF PUERULUS TO JUVENILE STAGE SPINY LOBSTERS IN ARTIFICIAL NURSERY HABITATS AND POTENTIAL APPLICATION OF SUCH HABITATS TO FLORIDA'S FISHERY.

Michael D. Calinski

The puerulus stage of the spiny lobster, Panulirus argus, is extremely abundant in the nearshore waters of the Florida Keys; an extrapolation based on the average number of pueruli that settle in Witham collectors, indicates roughly 4 billion pueruli enter the Keys annually, and that about 1 in 600 survive to be (legally) harvested.

In an attempt to increase survival, I tested a series of prototype floating habitats. Of 4 designs (Witham collector, Australian collector, plastic 6-pack rings, "condo") tested, the condo worked best in attracting and supporting puerulus to 20+ mm CL juveniles; puerulus survival to 20+ mm CL was 20 percent, and after 5 months the fouling assemblage was lush enough to support 37 developing lobsters (6 to 21 mm CL). This habitat had 3 tiers, covered 1/4 square meter of water surface and was 1/8 cubic meter in volume.

To determine if a single large habitat would function in the same manner as numerous smaller units of the same volume, 3 2.4 cubic meter floating nurseries of the condo design were pre-fouled in a boat basin, placed at a test site within 5 meters of the oceanside shore of Stock Island, and sampled with a large wood-frame net 1 week after each new moon from May to November, 1983. Animals were tagged with a right or left uropod clip, or a telson notch; each new-moon "set" received a different tag.

A total of 1,167 measurements were made from 866 pueruli that settled in the habitats during the 7-month period. Settled pueruli molted 3 to 4 times and averaged 10.7 mm CL (range = 8.0 - 13.0) after 1 month. Two month old animals averaged 16.2 mm CL (range = 14.0 - 19.0) after molting 2 to 3 times. Three month old animals averaged 24.2 mm CL (range = 19.5 - 27.0) after molting 1 to 2 times. Four month old animals averaged 32.4 mm CL (range = 27 - 34.5) and all animals but 1 molted at least once. Average growth was 6.5 mm CL/month; average increment per molt was 16 percent. No evidence was found that juvenile or other post-puerulus stage animals were entering the habitats from the bottom. With an average growth of 6.5 mm CL/month for the first 4 months, plus an average growth of 5 mm CL/month (Eldred et al., 1972) for the next 6 months, and an average growth of 3.3 mm CL (Lyons et al., 1981) for the next 5 months, lobsters would first enter harvestable ranks (76 mm CL) 15 months after puerulus recruitment.

Puerulus survival data were obtained from a single habitat sampled consecutively for the 7-month period. Of 187 pueruli that settled in this habitat over 3 new-moon periods, 14.4% (27) survived for 1 month; 5.9% (11) survived through 2 months; 5.3% (10) survived through 3 months; and 4.3% (8) survived/stayed in the habitats for 4 months. It is believed they start to leave in search of benthic "denning" habitat after 3 months (none were observed to stay in the habitats for more than 4 months).

Mangrove snappers, Lutjanus griseus, were the major predator of lobsters within the habitats; 7 to 33 percent of snappers captured in the habitats had lobsters in the gut. Habitat modifications reducing tier spacing to keep snappers out showed an apparent 4X increase in survival; the modification also appeared to greatly reduce puerulus settlement (based on settlement still occurring in nearby Witham collectors).

Production of 24 mm CL juveniles averaged just under 2 per cubic meter per month over a 4-month period; production of 32 mm CL juveniles averaged just over 1 per cubic meter per month over a 3-month period. The one-eighth cubic meter prototype probably can produce up to 16 juveniles per month per (total) cubic meter; this habitat also had about one-half the surface area of the larger habitats, and comparitively speaking, could be considered of poor design. There is little doubt that a habitat much smaller than the large ones but larger than the one-eighth cubic meter ones can be developed that will produce 20 juveniles per cubic meter per month, 12 months per year; this is my next research goal.

Such a habitat would have to be built of materials, and anchored in such a manner, as to withstand hurricanes. An anchoring system capable of holding habitats in such an event has been developed; the only material that could withstand such an event and last in the marine environment for at least 10 years is polypropylene. A rough estimate would put the cost of such a system, including regular maintenance, at $250 to $300 per cubic meter per 10-year period.

Waugh (1981) estimated 30+ mm CL juvenile survival in the Bahamas to be 40 percent; Olsen and Koblic (1975) estimated juvenile survival in U.S.V.I. to be 60 percent; no estimates have been made for Florida, but for the following considerations it will be expected that 50 percent of nursery produced juveniles will survive to be harvested; harvested animals having a value of $3.00 each, ex-vessel. At a theoretical production of 240 juveniles per cubic meter per year, such a habitat would produce $360 worth of lobster per year, thus paying for itself within 1.5 years after deployment (allowing for 2 months initial fouling, 15 months to first harvestable animals, 12 months for first full year's harvest).

If the estimated annual puerulus recruitment figure of 4 billion is close to what actually occurs, then just under 6 hectares (14.5 acres) of such habitat deployed in a sufficiently diffuse manner (1 part habitat to at least 100 parts open water) would utilize 18 percent of available seed-stock to double Florida's (legal) recreational and commercial landings at a roughly calculated 10-year cost of 14.7 to 17.6 million dollars; ex-vessel wide returns (e.g., wholesalers, retailers, boat builders, restaurants, tourist trade, recreational spinoffs, etc.), this figure could theoretically reach the half-billion dollar mark.

This artificial nursery habitat concept has been tested successfully at the prototype level on stone crabs, blue crabs, calico scallops, and various fishes, such habitats can effectively replace natural nursery habitat destroyed by coastal development.

(Citations: Eldred, B., C.R. Futch, and R.M. Ingle. 1972. Studies of juvenile spiny lobsters, Panulirus argus, in Biscayne Bay, Florida. Fla. Dept. Nat.

Resour. Mar. Rs. Lab., Spec. Sci. Report 35. 15 pp; Lyons, W.G., D.G. Barber, S.M. Foster, F.S. Kennedy, Jr., and G.R. Milano. 1981. The spiny lobster, Panulirus argus, in the middle and upper Florida Keys: population structure, seasonal dynamics, and reproduction. Fla. Mar. Rs. Publ. No. 38. 38 pp; Olsen, D.A., and I.G. Koblic. 1975. Population dynamics, ecology and behavior of spiny lobsters, Panulirus argus, of St. John, U.S.V.I. II. Growth and Mortality, Pp 17-21 In: S.A. Earle and R.J. Lavenberg, eds. Results of the TEKTITE program: coral reef invertebrates and plants. L.A.C.M. Nat. Hist., Sci. Bull. 20; Waugh, G.T. 1981. Management of juvenile spiny lobster (Panulirus argus) based on estimated biological parameters from Grand Bahama Island, Bahamas. Proc. Gulf Carrib. Fish Inst. 33: 271-289).

2. PHOSPHOGLUCOMUTASE AND PHOSPHOHEXOSE ISOMERASE ISOZYMES OF SLIPPER LOBSTERS, SCYLLARIDES NODIFIER FROM THE GULF OF MEXICO AND SYLLARIDES AEQUINOCTIALIS FROM THE EASTERN CARIBBEAN SEA.

George B. Cline

S. nodifier is a migratory lobster found principally in the Gulf of Mexico and waters draining from it while S. aequinoctialis seems to be a reef dweller and is found principally in the Caribbean Sea and its waters that reach the shores of the Americas. The range of the two species thus overlap in the Florida Keys and Bay. Some aspects of their biology and species' descriptions have been reported elsewhere (see below). Biochemical data in the form of polymorphic isozymes is presented here to give further distinctions between these two species. In this study, 7 S. aequinoctialis from the American Virgin Islands are compared with 10 S. nodifer from the northern Gulf of Mexico using PGM (E.C.2.7.5.1.) and PHI (E.C.5.3.1.9) zymograms as the basis for comparison.

Legs were excised from live animals and the muscles ground with a mechanical grinder and sonicated to further break open the tissues under ice cold conditions. The soluble phase was collected by centrifugation, dialyzed against 3 changes of ice cold distilled water, and frozen in 3 to 5 ml aliquots. The zymograms were prepared by isoelectric focusing in pH 5.0 to 6.5 polyacrylamide gels (LKB PAG plates) under constant power at 1500 volts maximum. Isozymes were detected by standard reactions coupled to a tetrazolium indicator.

Results of PGM assays for S. nodifer showed all 10 animals had a single band at approximately pH 6.1, with either single or double bands (sets) at 5.75, 5.55, 5.3, 5.2, and 5.1. Five animals had a single band at 5.4 while eight animals had one or more bands centered around pH 4.8. S. aequinoctialis showed fewer overall bands with 2/7 having a 4.8 band, 4/7 having 5.0 band(s), 5/7 having a 5.2 band, 6/7 having a 5.4 band, 6/7 having a 5.7 band(s), 7/7 having both 5.8 and 6.0 bands. Occasional bands appeared at higher pHs in some animals. PGM patterns could not be correlated with sex. The two species have he 4.8 and the 5.2 isozymes in common (and possibly the 5.7 set). Some of the unshared isozymes are possibly species specific.

The PHI isozymes are quite sensitive to oxidation, thus all samples contained a reducing agent, DTT. One S. nodifer never showed PHI isozymes while of the remaining nine, 5/9 had isozymes at 5.1, 8/9 had bands at 5.25 to 5.3, 9/9

had 5.4 and 5.55 bands, 8/9 had 5.65 bands, several had weak bands at 5.8 and 7/9 had a strong band at 6.3. The seven S. aequinoctialis showed more isozymes overall. Six/seven had bands at 5.1 while 7/7 had bands at 5.2, 5.25, 5.3, 5.4, 5.5, 5.6, 5.7 and 5.8. Occasional bands appeared in some animals at higher pHs. PHI isozymes at pH 5.1, 5.25, 5.4, 5.5, and 5.7 are common between both groups and no pattern correlation could be made with respect to sex.

PGM and PHI zymograms of these two species are distinctly different and help to further define these animals. Further isozymic analysis of animals from other regions of the Gulf and Caribbean are important for stock assessment.

(Citations: Lyons, W.G. 1970. Memoirs of the Hour Glass Cruises, Vol. 1, Part IV; Cline, G.B., D. Chilcutt and R. Lindsay. 1978. Histological studies and rearing of phyllosomes of the Slipper Lobster, Scyllarides nodifer. J. Ala. Acad. of Science 49:73; Cline, G.B. and J. Hinton. 1983. A comparison of phosphoglucomutase and phosphohexose isomerase isozymes of muscle extracts of slipper lobsters S. nodifer and S. aequinoctialis by isoeletric focusing. Isozyme Bulletin 16:78; Hardwick, C. and G.B. Cline. 1984. Genetic characterization of a population of Scyllarides nodifer using isoelectric focusing (IEF) of some gene products. J. Ala. Acad. Sci. In press.

3. STATUS OF CHEMORECEPTION RESEARCH ON THE SPINY LOBSTER AT THE C.V. WHITNEY LABORATORY

Richard A. Gleeson

A project is described in which the physiological mechanisms of "mixture suppression" in the olfactory pathway of the lobster were examined. In this study a 31 component stimulus mixure, which mimics the composition of a natural food (the soluble organics of crab muscle tissue), was utilized. Neural responses to the mixture and its components were assessed at both the receptor cell level and in high-order interneurons in the olfactory pathway. Of the 31 components, 12 were identified as stimulatory and 3 were classified as non-stimulatory suppressants. At both the receptor cell and CNS levels, response intensity to a mixture of the stimulants and suppressants were significantly less than that to the stimulants alone. By presenting the stimulants and suppressants to separate antennular filaments, the central neural contribution to mixture suppression was assessed. Of the 20 interneurons examined in these latter experiments, half exhibited suppression when the stimulants and suppressants were simultaneously presented, but spatially separated by application to different antennular filaments.

A second project is discussed in which the objective was to develop a bait alternative to the use of short lobsters in the lobster pot fishery. Tank tests were performed in which the lobster catch rate was compared for: (1) pots "baited" with short lobsters; (2) empty pots; and (3) pots containing experimental baits. A system for dispensing homogenized slurries of food stimuli (e.g., shrimp heads) over several days was developed. In tank tests this approach was very effective at outfishing pots containing short lobsters. Initial field trials, however, were equivocal and warrant further study.

4. SPINY LOBSTER MOVEMENTS IN THE LOWER FLORIDA KEYS AND SIZE FREQUENCY ANALYSIS OF LOBSTERS CAPTURED IN THE SHRIMP FISHERY

Douglas R. Gregory, Jr. and Ronald F. Labisky

Long distance movements of the spiny lobster, Panulirus argus, were studied in two Gulf of Mexico habitats (Shallows, Middepth) and three Atlantic Ocean habitats (Shallows, Patch Reef, and Deep Reef) in the lower Florida Keys during the mid-1970s. Thirteen percent (N = 783) of 6,125 spiny lobsters tagged and released at the five sites between June, 1975 - August, 1976 were recovered, principally by commercial fishermen; 80 percent of the tags were recovered within the first three months of the eight month commercial fishing season (26 July - 31 March). Males and females were recovered in the same proportion as they were captured and tagged. Directions and rates of movements differed significantly ($P > 0.05$) among sites. Movements of spiny lobsters from Gulf sites were generally oriented to the west and southwest, toward the Atlantic offshore reefs, at mean rates of 0.57 km/day (Mid-depth) and 0.24 km/day (Shallows). Movements of spiny lobsters from the Atlantic sites were principally eastward and westward, parallel to the reef line and island chain, at mean rates of 0.02 km/day (Deep Reef) and 0.05 km/day (Shallows, Patch Reef). The more directed movements of spiny lobsters from Gulf sites may reflect a migration from nursery grounds to the Atlantic reefs, which not only constitute the primary spawning habitat but also exhibit a more stable winter environment than the shallow Gulf. Movements of spiny lobsters from Atlantic waters reflect localized random onshore-offshore disperal patterns characteristic of reef environments.

Size Frequency Analysis: Carapace lengths of 379 lobsters were taken of the lobster by catch of an individual shrimp trawler during the period July, 1975 - January, 1979. No overall size differences between sexes (m, f) or seasons (September - February, March - August) were observed, however, carapace lengths generally decreased during the study period. Significant three-way interaction existed in carapace length between sex, season, and year. During the reproductive season (March - August) females were larger than males, but during the nonreproductive season both sexes were of similar size. Carapace lengths in the reproductive season were larger than those in the nonreproductive season for the years 1976-1977 but the reverse occurred in 1978 - possibly due to the expansion of the lobster fishery to the FCZ during the 1978 closed season (April - July) in Florida's waters. Overall, that segment of the lobster population peripheral to the shrimp fishery experiences a lower mortality rate than does the traditionally fished component of the population in the Florida Keys.

5. GULF OF MEXICO AND SOUTH ATLANTIC SPINY LOBSTER FISHERY MANAGEMENT PLAN

Douglas R. Gregory, Jr. and Greg Waugh

The management unit is the spiny lobster, Panulirus argus, inhiabiting that portion of the FCZ within the areas of authority of the Gulf of Mexico and South

Atlantic Fishery Management Councils. The fishery occurs principally in the waters off South Florida, and approximately 50 percent of the catch is taken from the FCZ.

The objectives of the FMP implemented in July 1982 address a number of problems. Foremost among these was the need to manage the fishery throughout its range. Florida had been managing the fishery for years, but its enforcement efforts were limited to state waters. The objectives were designed to: (a) increase long-term yield of lobster by weight; (b) protect the stocks by reducing mortality and illegal harvest of undersized lobsters (including those used as attractants in traps); (c) reduce conflicts among users of the resource; (d) increase efficiency in the fishery, and (e) acquire the data necessary for future management decisions. The FMP projected an estimated increase in yield of 1.5 million pounds in the first year over the estimated legal catch of 8.0 million pounds, (includes 1.0-2.6 million pounds or unrecorded commercial and recreational catches) and an eventual long-term increase in yield of approximately 4.0 million pounds to the MSY of 12.0 million pounds. Projected increases in annual revenue to the harvesting sector parallel the projected increases in yield. Management measures designed to achieve these objectives in the FCZ included a minimum size limit (3.0 inches carapace length or 5.5 inches tail length), a closure during the spawning season (April 1 - July 25), the use of degradable escape panels, the prohibition of certain gear (such as spears and hooks) that could injure or kill sublegal-sized lobsters, a prohibition against molesting or pulling another's traps, the required return of undersized lobsters to the water unharmed except for those used as attractants in traps (allowance for three for each trap aboard or 200 per vessel, whichever is greater), issuance of trap permits, color coding of trap buoys, a special two-day recreational non-trap season, and finally, a prohibition against striping or possessing egg-bearing females.

The first Council review of the Spiny Lobster FMP was conducted in Key West, Florida in July 1984. The plan review identified three major topics of concern: (1) a significant fishery-induced mortality of undersized lobsters used as attractants. (2) The lack of an adequate statistical reporting system. (3) The continued overcapitalization of the fishery. Alternative management measures to address the above problems will be considered for the spiny lobster fishery next year by the Councils.

6. BIOCHEMICAL CHARACTERIZATION OF A POPULATION OF SCYLLARIDES NODIFER USING ISOELECTRIC FOCUSING (IEF) OF SOME GENE PRODUCTS.

Charles W. Hardwick and George B. Cline

Electrophoretic patterns of proteins and of isozymes can be used to measure genetic relationships among animals and populations. In this progress report, IEF is used to assess the biochemical characteristics of 15 slipper lobsters collected from 2 locations 25 miles south of Pensacola, FL. IEF is done in thin-layer agarose gels containing ampholytes with pH range 4-7. The focused gels are assayed for gene products using several methods.

The results for the Commassie Blue R-250 protein staining, PGM isozyme patterns, PHI isozyme patterns, and MPI isozyme patterns have been previously reported from this lab. The additional enzyme work done supports the conclusion previously drawn, that all the animals in this study share a common gene pool. In addition to the enzyme assays, a newly developed silver stain for proteins focused on charge balanced agarose shows greater detail using smaller sample sizes and lower ampholyte concentrations.

A new technique developed in this lab for zymogram detection of isozyme patterns was used for these enzymes. This method,using a filter paper overlay that remains permanently bound to the IEF gel, increases the accuracy of the pI interpretation and gives increased resolution even on grossly overloaded samples.

Additional data on mannose phosphate isomerase indicate a high degree of polymorphism, however, this enzyme does not appear to be sex-linked as in some other lobster species. Major isozyme bands for MPI appear at pIs 5.00, 5.55, 5.85, and 7.15 (2). Esterase isozymes also showed individual differences, with major bands at pIs 4.50, 4.60, 4.75, 4.85 (2), 4.95, 5.25, and 5.50 (2). Some animals showed bands around pI 5.7. Hexokinase activity was tested in separate experiments using two substrates, glucose and fructose, and common bands appeared at approximately pIs 5.50 and 6.35. These experiments have not been repeated enough to assign possible loci. None of the enzyme or protein band pattern differences between animals appear to be due to the sex or the size of the animal.

7. EFFECTS OF EXPOSURE AND CONFINEMENT ON SPINY LOBSTERS, PANULIRUS ARGUS, USED TO BAIT TRAPS IN THE FLORIDA FISHERY

John H. Hunt

Fishermen in the south Florida spiny lobster fishery typically use sublegal lobsters (shorts) as live attractants inside traps, many shorts so utilized are exposed for considerable periods aboard vessels before being placed in traps and returned to the sea. Field tests mimicking this fishing method were conducted to determine capture rates by variously baited traps and mortality rates of lobsters used as attractants.

Catch rates of traps containing 1 or 2 lobstes as live attractants were nearly twice those of empty traps or traps baited with cowhide. Shorts were relatively more effective as attractants during times of lobster scarcity than during times when lobsters were plentiful.

Average mortality rate of lobsters exposed 1/2, 1, 2 and 4 hours in controlled field tests was 27% after 4 weeks; unexposed (control) lobster mortality was 10%. Approximately 42% of observed mortality occurred within 1 week after exposure, indicating exposure to be a primary cause of death. Neither air temperature during exposure nor periodic dampening with seawater had significant effects on mortality rate. Mortality among confined lobsters increased markedly in the ocean but not in Florida Bay during the fourth week of confinement following exposure, probably because more natural food organisms entering traps from nearby seagress beds delayed starvation at the latter site.

Another estimate of mortality was made by comparing return rates of tagged lobsters deliberately released before or after confinement with return rates of others that "disappeared" from traps while serving as live attractants. The return rate of each set of deliberately released lobsters was 18%, whereas that of bait lobsters that disappeared was 10.5%. When added to the number of lobsters known to have died during confinement, estimated mortality rate of bait lobsters derived using this method was 47%.

Mortality caused by baiting traps with shorts may produce economic losses in dockside landings of 1.5 to 9.3 million dollars annually.

8. RESEARCH FOR MANAGEMENT OF THE FLORIDA SPINY LOBSTER FISHERY

William G. Lyons

Topics on a list of major problems and information needs resulting from the 1974 Florida spiny lobster workshop are reviewed a decade later. Declining catch per unit effort: CPUE in the Florida fishery declined from 35.1b/trap/yr in 1973 to 8 lb/trap/yr in 1983. Determination of "maximum sustained yield" (MSY): The Fishery Management Plan (FMP) inaugurated in 1982 proposed an MSY of 12.7 million lbs and a possible optimal yield of 12 million lbs; however, reported commercial landings dropped from 6.5 million lbs in 1982 to 4.5 million lbs during 1983, a 31% decline. Amount of entry into the fishery: Reliable statistics are not available on the number of spiny lobster fisherman, but effort increased from 304,000 traps during 1973 to 555,000 traps during 1983, with a maximum 622,000 traps deployed during 1981; the FMP model predicts that maximum yield can be achieved with 39% of present effort. Seasonality of the fishery: A 1984 summary concluded that almost all annual recruitment to the fishery is removed between August and November of each season, in contrast to a longer 6-8 month season during earlier years. Size at reproductive maturity: The present 3" carapace length minimum size resulted from compromise between an earlier 3 1/8" biological estimate of average size at first reproductive maturity and industry requests for a smaller minimum at 2 3/4"; recent estimates based upon lengths of pleopodal setae and histological examination of ovaries indicate 3 1/4" and 3 1/2", respectively, as average sizes for attainment of first reproductive maturity. Recruitment: Transport of larvae from Caribbean stocks is believed to support much of Florida's recruitment. Electrophoretic analyses of produced promising but inconclusive indications of population relationships. Recent studies demonstrated year-round recruitment of pueruli to Florida and developed techniques to quantitatively monitor that recruitment. An index of reproductive potential developed during the late 1970's indicated reproductive output had declined 88% in the south Florida stock. A study of juveniles in Biscayne Bay suggested recruitment may have declined 67% between the late 1960's and the late 1970's. Research has shown that injuries to juveniles may retard growth rates as much as 40% below those of uninjured lobsters and delay recruitment into the legal fishery. The most recent landings review indicated that fewer legal lobsters are available at the beginning and fewer remain at the end of each fishing season. Nevertheless, no strong data exist to conclusively demonstrate actual recruitment decline. Migration: Studies during the last decade have delineated developmental and

reproductive movement patterns of lobsters in and near the major fishery population, but have not identified the source of some seasonal movement into northern Florida Bay. There remains no evidence of adult movement across major barriers such as the Gulf Stream. Age and growth: Although several studies described general characteristics of juvenile and adult populations, most age/growth evidence is still extrapolated from small data bases or from data developed elsewhere. Contributions of estuaries and bays as lobster nurseries was solidly demonstrated, and some juvenile sanctuaries were established. Reproductive sizes and spawning sites were also identified. One recent estimate suggests lobsters attain legal size slightly less than 3 yr after hatching, but other studies indicate growth of young juveniles may be twice as fast as values used to obtain this estimate. Very few lobsters survive to yr 4 in the south Florida fishery. Larval identification: Despite several attempts, no real progress has been achieved in efforts to differentiate Panulirus argus larvae from those of other western Atlantic Palinuridae. Effects of pollution: The fishing industry in 1984 expressed concern about survival of juvenile lobsters when mosquito control toxins are released near nursery areas. Scientific data on effects of these or other pollutants remain unavailable. Thermal/hydrographic studies: Available data have been scrutinized and related to larval collections, demonstrating several pathways of larval distribution in response to oceanic water masses and subject to specific thermal constraints. Law enforcement: Efforts to curtail vandalism and curb illegal harvest have been strengthed by additional State regulations and by enactment of the Federal Fishery Management Plan; violations of the FMP result in more severe penalties than those specified by State of Florida statutes. Federal prosecutions for illegal possession of sublegal lobsters are ongoing. Statistics of commercial and sport fisheries: Until 1984, commercial landings statistics were gathered by National Marine Fisheries Service; other data on the fishery were acquired during aperiodic contractual socio-economic surveys. Several lines of evidence were used to produce estimates of the magnitude of recreational harvest; these range from 0.5 to 1 million lbs. During 1984, the Florida Department of Natural Resources assumed responsibility for collecting fishery statistics; data from surveys of commercial dockside landings will be supplemented by a trip ticket reporting system, and a recreational catch survey will be initiated. Economics of the fishery: Several studies conducted during the late 1970's provided the information base used to prepare the FMP. Workshops on specific problems: Five workshops on research and managment informational needs have been conducted subsequent to the 1974 meeting; proceedings of four of these (including the present meeting) have been made available as published proceedings.

An additional topic addressed but not identified as a problem during the 1974 meeting was then then illegal practice of possessing and transporting sublegal lobsters to be used as attractants in traps. This practice, which received legal sanction during the mid-1970's, has since been shown to be deliterious to fishery stocks. Mortality due to exposure and starvation averages 27% after 4 wk, and daily escape rates are low (1-3%). Exposure, starvation, predation, and other factors may together result in 47% mortality among bait lobsters. A model predicts yield per recruit would increase 40% if this practice were stopped. Illegal harvest of undersized lobesters is also abetted by this access to the sublegal stock; magnitude of illegal harvest is estimated to be 20-50% that of the legal fishery. Effectiveness of alternative baits and escape gaps are being evaluated as measures to reduce these losses.

Although much progress was made in research related to reproductive biology, migration and other aspects of population dynamics during the past decade, considerable work remains for such topics as recruitment sources, larval identification, and growth. Meanwhile, management must work to improve yield per recruit among existing stock by correcting injurious fishery practices brought about by a severely overcapitalized industry.

8. ECOLOGY AND POPULATION CHARACTERISTICS OF ALGAL DWELLING POST-SETTLEMENT SPINY LOBSTERS

James M. Marx

Field surveys were conducted in the middle Florida Keys from May through September 1982 to better document habitat use by newly settled juvenile spiny lobsters. Early benthic stages, discovered at several bayside locations, resided in or beneath attached macroalgal masses of Laurencia spp. Macroalgae provide refuge and support an abundant, diverse fauna preyed upon by young lobsters, as confirmed by examinations of lobster stomach contents.

Burnt Point on the bayside of Crawl Key was sampled weekly during the survey period. Puerulus settlement there occurred at monthly intervals, indicating continuous use of the algal microhabitat by successive settlement classes. Mean density of lobsters between 6 and 19 mm carapace length (CL) was only one per $36m^2$, despite luxuriant algal growth which averaged 7 liters per m^2. Low densities may be the norm for this particular life stage, due to a) asocial behavior, which tends to disperse the recently settled population, b) variable rates of postlarval recruitment, and c) the dispersed distribution of algae within used habitats. Despite "low" densities, small pockets of algal habitat are probably highly productive over a yearly cycle due to year-round postlarval recruitment and rapid growth of young juveniles.

Patterns of resource use at Burnt Point were well defined ontogenetically. From settlement (6 mm CL) through approximately 15 mm CL, young lobsters remained within or beneath algal clumps, thereafter taking residence in various den structures independent of algae. The transition from algal to den dwelling was accompanied by a shift from solitary to aggregate habitation. Solitary spacing probably reduces required foraging area and consequent exposure to predators.

10. MOVEMENT DYNAMICS OF FLORIDA KEYS SPINY LOBSTER

James M. Marx

Between April 1978 and March 1979, the Florida Department of Natural Resources conducted a major survey of the lobster populations in the middle and upper Florida Keys. A total of 19,180 lobsters were collected by trap, described, tagged, and released from nine sampling locations spanning bay, bridge, shallow reef (10 m) and deep reef (30 m) habitats. Movement information was

obtained for 2,828 recaptured lobsters.

Overall, only 34% of the returned lobsters moved; lack of movement being defined as any distance travelled less than one mile. Percent movement increased slightly to 40% for lobsters at large longer than 60 days. Extended periods of residency were characteristic of a large segment of the sampled population.

The effect of lobster size on movement depended on the release location. At habitats void of reproductive activity (bay, bridge, and middle Keys shallow reef), population movement tendencies were strongly size dependent, with increasing percent movement as size increased. Once lobsters reached habitat supportive of reproductive activity (upper Keys shallow reef and deep reef), percent movement declined and was independent of size.

Percent movement values obtained for specific populations were generally closely correlatd with the catch rates observed at particular sampling locations. At all locations, increasing catch per unit effort (C.P.U.E., expressed as the total number of lobsters caught per trap pull) through the summer was positively correlated with rising percent movement. This suggests that overall movement tendencies may be density dependent. In Florida Bay, declining C.P.U.E. through the fall was accompanied by increasing percent movement, suggesting that movement tendencies then were influenced more by autumnal migrational cues rather than density.

The character of movements originating from all shallow water locations changed dramatically in October, with rates (miles travelled per day) increasing nearly three-fold. The deep reef population showed a marked rise in speed in January and February. This heightened activity was primarily by females, and may have represented the first expressions of mate-searching behavior; females bearing fresh spermatophores were first observed in January of the 1979 reproductive season.

11. DEMAND AND CONSUMPTION ANALYSIS OF SPINY LOBSTER

Fred J. Prochaska and Walter R. Keithly

World production of spiny lobsters appears to be reaching a maximum. Production of cold water spiny lobsters reached a peak in 1969 and has since declined. Reduced landings in South Africa have accounted for most of the decline in worldwide cold water spiny lobster landings. Warm water landings of spiny lobsters have offset the loss in cold water landings.

Imports of spiny lobsters into the U.S. account for at least 90 percent of the total annual supply available for domestic consumption. The U.S. has traditionaly imported most of the total world production. However, due to increased world demand for spiny lobster the share of world production imported by the U.S. has declined to approximately 80 percent in the 1980s. Relatively stable Florida and worldwide production along with increased demand for imports suggests total U.S. supply of spiny lobster for consumption will be stable or

declining in the near future.

Demand analysis for consumption of all lobsters in the U.S. shows quantity consumed to be significantly related to income and prices. A 1.0 percent increase in real disposable per capita income results in an increase in lobster consumption of 1.37 percent. With respect to price, the demand is inelastic; a 1.0 percent increase (decrease) in price results in only a .69 percent decrease (increase) in consumption.

At the Florida dockside level exvessel price changes were explained by import prices and Florida spiny lobster landings. Given the importance of imports in determining total U.S. consumption of spiny lobster, import prices were extremely important in determining domestic exvessel prices. A 1.0 percent change in import prices resulted in a 1.07 percent change in exvessel prices in the same direction. The quantity of spiny lobster landed by U.S. fishermen had a statistically significant negative impact on exvessel prices. However, given the relatively small level of Florida landings as a percentage of the total consumed in the U.S., the impact is economically insignificant with only a -.123 percent change in exvessel prices for a 1.0 percent change on domestic landings.

Participation rates classified by socioeconomic groups showed very few households consuming lobster at home. Greatest at home consumption occurred in the Northeast where still only 1.07 percent of the households reported at home lobster consumption during any one week period. With respect to race only .17 percent of the black households consumed lobsters at home for a given week compared to .47 percent of the white households. Family size and seasonality do not appear to be related to at home consumption. Income does not appear to affect quantity consumed per household but does impact the number of households consuming lobsters. Approximately .30 percent of the households in the less than $10,000 income group consumed lobsters at home compared to .95 percent for those households with incomes in excess of $30,000.

12. THE EFFECTS OF AIR-EXPOSURE ON PANULIRUS ARGUS BLOOD CHEMISTRY AND DESICCATION RATE

Gregory K. Vermeer

Desiccation rates and biochemical changes in the hemolymph of air-exposed spiny lobsters were examined to understand physiological mechanisms associated with mortality related to exposure. Air exposed lobsters lost approximately 2% of body weight per hour of exposure. Smaller, sublegal sized animals lost weight faster (2.35% per hour) than did larger, legal sized animals (1.82% per hour). Smaller lobsters have a larger surface area to volume ratio which accounts for their higher rate of water loss. An increase in blood serum osmolarity resulting from water loss was not evident. A severe metabolic acidosis, induced by the rapid accumulation of lactic acid, occurred in air-exposed lobsters. Within 30 minutes after emersion, hemoloymph lactic acid concentrations increased to almost 7 times normal lavels and pH declined from 7.91 to 7.62. After 2 hours, lactic acid levels were more than 11 times normal and pH dropped to 7.41. Concentrations of ammonia, a toxic waste produce, approximately doubled during exposure. Hemolymph pH, lactic acid, and ammonia

concentrations among lobsters exposed for 2 hours returned to normal levels within 24 hours after reimmersion in seawater. Chronic effects of exposure persisted in the form of reduced responsiveness to threatening stimuli and a diminished "tail flip" escape response. These behavioral changes are probably caused by exposure-related neural damage. Lobsters chased to exhaustion (5 minutes) while immersed in seawater had hemolymph pH, lactic acid, and ammonia concentrations similar to those of air-exposed lobsters.

13. MAJOR MANAGEMENT ISSUES IN THE SPINY LOBSTER FISHERY

Gregg T. Waugh

There are four major management issues facing the Councils in the spiny lobster fishery. The continued harvest of lobsters below the minimum size (3 inch carapace length or 5.5 inches tail length) is preventing the fishery from harvesting the optimum yield. Increased enforcement is necessary to prevent the harvest of shorts.

The determination of whether the fishery is dependent on local recruitment or recruitment from the Caribbean area has yet to be made. Before investing large quantities of money and effort one should ask whether or not the management implications would be different under either situation. If the Florida fishery is dependent on local recruitment, then the minimum size should be increased to increase egg production. If Florida recruitment is from the Caribbean then it would be in our best interest to have them raise their minimum size. We would also have an incentive to raise our minimum size both as an example to other countries and to provide maximum egg production for Bermuda and other countries that may depend on us for recruitment. Thus, under either alternative it is in the best interest of the countries with lobster fisheries to manage them together, perhaps through an organization like the Gulf and Caribean Fisheries Institute.

The Florida lobster fishery is overcapitalized. It has been pointed out that 100,000 traps could harvest the annual yield but in 1983 there were approximately 555,000 traps in the fishery. The South Atlantic Council will conduct a study to evaluate the feasibility of limited entry in the lobster fishery. Based on this study the issue of overcapitalization will be addressed by the Councils.

Finally, the issue of fishery induced mortality through the use of shorts as attractants has the greatest potential for increasing yield in the Florida lobster fishery. Recent estimates of the fishery induced mortality range from 27% to 47%. If this mortality is in the range of 40%, losses in yield could be between 20% and 50%. The Councils are considering the use of live wells and escape panels as a mechanism to increase yield while at the same time allowing the fishery to continue using shorts as attractants.

The Spiny Lobster Fishery Management Plan will be reviewed on an annual basis and anyone wishing to receive further information may contact the Council at the following address:

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SELECTED RECENT LITERATURE PERTINENT TO SPINY LOBSTER RESEARCH AND MANAGEMENT

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