Ecological Research Associates

ECOLOGICAL EFFECTS OF ENERGY DEVELOPMENT ON REEF FISH OF THE FLOWER GARDEN BANKS

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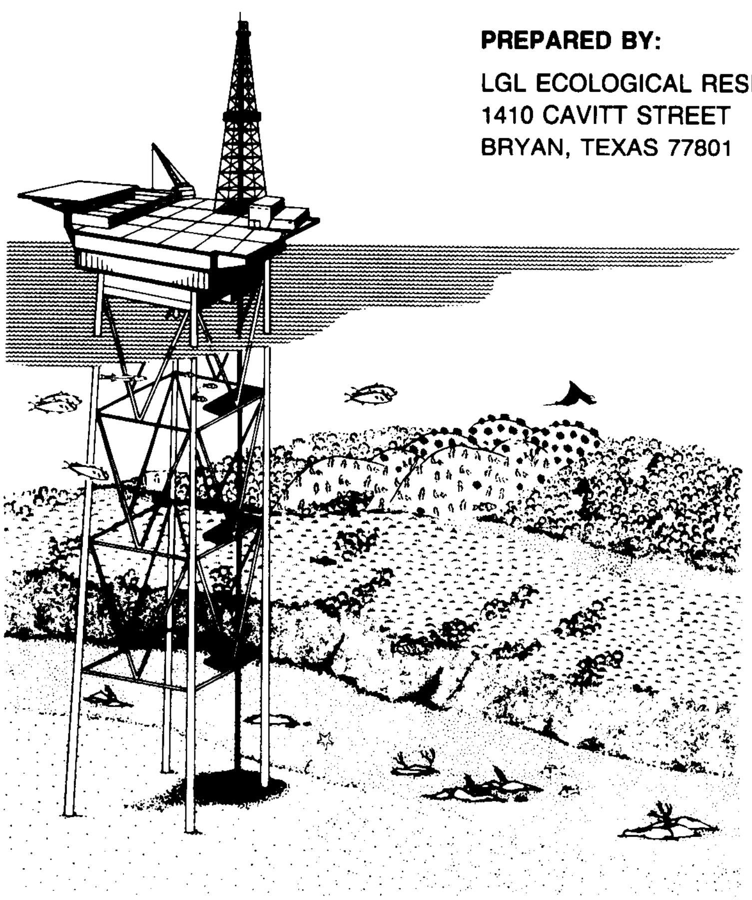

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FINAL REPORT
For Work Unit B1/B5

by

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ABSTRACT

Eight research cruises were conducted at the Flower Garden Banks in the northwestern Gulf of Mexico over the period 1980 to 1982 as part of a study designed to evaluate the effects of operations of a drilling platform (Mobil HI-A389-A) adjacent to the East Flower Garden Bank on reef fish populations. The platform was not installed until early fall of 1981.

The first two cruises were undertaken during fall and winter of 1980 and were largely for (1) reconnaissance surveys of each bank and a drilling platform (Mobil HI-A595-D) which, although 9 nautical miles west of the banks, was the closest of any active drilling structure, and (2) development and refinement of underwater research techniques. During spring and summer of 1981 (Cruises 3 and 4) quantitative surveys were conducted at each bank and at the platform. Based upon the results of these surveys, it became obvious that sample sizes would have to be considerably increased in order to obtain the requisite levels of accuracy and precision necessary to be able to detect any effects on fish population levels following installation of the platform adjacent to the banks.

The platform was installed adjacent to the East Flower Garden Bank shortly before Cruise 5, and fish population sampling effort was focused around this bank and the platform for the balance of Cruises 5-8. Data from these cruises were representative of fall 1981, and spring, summer and fall of 1982, respectively.

The Flower Garden Banks were found to have characteristic fish assemblages, primarily zoned by depth and/or habitat types. Each of these habitat types were mapped to determine total area and fish densities were determined based upon a total of 357 h of samples with the data recorded by 1-min intervals. Using maximum likelihood estimation procedures, seasonal standing stocks were estimated for each of 16 reef fish taxa. Confidence limits were also calculated for these standing stock estimates within each major habitat type. The creole fish, a serranid, was the most abundant fish on the East Flower Garden Bank, having populations estimated to range from over 400,000 to some 993,948 individuals. Red snapper were much less abundant (4,000 to 20,000) and population levels of

mycteropercid groupers, also commercially fished, ranged between 20,000 and 47,000 individuals. In general, all of the reef fish species having the highest population levels were plankton feeding forms.

Based upon the abundance levels of fishes before and during drilling activities, and analysis of spatial abundance patterns of fish vis-a-vis the platform, the bottom-water discharge of drill muds and cuttings during 1982 did not result in any measurable impacts on the spatial density patterns or overall population levels of reef fish. One of the most significant overall effects of the installation of the Mobil Platform HI-A389-A in proximity to the East Flower Garden Bank was its colonization by a diverse community of epibiota and fishes where none existed before.

COLOR PLATES

Following are a series of eight color plates depicting some of the sampling apparatus which were used in this project, representative reef habitats and biota, and the observed colonization of the drilling platforms which were in place or installed and operated during this study near the Flower Garden Banks. In Plate 1, the primary sampling apparatus, an Underwater Television System, is depicted along with photographs of Flower Gardens Bank habitat. Plate 2 presents photographs of some of the tropical reef fish species occupying reef and platform habitats, followed by Plate 3 which depicts underwater tagging procedures used during the project along with photographs of the common turtle and lobster of the Banks. Identifications of fish appearing in Plate 3 were made by George D. Dennis III.

Plate 4 depicts drilling platforms and discharges, coupled with photographs showing catches made by trawling over soft bottom habitats near the platforms and reefs. Plates 5-8 show the development of a reef community on a deep water platform from an age of approximately 3 weeks to 13 months. Unfortunately, there are no data from a control platform without drilling discharges. The platform reef community developed and diversified rapidly while drilling effluent was being discharged. This observation suggests that the discharges were non-toxic.

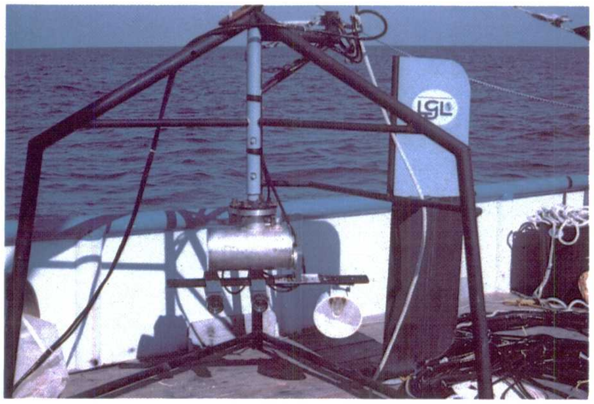
COLOR PLATES

Key to Locations

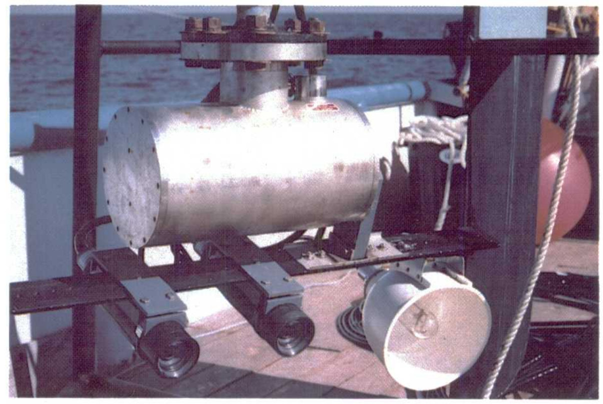
MO-HI-A595-D	Operator: Mobil	27°	52′	19″	N	93°	59′	35″	W
MO-HI-A389-A	Operator: Mobil	27°	54′	1″	N	93°	38′	38″	W

Coral reef locations in Plates 1 and 2 at East or West Flower Garden Bank.

Photographs by Gregory S. Boland

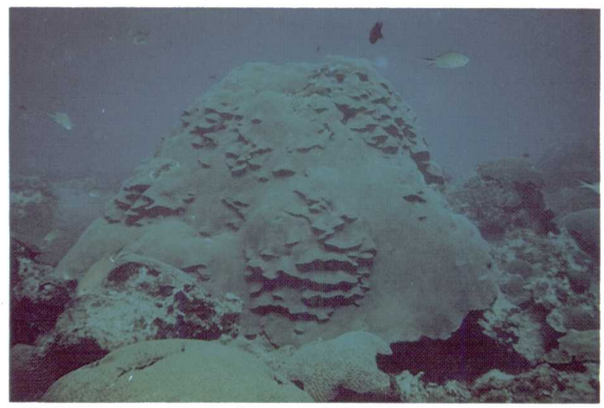


1) LGL video frame; Note stabilization fin and recovery buoy



2) Pan and tilt motor, lamp and optically parallel video cameras

3) Video frame underwater

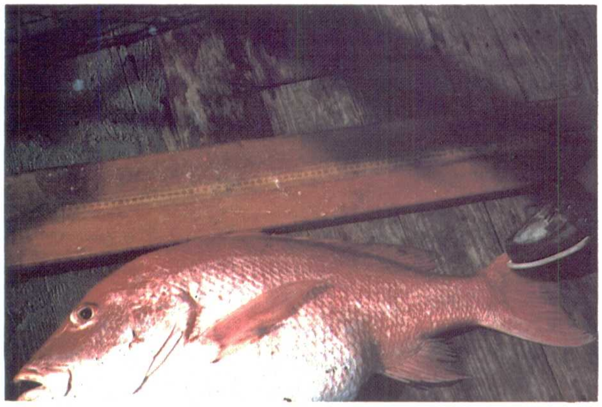


4) Head of common star coral, *Montastrea annularis*, and brown chromis, *Chromis multilineatus*

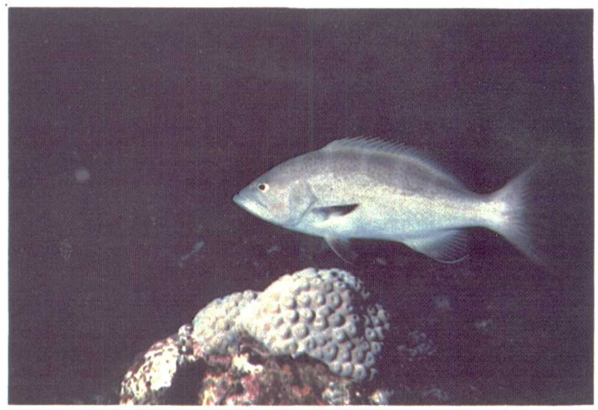
5) Aggregation of feeding creole-fish, *Paranthias furcifer*

6) Individual creole-fish, *Paranthias furcifer*, on coral reef

Plate 1:

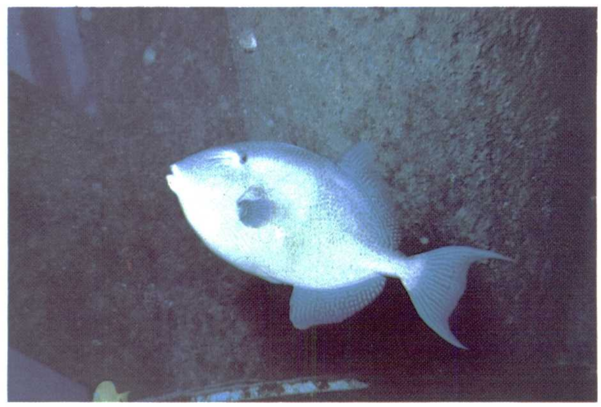


1) Large red snapper, *Lutjanus campechanus*, caught in fish trap



2) Grouper, *Mycteroperca* sp.

3) French angelfish, *Pomacanthus paru*



4) Gray triggerfish, *Balistes capriscus*, at MO-HI-A595-D, 10 m depth

5) Squirrelfish, *Holocentrus rufus*

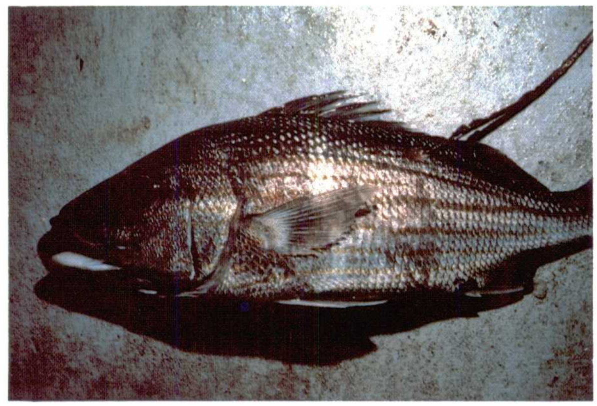
6) Queen angelfish *Holacanthus ciliaris* and hybrid

Plate 2:

1) Administration of fish anesthetic to trapped fish near tagging station

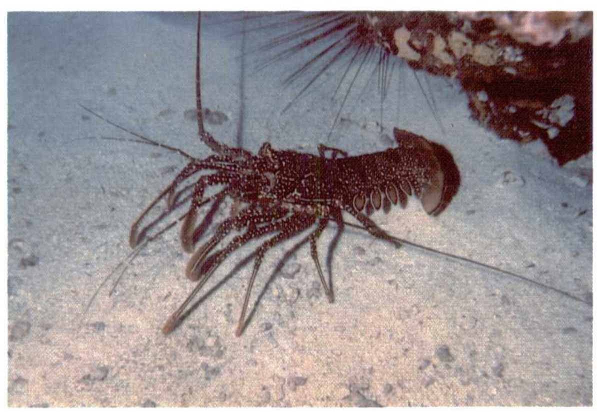
2) Tagging red snapper, *Lutjanus campechanus*, inside mid-water tagging station

3) Tagged gray triggerfish, *Balistes capriscus*, released from mid-water tagging station after recovery



4) Recaptured tagged cottonwick, *Haemulon melanurum*, at large 92 days

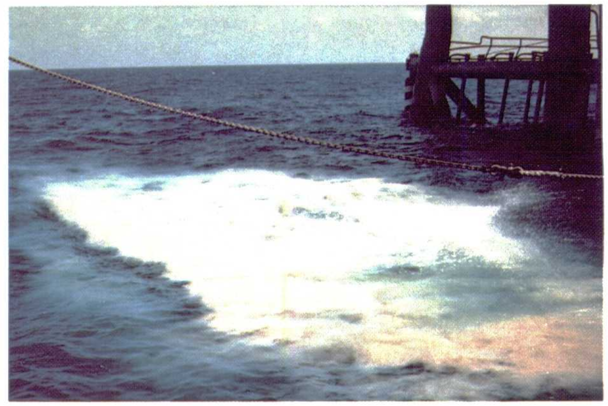
5) Loggerhead turtle, *Caretta caretta*, on West Flower Garden Bank



6) Spotted lobster, *Panulirus guttatus*, common on the coral reef banks

Plate 3:

1) West Flower Garden study platform, MO-HI-A595-D; note surface discharge plumes

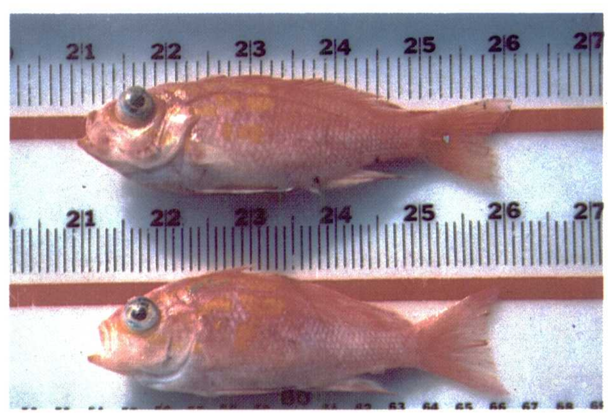


2) Mud discharge contacting surface near platform MO-HI-A595-D

3) Underwater view of surface discharge (from 2 m depth), MO-HI-A595-D

4) Trawl catch near MO-HI-A389-A, 130 m depth, with giant snake eel, *Ophichthus rex*

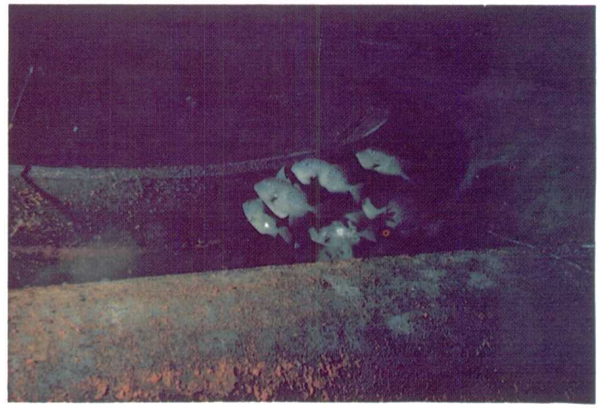
5) Red Barbier, *Hemanthias vivanus*, 110 m depth, collected between East and West Flower Gardens



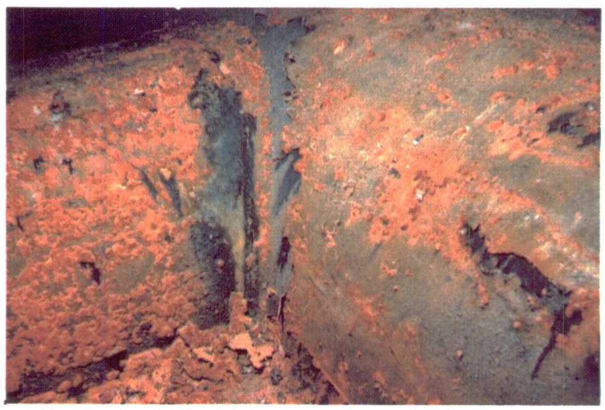
6) Roughtongue bass, *Holanthias martinicensis*, 110 m depth, collected between East and West Flower Gardens

Plate 4:

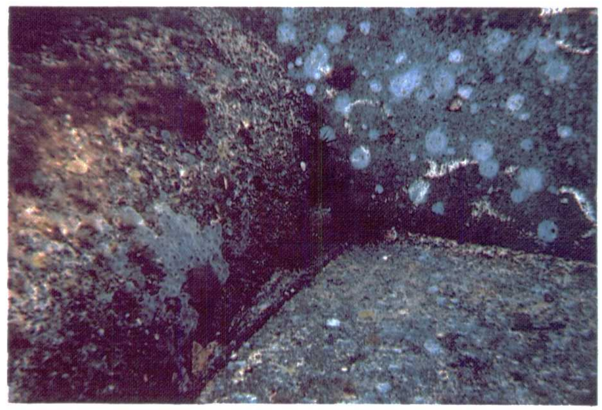
1) Phase II study platform MO-HI-A389-A partially completed; October 1981



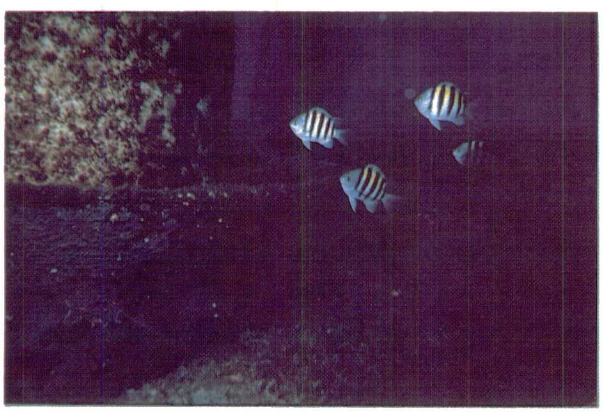
2) Small group of juvenile gray triggerfish, *Balistes capriscus*, recruited to platform; platform age 3 weeks



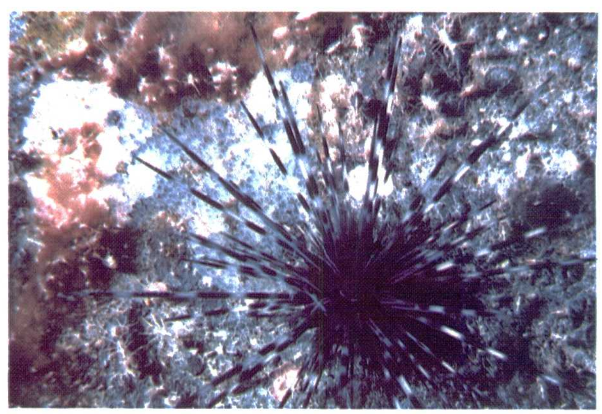
3) Bare horizontal structures at 36 m depth; platform age 3 weeks



4) Horizontal structure, depth 36 m; fouling by hydroids, colonial tunicates, algae, sea urchins; platform age 7 months



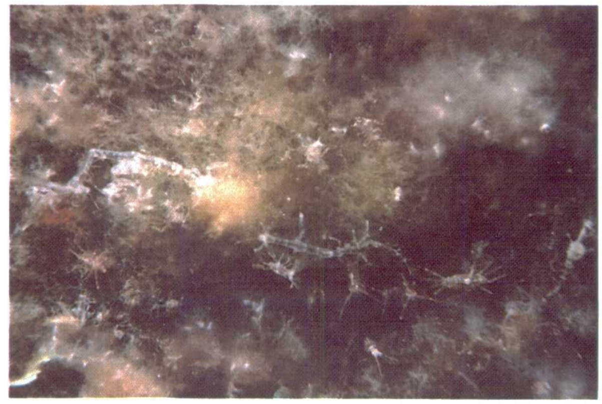
5) Sergeant major, *Abudefduf saxatilis*, 8 m depth; new species for Flower Gardens



6) Sea urchin, *Diadema antillarum*, 8 m depth; platform age 7 months

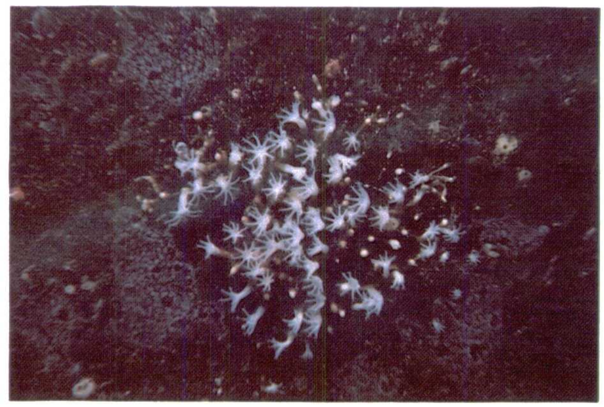
Plate 5:

1) Feeding gooseneck barnacle, *Lepas* sp., and filamentous green algae; 1 m depth; platform age 7 months



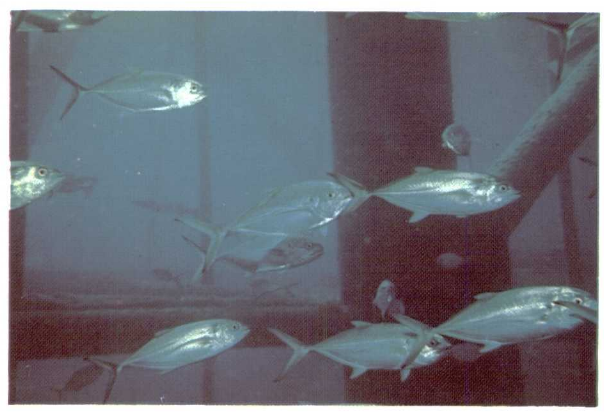
2) Early successional community; dense hydroid/algal mat; numerous amphipod grazers; platform age 7 months

3) General view of 8 m level fouling community; platform age 7 months



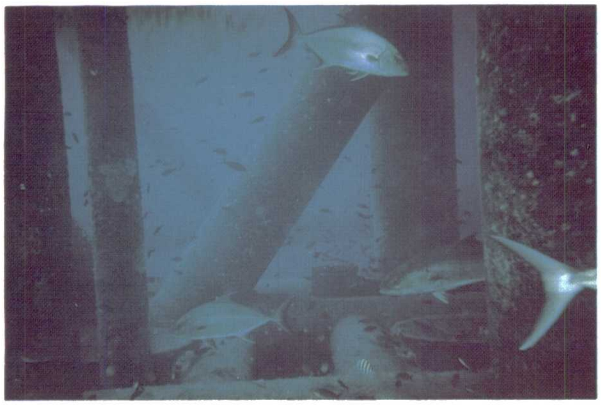
4) Octocoral, *Telesto riisei*; 12 m depth; platform age 7 months

5) Frogfish, *Antennarius* sp.; 30 m depth

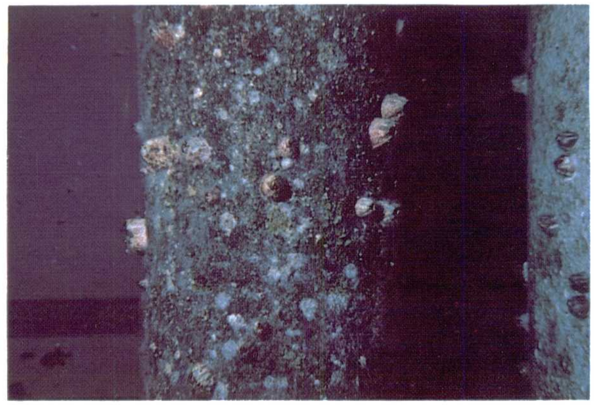


6) School of blue runner, *Caranx crysos*; 10 m depth

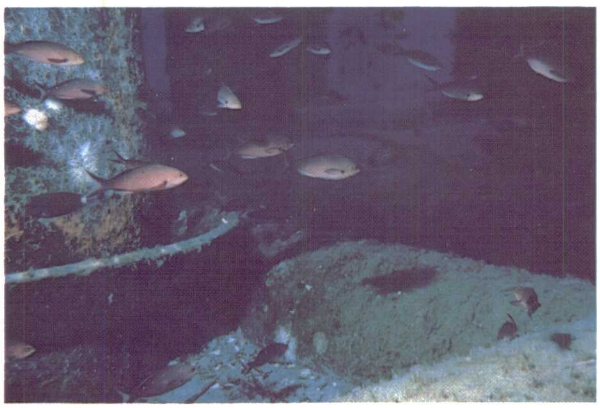
Plate 6:



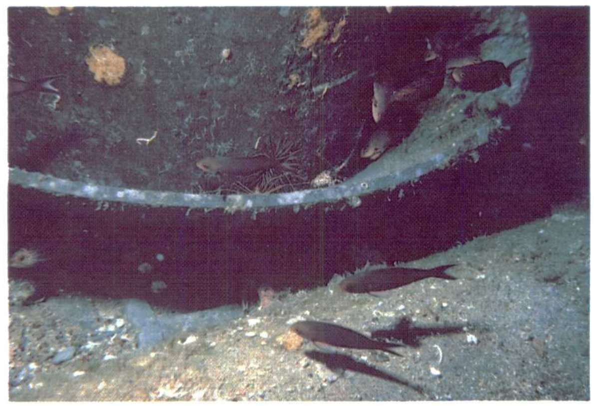
1) Overview of 8 m level; platform age 11 months; (all photos this plate) creole-fish, *Paranthias furcifer*, dominating



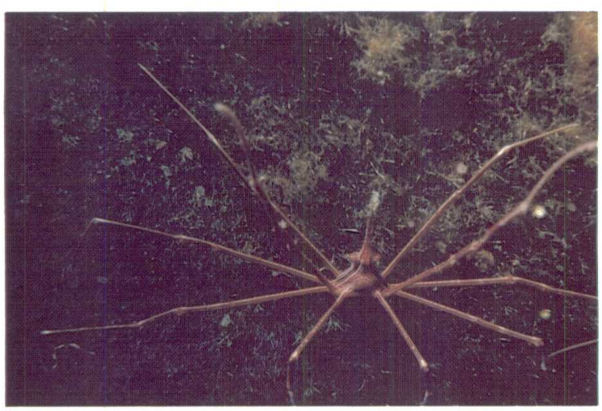
2) Barnacles, *Balanus* spp., colonizing vertical leg near 8 m depth



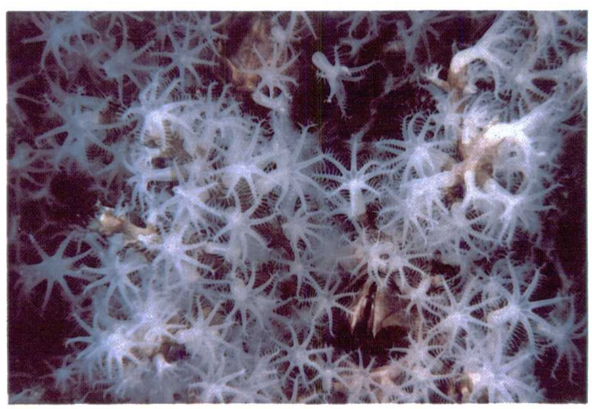
3) Concentrated fish at well-collar; creole-fish, *Paranthias furcifer;* doctorfish, *Acanthurus chirurgus;* and small *Mycteropera* groupers; 8 m depth



4) Diverse well-collar community; creole-fish, *Paranthias furcifer;* arrow crab, *Stenorhynchus seticornis;* spiny lobster, *Panulirus argus;* and sea urchin, *Arbacia punctulata;* 8 m depth

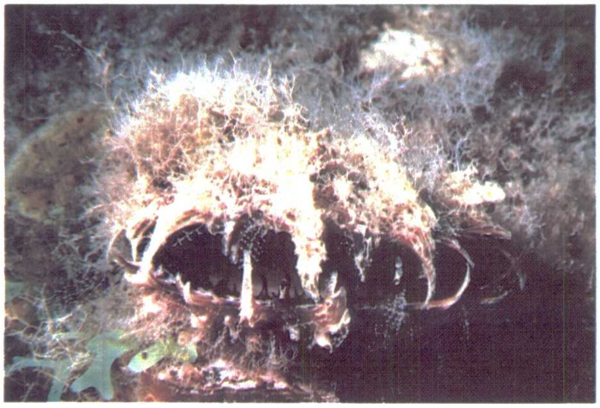


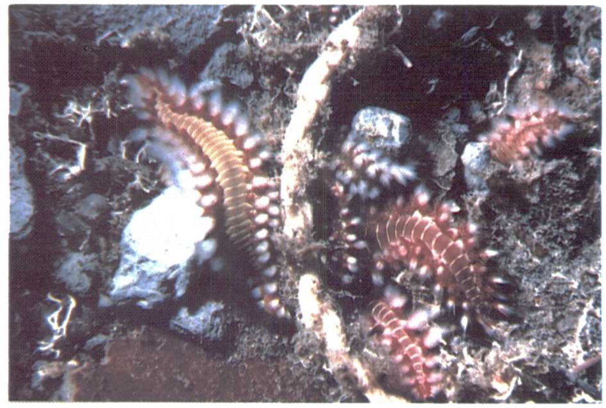
5) Close up of arrow crab, *Stenorhynchus seticornis*; 35 m depth



6) Octocoral colony, *Telesto riisei*, overgrowing barnacles; 12 m depth

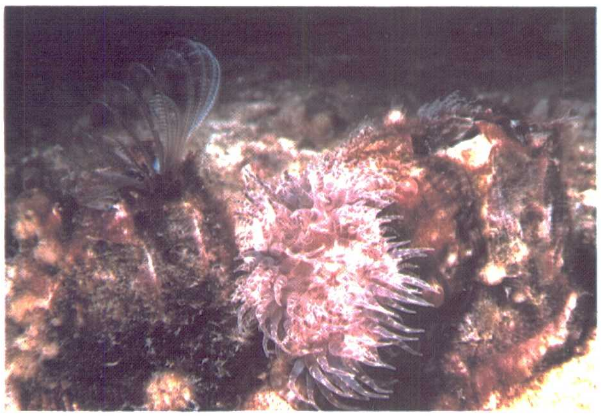
Plate 7:

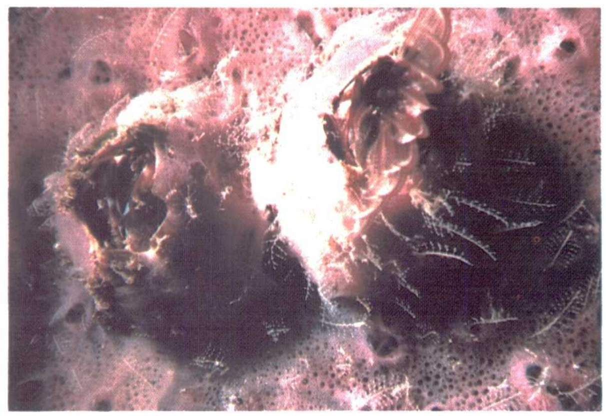




1) Atlantic pearl oyster, *Pinctada imbricata*; 8 m depth; platform age 13 months (all photos this plate)

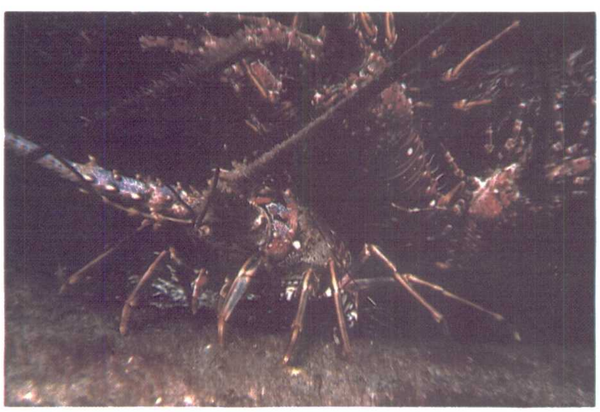
2) Fireworms, *Hermodice carunculata*, 8 m depth

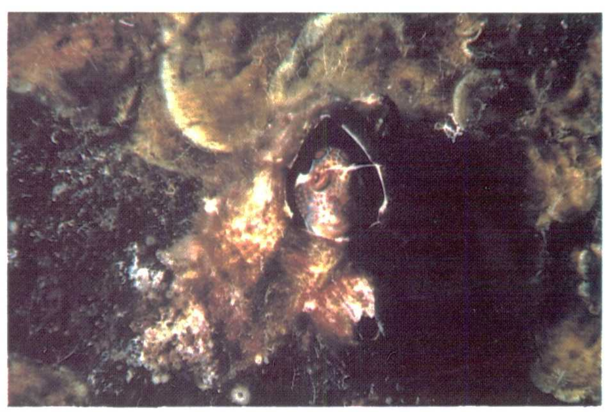




3) Barnacles, *Balanus tintinnabulum*, and anemone, probably *Calliactis tricolor*; 3 m depth

4) Barnacles, *Balanus tintinnabulum*, with encrusting sponge; 5 m depth





5) Cluster of four spiny lobsters, *Panulirus argus*; 36 m depth

6) Barnacle blenny, *Hypsoblennius invemar*; 3 m depth

Plate 8:

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ACKNOWLEDGEMENTS

The success of a study involving 18 cruises, 143 sea-days and three years of effort certainly could not have been attained without the participation of a large number of highly-qualified people. Special thanks are due Larry Martin, the co-principal investigator for Work Unit B1 who also served as diving and field supervisor for the majority of cruises. His coordination efforts and valuable participation in field sampling cruises deserve particular credit. Likewise, the logistical services and assistance during cruises provided by Field Party Chiefs from the National Marine Fisheries Service (particularly Mr. Gregg Gitschlag) were greatly appreciated.

Participants in the field sampling cruises who spent 30 days or more at sea working for long hours of the day and night merit recognition. Deserving particular thanks is Colleen Zastrow who freely volunteered her services for the dissection of literally thousands of fish--a task requiring confinement within the depths of the ship. LGL employees participating in numerous cruises included George D. Dennis III, Frederick S. Lane, Lawrence A. Reitsema, Robbie Shumaker, Pamela Snodgrass, Randall Howard and Eddy Kornegay and Richard Christian. The efforts of these people were directed towards sampling for virtually all work units, and the work was laborious.

Subcontractor Jim Brooks and his staff from Texas A&M University, Department of Oceanographhy provided personnel and equipment for the collection of the hydrographic data obtained during this study. Dr. T.J. Bright, also of Texas A&M's Department of Oceanography, provided expert advice and assistance in the identification of reef-fish.

The excellent vessel Jeff and Tina and her outstanding captains Pete Smirch and Angelo Smircic have once again proven invaluable to our Gulf of Mexico research efforts. The helpfulness and patience of the Smirch brothers and their crews were inspirational. The working conditions were exceptionally good and the vessel was more than adequate for every facet of the offshore work. The vessel was provided under contract with NMFS.

Special recognition goes to Scott Anderson who, with William Gazey, worked extensively on the development of the statistical methodologies developed for use in this study prior to his untimely death in 1982. We all hope he would approve of the end result of those efforts. Data management was provided by Alice Doerge early in the project and later by Lynn Maritzen. Their diligence in managing nearly 39,000 data records was exemplary and Lynn's patience with us as we continuously asked for "just one more summary, it shouldn't take too much effort" right up until the report was submitted would have done Job credit.

We give special thanks to Jean Erwin and her assistant, Martha J. Gazey, for the typing, editing and physical preparation of this report. The graphic and illustrative skills of Betsy Sturm and Bonnie Bower-Dennis are gratefully acknowledged.

SECTION 1

INTRODUCTION

Demands for increased energy development and reduced dependence on unreliable foreign sources of petroleum have spawned the necessity for this study. The Gulf of Mexico contains extensive oil and gas deposits. The development of the Gulf of Mexico petroleum resources has just taken place in the last 50 years. Offshore oil and gas leasing began in the Gulf of Mexico in the late 1930's off the state of Louisiana. With the passage of the OCS Lands Act in 1953, activities spread to Federal waters. Since that time about 3500 Outer Continental Shelf (OCS) leases have been awarded comprising approximately nine million acres in the Gulf of Mexico (Defenbaugh 1982). Currently there are 2903 structures within the Gulf [Minerals Management Service (MMS), New Orleans, LA, pers. comm. April 1983]. Total production from the Gulf's OCS from 1954 through 1982 was about 4.8 billion barrels of oil and 49 trillion cubic feet of gas (Defenbaugh 1982, MMS). A continued increase in offshore drilling is expected through 1983.

Offshore petroleum platforms act as artificial reefs, attracting rich biological assemblages. However, the biological communities associated with these artificial reefs, as well as passing planktonic or other non-resident populations, are potentially exposed to pollutants emanating from these structures, including drilling fluids and cuttings, petroleum hydrocarbons, trace metals and effluents from sewage treatment facilities. Other activities associated with the transport of materials and personnel to and from offshore platforms also have possible biological impacts including pumping of bilges, discharge of sewage wastes and disposal of garbage or similar wastes.

Frequently oil and gas reserves are found near natural reefs. Reef fishes associated with both the artificial reefs created by offshore platforms and nearby natural reefs, support a significant commercial fishery. These fishes can be directly exposed to contaminants, and the possibility also exists for exposure of humans by consumption of contaminated fish. Additionally, these areas are valuable for recreational fishing and other activities such as SCUBA diving.

It is generally accepted that the Flower Garden Banks represent the richest natural reef system in the northwestern Gulf of Mexico (see literature listed in Appendix 1-1, a bibliography of literature on the Flower Garden Banks). Further, the banks are indeed located in an area which appears to have a high potential for harboring appreciable hydrocarbon reserves, particularly gas. Because of its uniqueness, the Flower Garden Banks and a large surrounding area (Fig. 1-1) were proposed as a Marine Sanctuary in 1980 (Federal Register Vol. 45, No. 125, June 16, 1980). Some of the ramifications of this proposed designation were that (1) zones of maximum sensitivity were defined in which no activities would be allowable (Figs. 1-2 and 1-3) and (2) that the existing offshore regulatory requirements regarding environmental protection would be supplemented, becoming much more restrictive within the boundaries of the proposed sanctuary. Subsequently, in 1983 (Federal Register Vol. 48, No. 41, March 1, 1983) the proposed sanctuary boundaries were modified to conform to the no-activity zones shown in Figures. 1-2 and 1-3.

Considerable controversy remains concerning the best use of the Flower Garden resource. On one side of the issue, environmental advocates claim that the proposed rules for protecting the ecological system in question are inadequate to protect the resources and that if oil and gas development is allowed to proceed, the reefs will inevitably be destroyed. In contrast, advocates of energy development believe that the proposed regulations are overly restrictive and that oil and gas operations can safely proceed near the banks subject only to the Department of Interior restrictions. As evidence for their position, they cite the lack of effects based upon the case history of the development which has already occurred near the banks dating from the mid-1970's. Following a description of the Flower Garden Banks, we provide a precis of the development activities which have occurred near the banks.

BACKGROUND ON FLOWER GARDEN BANKS

Within the Gulf of Mexico, the Flower Garden Banks are part of a discontinuous arc of reef structures along the edge of the continental shelf (Fig. 1-4). Parts of this arc represent ancient shoreline (Bright and Rezak 1978), while other banks (including the Flower Gardens) are

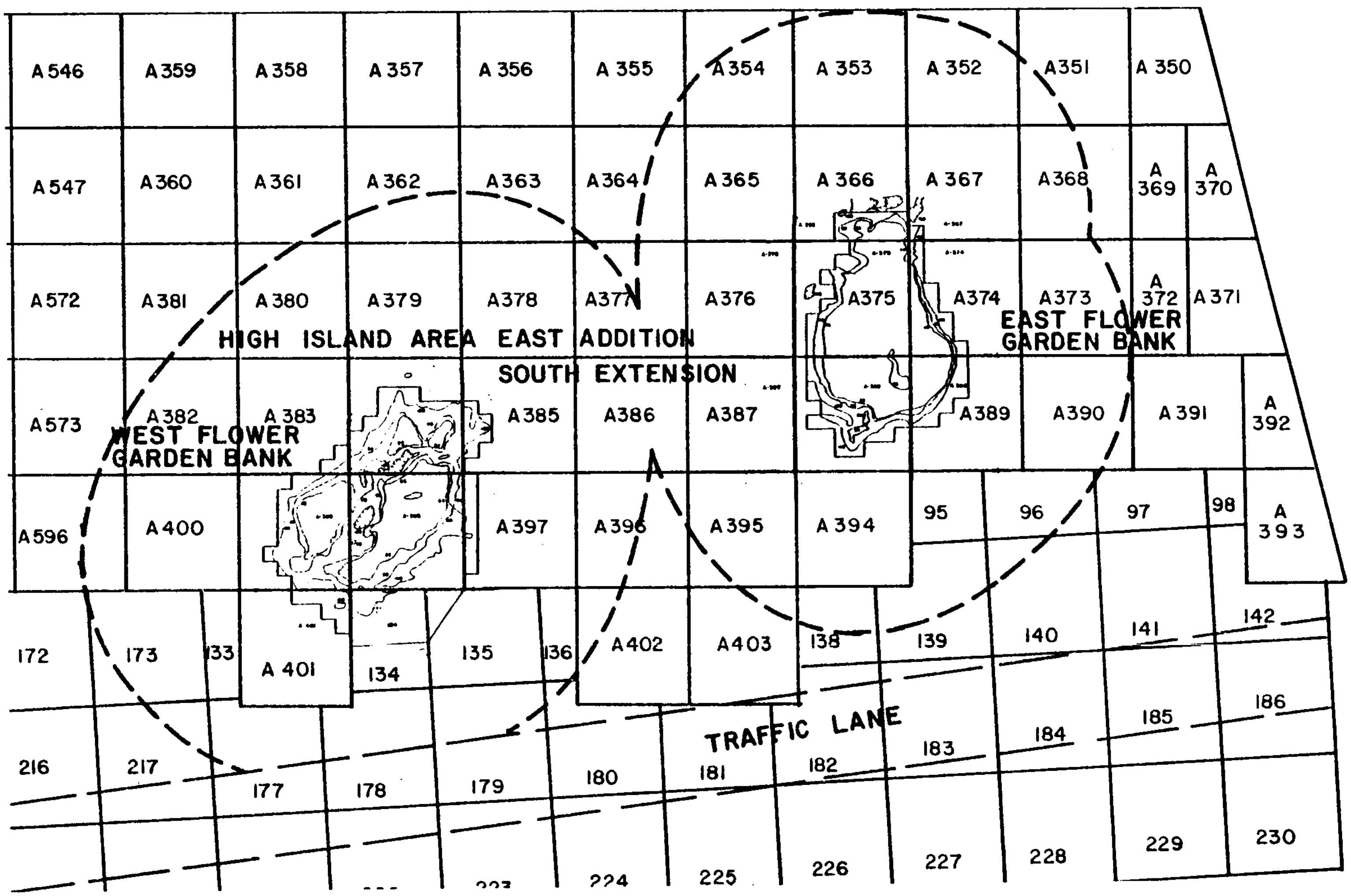


Fig. 1-1. Proposed Flower Garden Banks Marine Sanctuary. Federal Register Vol. 45, June 26, 1980.

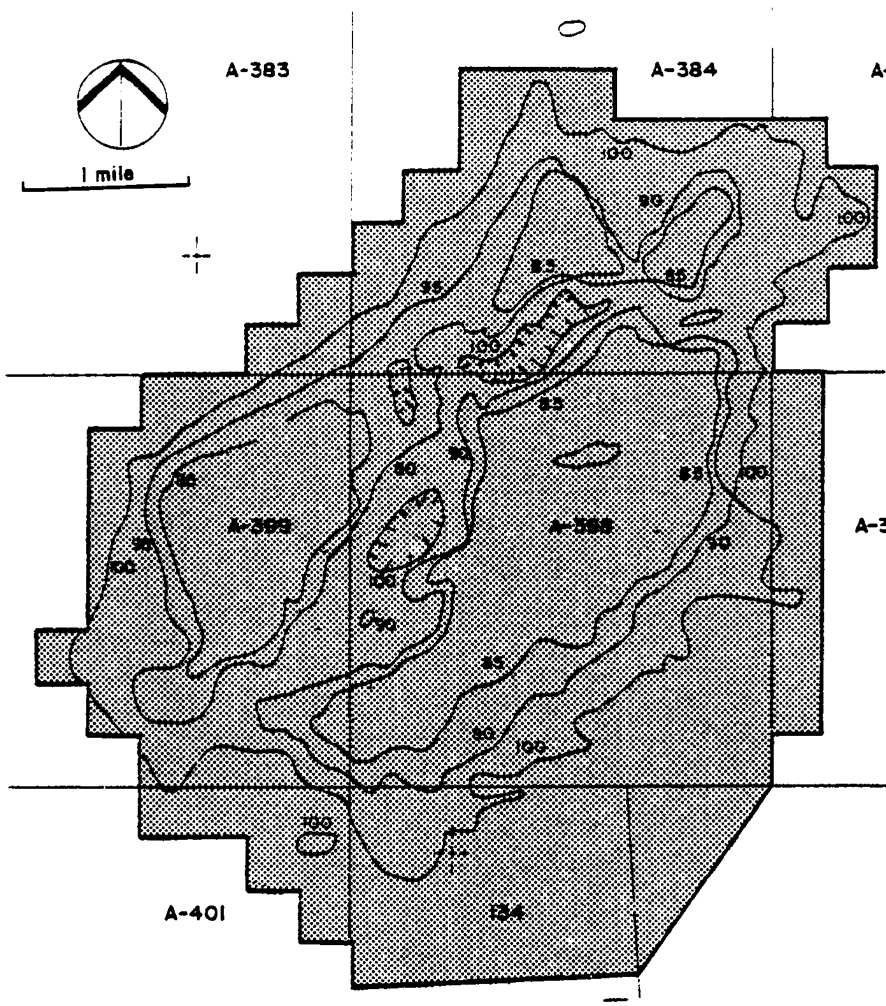


Fig. 1-2. Proposed no-activity zone at West Flower Garden Bank. Federal Register Vol. 45, June 26, 1980.

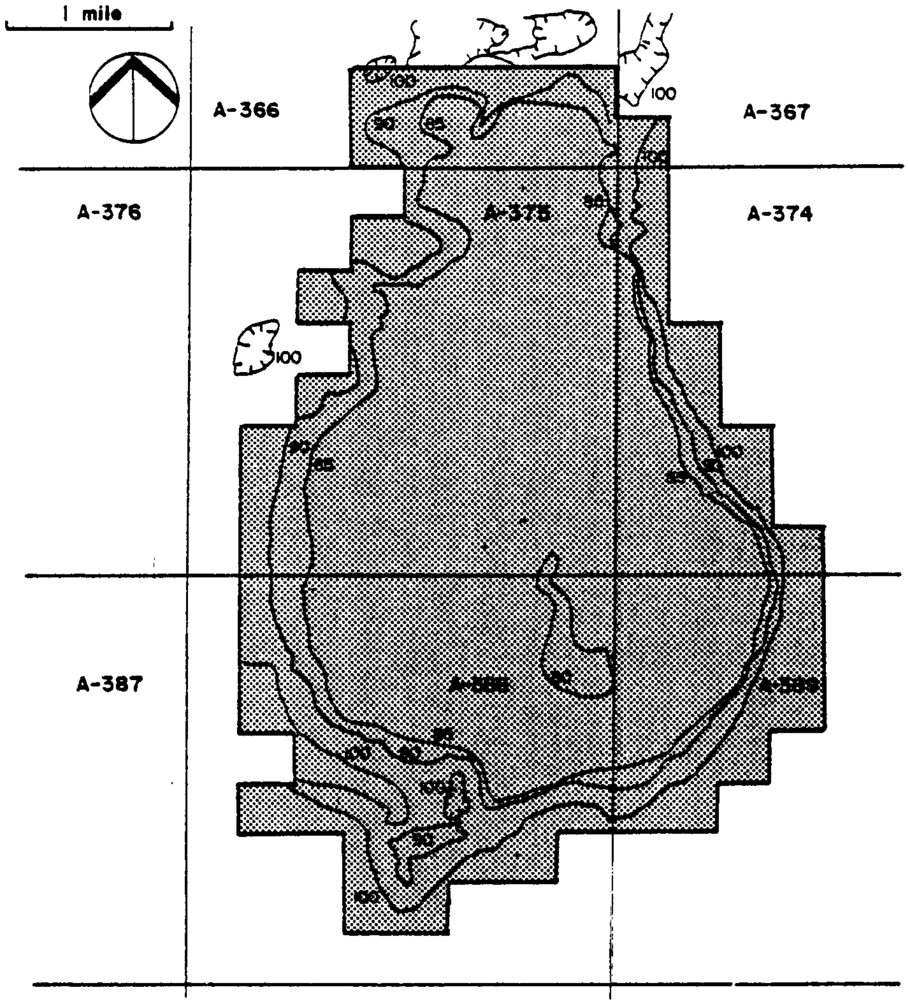


Fig. 1-3. Proposed no-activity zone at East Flower Garden Bank. Federal Register Vol. 45, June 26, 1980.

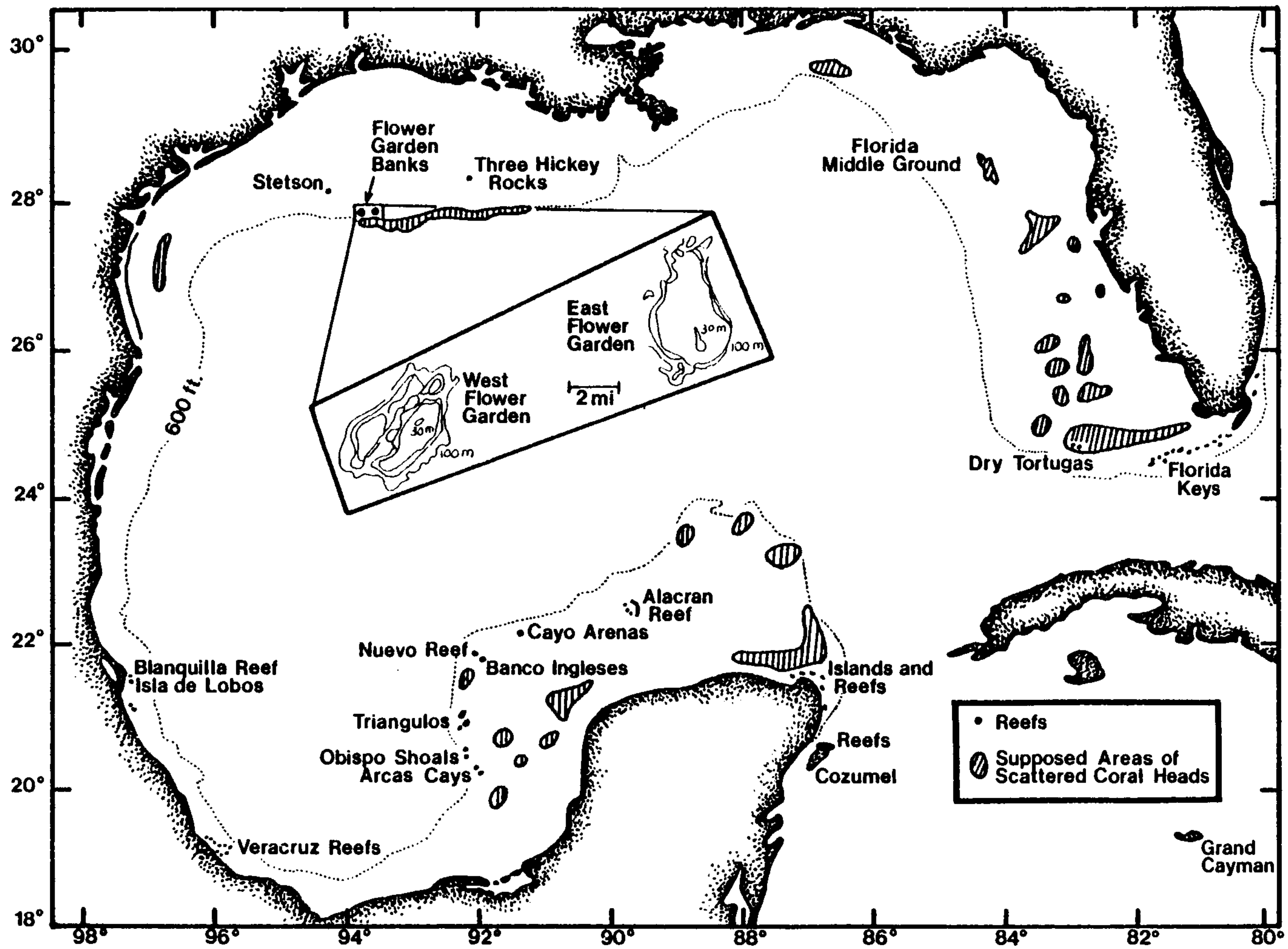


Fig. 1-4. Location of Flower Garden Banks and other areas of known coral reefs and zones of limited coral growth. Gulf map after Bright and Pequegnat 1974.

surface expressions of salt domes. These structures arose due to an accumulation of over 3000 m of rock salt in the ancestral Gulf of Mexico during the Jurassic period, about 150 million years ago. Towards the end of that period, salt deposition ended and the accumulation of normal marine sediments began. Nettleton (1934) first described the fluid-like nature of these salt deposits and stated that they followed the principals of fluid mechanics. The density differences between the overlying marine sediments and the salt layer resulted in an upthrusting of diapirs or plugs, deforming the surrounding and overlying sediments. In the case of the Flower Garden Banks, the resulting total relief was about 130 m above surrounding bottom. The shallow depths created by these events along with the offshore water quality characteristics of the area allowed the development of healthy, hermatypic coral reefs.

These salt bed tectonic movements and related growth faults resulted in the formation of structural traps permitting pre-existing migrating petroleum and natural gas to accumulate and be preserved (Tissot and Welte 1978). These traps may be formed along the folded or faulted flanks of salt plugs as well as on top of plugs where arching or faulting was produced in the overlying sediments. Such oil and gas accumulations are what is sought by the oil companies. The relationship between the reefs and their underlying salt domes is only structural.

The Banks are the northernmost thriving, tropical, shallow-water, hermatypic coral reefs on the eastern and Gulf coast of North America. Coral reefs off Bermuda are located about 480 km north of the Flower Gardens' latitude but are situated 918 km offshore North Carolina and not considered part of the Continental United States. These coral reefs are supported by the warm Gulf stream current which passes around the island (Bright and Pequegnat 1974). Areas of the Florida Middle Grounds extend as much as 72 km to the north of the Flower Garden Banks but are largely dominated by soft corals and the hydrozoan firecoral. These reefs also undergo periodic depauperation of most hermatypic corals present due to cold water temperatures (Rezak and Bright 1981).

Specifically, the East and West Flower Garden Banks are located approximately 103 nautical miles southeast of Galveston, Texas (Fig. 1-4). The West Bank is the larger of the two, its oval base covering an area of about 137 km^2. The crest, at a depth of about 20 m, is located at approximately 27°52.52'N latitude and 93°48.97'W longitude. It occupies Federal Lease Blocks A-383, A-397 and A-401 of the High Island East Addition Area, South Extension and Lease Block 134 of the Flower Garden Banks Area (Fig. 1-1). The East Flower Garden Bank is a smaller, pear-shaped bank covering a basal area of about 67 km^2. The shallowest depth encountered at the East Bank in this study was 17 m. The mid-point of the largest shallow coral area on the East Bank is at approximately 27°54.50'N latitude and 93°35.95'W longitude. This reef occupies portions of Lease Blocks A-366, A-367, A-374, A-388 and A-389 of the High Island East Addition Area, South Extension (Fig. 1-1). Surrounding the banks, water depths range from 100-150 m (Rezak and Bright 1981).

Based upon substrate type, the Flower Garden Banks can be divided into five major habitat categories (Figs. 1-5 and 1-6) following McGrail et al. (1982): (1) upper coral reef (crest of reef to about 40-m depths); (2) lower live bottom (an algal-sponge zone generally between 40- and 90-m depths); (3) shallow drowned reef structures above the 90-m depth contour; (4) deep drowned reef structure below the 90-m depth contour; and (5) soft bottom (below 90-m depths). Of these, it is the upper coral reef community which is of the most public concern, occupying about 0.5 km^2 on the West Bank and about 3 km^2 on the East Bank.

The upper coral reef area on the Flower Garden Banks seem to be thriving and in relatively pristine condition. Water temperatures occasionally reach levels near the lower range of coral tolerance, but the coral community appears to be very healthy. Approximately 60% of the hard substrate is covered with live coral as determined from extensive transect photography performed by LGL on both banks for Texas A&M University (Rezak and Bright 1981). The mountainous or common star coral, Montastrea annularis, comprises approximately half of the living coral population. The average accretionary growth rate over the past 15-20 years for M. annularis from the Flower Garden Banks was estimated to be 7.2 mm/yr by Hudson (1981). Texas A&M University (McGrail et al. 1982) found a similar average growth rate of 7.4 mm/yr for M. annularis at the Flower Gardens Banks. These growth rates are similar to, and in some cases higher than, growth rates determined by Hudson (1981) for the same species in the Florida Keys. Hudson determined growth rates at several stations off Key

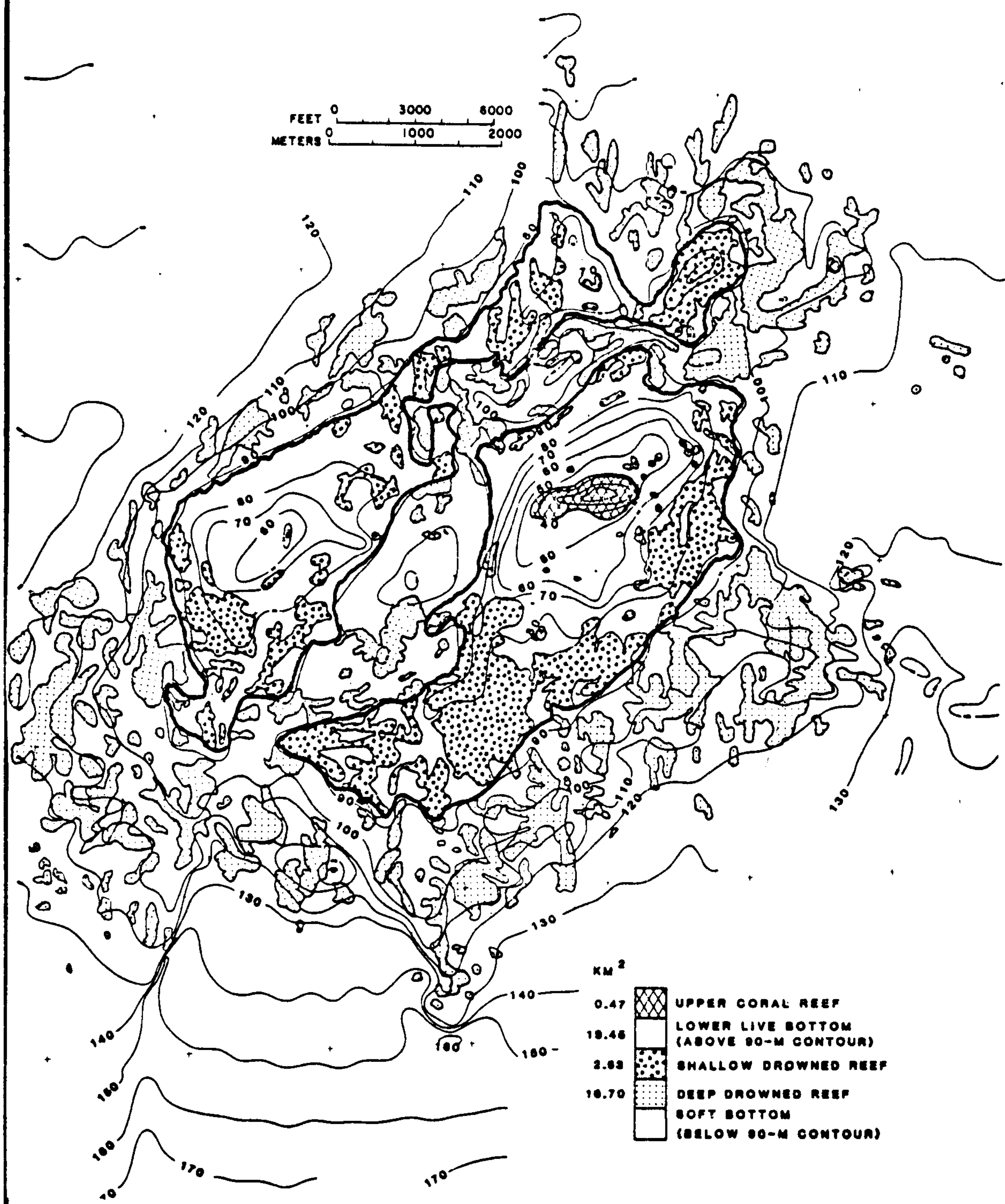


Fig. 1-5. West Flower Garden Bank bathymetry and major habitat zones. (modified from McGrail et al. 1982)

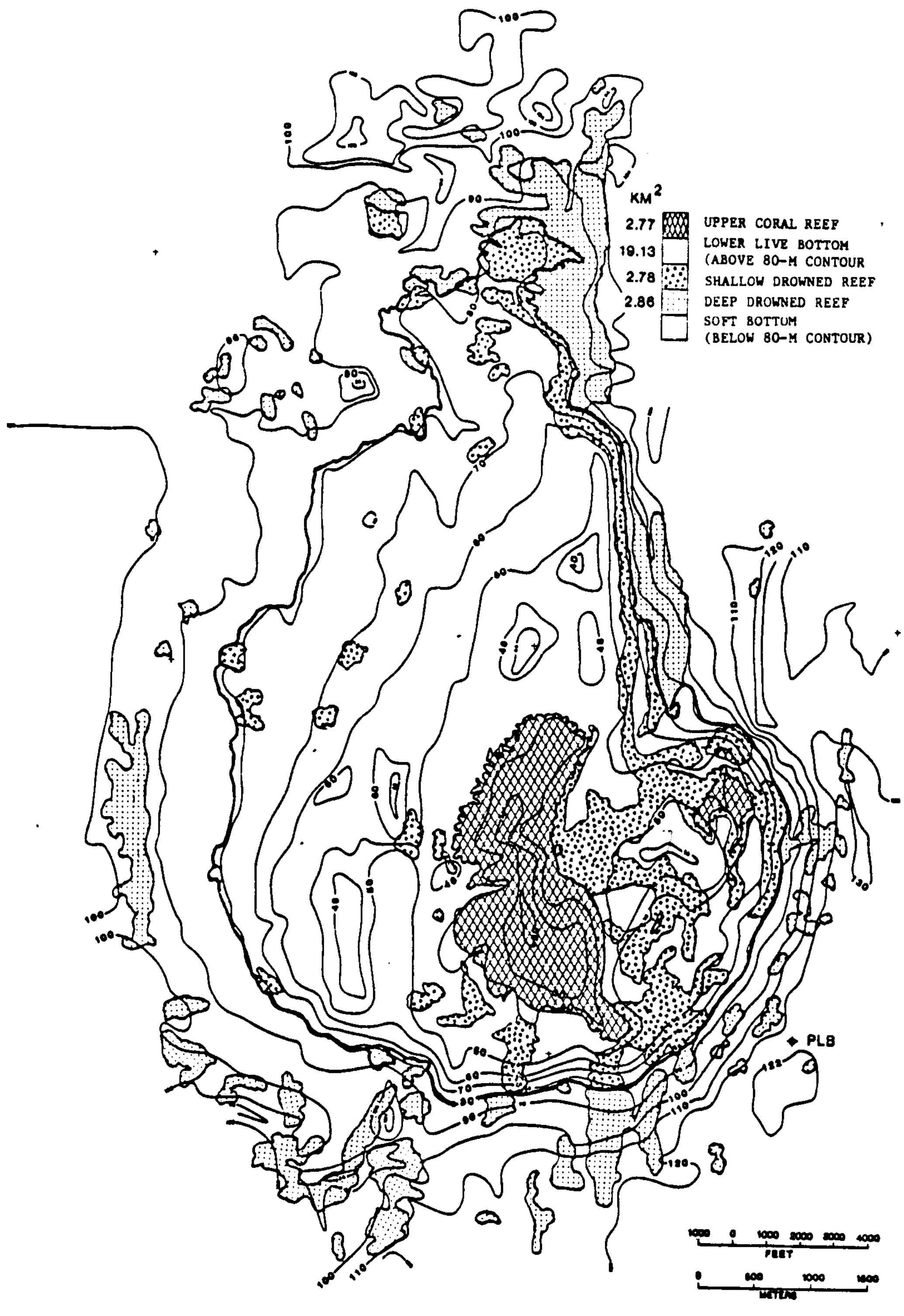


Fig. 1-6. East Flower Garden Bank bathymetry and major habitat zones. (modified from McGrail et al. 1982)

Largo but only two were in the offshore fore-reef area, more analogous to the Flower Garden environment. Growth estimates from these two stations averaged only 6.3 mm/yr over the last 50 years.

Some groups of species typically found in Caribbean coral reef benthic communities are conspicuously lacking from the Flower Garden biota. Elkhorn (*Acropora palmata*) and staghorn (*A. crevicornis*) corals and all species of shallow water octocorals are absent. Elkhorn coral does not generally occur below 10 m (Logan 1969) which would account for its absence on the Flower Garden Banks where the shallowest depth is about 17 m. The reasons for the lack of the staghorn coral and the octocorals are not clear. It is possible that larvae do not survive long enough to be transported to these banks from other areas in the Gulf of Mexico or Caribbean. These species occur abundantly in the Gulf and Caribbean at depths equivalent to those common at the Flower Gardens.

Structurally, the upper coral reef is comprised of closely-spaced coral heads often several meters in diameter; many are probably hundreds of years old. Substantial erosion is characteristic of the reefs, which are frequently very cavernous. Some coral heads have developed a "toadstool" appearance caused by various organisms (including parrotfish and sea urchins) feeding on substratum communities at the base of the corals. Eventually a base can be so reduced in size that severe storms or ships anchoring can cause the weakened structures to topple. These curious coral structures have often been misrepresented as evidence of the effects of chemical dumping or drilling discharges in the region (Barada 1980).

Below the upper coral reef zones, a low-relief, hard-bank community dominated by encrusting sponges and coralline algae occurs and extends to about 88 m. Algal nodules formed primarily from coralline algae and ranging in size from less than 1 cm to over 10 cm in diameter create a biotope comparable in diversity to the upper coral reef. Within the algal-sponge zone, the nature of the bottom begins to change between 73 and 76 m, grading from the algal nodules to a soft, level bottom of coarse sand-, silt- and clay-sized particles. With increasing depth, coarser sediments are replaced by fine muds.

Numerous deeper, partially drowned (some living coral may occur) and drowned reefs (no living coral) occur on both banks. These outcrops are presumably relics of previous distributions of thriving coral zones dating to periods of lower sea levels (Rezak et al. 1983). These relict outcrops now exist at depths below which reef-building corals are capable of growing substantial heads. Partially drowned reefs are generally restricted to the algal-sponge zone, where they contribute significant relief and hard substrate. Totally drowned reefs are typically present below 82 m, where coralline algae do not thrive and reef-building corals are absent. Both zones of drowned reefs have characteristic and different assemblages of fishes and invertebrates.

HISTORY OF HYDROCARBON DEVELOPMENT

The first exploratory drilling in close proximity to the Flower Garden Banks occurred adjacent to the East Flower Garden Bank (Lease Block High Island A389) and was performed by Mobil Oil Corporation who drilled two wells in the spring of 1975. Monitoring surveys for these wells were performed by Continental Shelf Associates, Inc. (CSA) which has been retained by Mobil to monitor the present drilling activities as well. CSA (1975) detected no significant effects on the bank attributable to the initial exploratory drilling. In 1974, Dr. T.J. Bright of Texas A&M University independently surveyed the southeastern quadrant of the East Flower Garden Bank in the area where the first exploratory Mobil wells were to be drilled. The Texas A&M Research Submersible *Diaphus* was utilized by Bright who conducted visual surveys to a depth of 85 m. Following the exploratory drilling, the baseline survey was repeated by Bright in 1975 for the Bureau of Land Management (BLM). No adverse effects (e.g. recent coral mortality or undue sedimentation) which could be attributed to drilling operations were detected based upon the pre- and post-drilling surveys (Bright and Rezak 1976).

Exploratory drilling (Wells Nos. 3 and 4) was continued by Mobil in the fall of 1977, again in the southeast corner of the Bank, but in 129 m of water, approximately 650 m from the site of Well Nos. 1 and 2. A total of approximately 129,000 l of drilling fluid and 1,035,000 kg of drill cuttings were discharged during the drilling phase in October and November 1977 (CSA 1978). Results from the CSA surveys conducted during and after the 1977 exploratory drilling demonstrated that although some portion of the drilling fluids and cuttings was distributed to a distance exceeding 1000 m from the drill site, residues were not detected at monitoring stations on the coral reef at a distance of 2000 m. Again, coral were not believed to have been impacted by the exploratory drilling operations.

Results of the exploratory drilling activities indicated that commercial quantities of gas reserves were present, and plans were made to produce the resource. In the permitting process, industry agreed to conduct extensive physical oceanographic and biological monitoring studies prior to start-up, during drilling and afterwards. None of these studies, however, addressed effects of production drilling on reef fish populations--all of the stipulated biological studies were directed towards determining impacts on corals and/or the potential for bioaccumulation.

Initial start-up of production was delayed until late September of 1981 when the first permanent production platform was placed down in 122 m of water at 27°54'1.445"N and 93°38'38.184"W (PLB on Fig. 1-6), approximately mid-way between the two exploratory drill sites (Mobil Oil Civil Engineering Dept., pers. comm.). The platform (MO-HI-A389-A) is situated approximately 1500 m southeast of the nearest upper coral reef habitat and 750 m from the nearest live bottom and partially drowned reef habitat areas occurring above the 84 m isobath. This platform represents the first production platform in the United States to operate in close proximity to a thriving coral reef.

Drilling of the first production well did not begin until 26 April 1982. Drilling fluid and cuttings discharges were shunted to within 10 m of the bottom prior to release, as stipulated by the EPA discharge permit application in compliance with the provisions of the Federal Water Pollution Control Act, in order to reduce the potential for impact on the coral reef and other sensitive hard bottom habitats. Drilling continued over the rest of 1982 and into 1983, but drilling waste discharges essentially ceased around the first week of April 1983, when operations required the use of oil-based drilling muds. Present regulations for the area require drilling to be operated as a closed system when oil-based muds are used. Upon the advent of the use of oil-based muds, all muds, cuttings and discharge water were barged away from the banks for disposal elsewhere (Rusty Putt, CSA, Tequesta, FL, pers. comm. April 1983).

PROJECT OBJECTIVES AND DEVELOPMENT

The overall project was conducted during the period summer 1980 through fall 1982 under the auspices of the National Marine Fisheries Service (NMFS), Southeast Fisheries Center (SEFC), Galveston Laboratory, and was funded by the Environmental Protection Agency (EPA) through an interagency agreement with the National Oceanic and Atmospheric Administration (NOAA). In brief, the goals of the program were (1) to assess the impacts of drilling operations, plumes, and cuttings on biological characteristics, vital statistics and dynamics of populations of red snapper, *Lutjanus campechanus*, and other reef fishes associated with one drilling platform and the natural reef areas of the Flower Garden Banks, and (2) to assess impacts on benthic macro-infauna, reef fish histopathology and microbial communities. The project was designed to assess potential and actual hazards of offshore drilling to fish and soft bottom resources and their habitats in the Flower Garden Banks; subject areas not addressed by other studies. Specifically the overall objectives were:

1. To describe the biological characteristics, vital statistics and dynamics of populations of red snapper and other reef fishes associated with natural reefs and one drilling platform in the vicinity of the Flower Garden Banks, as related to drilling operations, plumes and cuttings;

2. To describe and characterize ichthyoplankton populations associated with natural reefs and one drilling platform in the vicinity of the Flower Garden Banks, as related to drilling operations, plumes and cuttings;

3. To describe and characterize the benthic macro-infauna communities associated with natural reefs and one drilling platform in the vicinity of the Flower Garden Banks, as related to drilling operations, plumes and cuttings;

4. To determine histopathology of red snapper and other reef fish populations associated with natural reefs and one drilling platform in the vicinity of the Flower Garden Banks, as related to drilling operations, plumes and cuttings; and

5. To describe and characterize microbial communities associated with natural reefs and one drilling platform in the vicinity of the Flower Garden Banks, as related to drilling operations, plumes and cuttings.

The project was oriented toward site-specific temporal-spatial assessment of reef fish and benthic macro-infauna populations associated with one drilling platform and natural reefs in the vicinity of the Flower Garden Banks. It was carried out by a combination of NOAA [NMFS and Environmental Data and Information Service, (EDIS)] and contract investigations. The project was originally organized into 13 work units, of which six were conducted by NOAA (Work Unit A6, project management; Work Unit A1, project data management; Work Unit A2, reef fish studies based upon observations gained by submersibles, (ultimately never funded); Work Unit A3, ichthyoplankton; Work Unit A4, development of reef fish bioprofiles; and Work Unit A5, reef fish system analysis and modeling); two were represented by contract vessel services and five (Work Unit B1, Catch-effort, Mark-recapture and Sampling; Work Unit B2, Benthic Macroinfauna; Work Unit B3, Histopathology; Work Unit B4, Microbiology; and Work Unit B5, Remote Sensing) were conducted by subcontractors to NMFS.

It will be noted that no less than three work units were originally designed to deal with assessing reef fish populations; one using submersibles (ultimately never funded); one based on mark-recapture and catch-effort studies (Work Unit B1); and one based on remote sensing (Work Unit B5). This duplication was intended as it was uncertain as to which, if any, of the methods might be successful--similar studies had not been conducted. LGL Ecological Research Associates, Inc. (LGL) was awarded two of these, Work Units B1 and B5. The specific objectives of these two work units on a combined basis were to:

1. Define, describe and characterize the movements, migration, recruitment and standing stocks of red snapper and other lower and upper reef fish species associated with natural reefs and one drilling platform in the vicinity of the Flower Garden Banks by methods including mark-recapture and the use of remotely-operated visual census equipment and instrumentation;

2. Conduct sampling, collecting and preliminary preparation of samples and sub-samples for analyses by Work Units A3 (Ichthyoplankton), A4 (Reef Fish Bioprofiles), B2 (Benthos), B3 (Reef Fish Histopathology), and B4 (Microbiology--Phase I only).

3. Make hydrographic measurements to determine temperature, salinity, dissolved oxygen and light transmissivity to locate and characterize thermoclines, pycnoclines, water masses, nepheloid layers and drilling effluent plumes and determine their effects on reef fish movements, migration, recruitment and standing stocks; and

4. Supplement the information obtained from Work Unit A4 in assessing movement, migration, recruitment and standing stocks of red snapper and other lower and upper reef fish species on the East and West Flower Garden Banks and one nearby drilling platform.

The delay in start-up of drilling near the banks resulted in the project being divided into two phases. During the first year of the project (Phase I covering fall and winter 1980-81, Cruises 1 and 2; spring 1981, Cruise 3; and summer 1981, Cruise 4), the closest active drilling platform to the Flower Garden Banks was Mobil's HI-A595-D (designated platform A=PLA) which was located approximately 9 nautical miles to the west of the West Flower Garden Bank. Research effort during this period was directed towards comparisons of the two banks and this remote drilling platform in terms of habitats represented, reef fish populations present and their health, and movements of fish among the habitats. Research effort was divided among the platform (PLA), the West Flower Garden Bank (WFG), the East Flower Garden Bank (EFG) and two soft bottom habitats, one located between the platform and West Bank (CNA--control A) and the other between the two reefs (BRC--between reef control). As a result, sample sizes representing a specific habitat were small although the total coverage was large.

With the placement of MO-HI-A389-A (designated platform B=PLB) in September 1981 we were able to focus the study to the vicinity of the East Flower Garden Bank which enabled us to obtain larger sample sizes, thus reducing variation attributable to sampling and enhancing the ability to discern effects. During Phase II, data collected during Cruise 5 (fall 1981) represented a pre-drilling survey which could be compared to conditions observed during the drilling period spanning spring (Cruise 6), summer (Cruise 7) and fall (Cruise 8) of 1982. A summary of all cruises by date and leg is provided in Table 1-1.

Table 1-1. Cruise summary.

Cruise	Leg	Vessel	Date	Activities
Phase I				
1	1	M/V Jeff and Tina	7-16 Oct 1980	Platform selection
				Hydrographic/Benthos/Plankton
	2	M/V Jeff and Tina	30 Oct-6 Nov 1980	Fish collection/video
				(Experimental)
	3	M/V Jeff and Tina	19-23 Nov 1980	Fish collection/video
				(Experimental)
	4	M/V Jeff and Tina	1-8 Dec 1980	Fish collection/video
2	1	M/V Jeff and Tina	22-28 Jan 1981	Fish collection/video
				Hydrographic/Benthos/Plankton
3	1	M/V Jeff and Tina	1-6 April 1981	Hydrographic/Benthos/Plankton
	2	M/V Jeff and Tina	13-24 April 1981	Fish collection/video
4	1	M/V Jeff and Tina	7-18 July 1981	Fish collection/video
Phase II	2	M/V Jeff and Tina	23-28 July 1981	Hydrographic/Benthos/Plankton
5	1	M/V Jeff and Tina	15-22 Oct 1982	Fish collection/video
		M/V Nancy Ann	20-21 Oct 1982	Fish collection
	2	M/V Jeff and Tina	29 Oct-1 Nov 1982	Fish collection/video
	3	M/V Jeff and Tina	5-9 Nov 1982	Hydrographic/Benthos/Plankton
6	1	M/V Jeff and Tina	27 Apr-7 May 1982	Fish collection/video
	2	M/V Jeff and Tina	17-24 May 1982	Hydrographic/Benthos/Plankton
7	1	R/V Oregon II	31 July-11 Aug 1982	Fish collection/video
	Supplementary			
		R/V Sea Hawk and	12-17 Aug 1982	Mixed gas diving
		R/V Oregon II		Fish collection/video
	2	M/V Jeff and Tina	6-9 Sept 1982	Hydrographic/Benthos/Plankton
8	1	M/V Jeff and Tina	19-30 Oct 1982	Fish collection/video
				Hydrographic/Benthos/Plankton

SECTION 2

SUMMARY AND CONCLUSIONS

Objective 1

"Define, describe and characterize the movements, migration, recruitment and standing stocks of red snapper and other lower and upper reef fish species associated with natural reefs and one drilling platform in the vicinity of the Flower Garden Banks by methods including mark-recapture and the use of remotely-operated visual census equipment and instrumentation."

To meet this objective required first that we develop sampling and statistical methodologies enabling us to measure the population parameters in question. Underwater mark-release procedures that were developed are described herein and enabled us to raise, tag, and release fish collected at depth with a minimum of physical damage. However, the mark-recapture program was basically unsuccessful because of the low catches of target species, namely red snapper. Data which were obtained from this effort suggested that vermilion snapper, *Rhomboplites aurorubens*, and cottonwick, *Haemulon melanurum*, were characterized by localized movements. Most recaptures were made within a kilometer of where the fish had been marked and released. Some of these fish had been at large for as much as 3 to 4 months. In contrast, one vermilion snapper which had been at large for 410 days was recaptured 320 km east of the banks. The single red snapper tag which was returned was taken from a fish which had moved some 180 km to the east of the banks during almost a year at large. Too few data were obtained to define migration and movement patterns of reef fish with certainty.

An underwater videosystem and sampling methodology was developed which provided data of the quality necessary to be able to measure standing stocks and recruitment patterns of reef fish. By using maximum likelihood estimation procedures instead of the commonly used method of moments, we were able to obtain seasonal population estimates of reef fish having reasonable levels of accuracy and precision.

Based upon historical records, red snapper populations at the Flower Garden Banks were heavily (over) exploited in the late 1950's and standing stocks, at present, remain low [Gulf of Mexico Fishery Management Council (GMFMC) 1980]. During fall 1981 through summer 1982, the estimated population of red snapper at the East Flower Garden Bank varied from only 13,000 to 20,000 fish. The population was predominantly associated with Deep Drowned Reef Habitat (below 85 m), although some fish occupied Shallow Drowned Reefs (approximately 50-85 m). In summer 1982, the population plummeted to an estimated 4,000 fish and was comprised of mostly smaller specimens (mean fork length=361 mm). These snapper were mainly associated with Shallow Drowned Reefs. There was no evidence of impact on the spatial density patterns or population levels of red snapper due to the bottom-water discharge of drill muds and cuttings during 1982 from the Mobile Platform HI-A389-A. We believe that the depletion of fish in Deep Drowned Reef Habitats may have been due to harvest of these fish by commercial fishermen. Many other equally good explanations could be proposed, but we think this one is most likely.

This thesis is maintained by our interpretation of the results of analysis of the historical catch/effort data for red snapper. The data were obtained from the GMFMC (1980). In SECTION 5, we suggest that a large portion of the recruitment of red snapper to reefs throughout the northwestern Gulf may be harvested and, if so, the present dynamics of this species may be controlled by a population of spawners which have not been heavily fished. The presence of substantial numbers of large snapper over soft bottoms has been documented by Cody et al. (1981). These populations have recently become the target of an expanding bottom-longline fishery (Cody et al. 1981). The importance of this stock in terms of maintaining harvestable levels of red snapper in the northwest Gulf of Mexico should be carefully evaluated before the fishery is further developed.

Assemblages of reef fish occurring on the Flower Garden Banks were quantitatively described in terms of their seasonal abundance patterns within habitats and depths. Standing stock levels were described for 16 taxa of upper and lower reef fish. The fish populations and biofouling communities which colonized the drilling platforms were qualitatively described. Based upon these data and results of ANOVA's comparing seasonal and spatial abundance patterns of fish with regards to the location of the drilling platform, we do not believe that there was any evidence suggesting that the drilling activities had any detrimental impacts on either the population levels or habitat utilization patterns of reef fishes. The main effect of the platform in this regard has been to provide (1) additional reef habitat which is being utilized by some of the bank species and (2) new habitat which has been colonized by some shallow water reef fish species heretofore not reported for the Flower Garden Bank area.

Objective 2

"Conduct sampling, collecting and preliminary preparation of samples and sub-samples for analyses by Work Units A3 (Ichthyoplankton), A4 (Reef Fish Bioprofiles), B2 (Benthos), B3 (Reef Fish Histopathology), and B4 (Microbiology--Phase I only)."

The contracted sampling activities were accomplished at an overall success rate of 102% based upon the 3354 sample units scheduled for collection, excluding Work Unit A4 (Reef Fish Bioprofiles). Sample goals for Work Unit A4 were not quantified beyond a request for the maximum number of specimens which could be dedicated for their use. A total of 3068 fish of the target species were provided to Work Unit A4.

Objective 3

"Make hydrographic measurements to determine temperature, salinity, dissolved oxygen and light transmissivity to locate and characterize thermoclines, pycnoclines, water masses, nepheloid layers and drilling effluent plumes and determine their effects on reef fish movements, migration recruitment and standing stocks."

Seasonal water column structure around the Flower Garden Banks and study area platforms were described. Mean surface water temperatures ranged from 20.6 to 31.0°C; bottom waters were typically cooler, ranging from a high of 21.2 to a low of 15.7°C. Salinity was less variable than temperature. Mean values were usually about 36 ppt, but mean surface values as low as 33.2 ppt were recorded during one spring cruise. Dissolved oxygen levels were typically in excess of 4 ml/l over much of the water column and levels decreased with depth. The lowest mean value recorded was 2.58 ml/l, which was observed at 110-m depths in summer 1982.

In general, water clarity in the study area was high, with the only significant reductions occurring in about a 10-m thick band (the nepheloid layer) just above the bottom. Surface discharge of drill muds and cuttings at a platform sited 9 nautical miles west of the banks was observed to reduce water transmissivity to near-zero levels at one station adjacent to the platform at the surface and to a depth of 20 m. This practice is not allowed near the banks. The platform studied near the East Flower Garden Bank discharged at the bottom, and this discharge had little observable effect on water clarity levels or fish populations. There was no evidence the discharge from this platform reached the reefs of the East Flower Garden Bank.

Objective 4

> "Supplement the information obtained from Work Unit A4 in assessing movement, migration, recruitment and standing stocks of red snapper and other lower and upper reef fish species on the East and West Flower Garden Banks and one nearby drilling platform."

The information in this report supplements that obtained from Work Unit A4 in that it provides the population level context for the results of the life history studies which were conducted by representatives of the National Marine Fisheries Service, Southeast Fisheries Center's Beaufort Laboratory, Beaufort, North Carolina.

CONCLUDING COMMENTS

A central requirement for an understanding of reef fish population dynamics is the ability to census the fish population with both reasonable confidence and cost. The redundancy of the work units, each calling for estimation of populations but based on different methodologies, was an explicit attempt to discover and test a suitable approach. Fortunately, the goal was achieved, primarily because of two developments.

First, the development of the technology and operational procedures to remotely census the fish resulted in the acquisition of high resolution data, rare in ecological studies. The second development was the derivation of estimation procedures incorporating statistical models appropriate for both the data and the behavior of the fish. These two developments are interrelated. For example, the historical treatment of transect data has typically involved the determination of the density of fish over the area censused after which simple extrapolation is used to determine population levels over the area of interest. Statistically, one assumes that the fish are characterized by a Poisson distribution, and then obtains parameter estimates through the method of moments. Since our data could be examined at high resolution (i.e., one minute intervals) this critical assumption was tested and found to be invalid for many species of fish. The blind application of the traditional methods would have resulted in gross underestimates of population size and highly volatile error bounds. Therefore, two further statistical models were assumed in order to better reflect the behavior of the fish. The ability to choose among three parsimonious models encompassing a wide range of behavior enabled the primary objective of population estimation to be fulfilled.

Even though the models presented herein are flexible, more complex or more holistic models may yield better estimates. The high error bounds for some of the estimates attest to the need for such models. The data provided by this study [Videotape data archived by NOAA/Environmental Data and Information Service (EDIS), Washington, D.C.] are of the quality necessary for development of holistic models.

SECTION 3

MATERIALS AND METHODS

In addition to the reef fish population studies incorporated in Work Units B1 and B5, LGL provided sampling services in support of other work units as part of Work Unit B1. Below we provide a description of the biological and oceanographic sampling which was provided for the overall project prior to discussing the two reef fish assessment methodologies (mark-recapture and remote sensing) which were developed and utilized for our specific work units.

BIOLOGICAL SAMPLING SERVICES

In support of other work units (A3, A4, B2, B3 and B4), a team of six marine scientists was provided by LGL to work under the direct supervision of each work unit representative or to sample as directed, following instructions provided by representatives of the respective work units. Sampling requirements and scheduling were under the overall direction of the NMFS Field Party Chief, who was present on all cruises. Specific field techniques used by other work units appear in their respective final reports.

In general, sampling involved the following. For Work Unit A3, ichthyoplankton samples were obtained with a surface Neuston net, opening and closing nets, and bongo nets. Nets were washed down, cod ends removed and samples preserved in alcohol. Sediment and benthos were sampled for Work Unit B2 using a standard 0.1 m^2 box core provided by Work Unit B2. Subsamples for sediment grain size and total organic carbon analysis were taken from two of five cores at all stations. Core samples were seived on the vessel through a 0.5 mm screen, then preserved and labeled following instructions from the representative of Work Unit B2 on the vessel, or written instructions provided before the cruise. Subsamples of core sediments were also provided to microbiology (Work Unit B4) for plating during Cruises 1-4. Water samples were also required by the microbiology work unit. Surface water was collected in sterile glass bottles and subsurface water was collected using Niskin sterile bag samplers provided and operated by a representative of Work Unit B4.

For Work Units B1/B5 and in support of other Work Units (A3, A4, B2, B3 and B4) lower and upper reef fish species associated with the Flower Garden Banks and the platforms were collected using hook-and-line, traps, divers, and trawls. Hook-and-line techniques utilized standard offshore fishing rods, and size 4/0, 6/0 or 9/0 trolling reels. Most fishing reels were also equipped with 12-volt electric motors, which greatly increased fishing efficiency, especially in water depths greater than 50 m. One to two pound (454-907 g) lead weights were used on the terminal tackle. Frozen squid was used as bait.

Extensive trapping efforts occurred during Phase I (Cruises 1-4) but were discontinued after Cruise 4 due to their relatively low productivity with respect to vessel use and manpower requirements. Three varieties of traps were deployed during the study. One type, a large box trap about 1.25 m on a side, was discontinued after the first cruise due to its awkward size and similar catch efficiency to the smaller, more manageable traps. The other two types of traps used were rectangular types typical of most reef fish traps used in Florida (Owens 1980). Each type of trap enclosed a volume of about 0.65 m^3 (20-25 ft^3) and was constructed of polyvinyl-coated fencing wire. The only difference between the traps was that they had different mesh sizes. The larger mesh measured 50 x 100 mm and the smaller mesh was 22 x 48 mm. The trap throat or funnel extended 1/3-2/3 the distance into the trap chamber ending in an oval opening about 6-10 cm wide. An additional flat-hinged door section was located at the back of the trap for removal of fish. Before deployment, the traps were baited inside and out in a process called "fundering" which was believed to attract fish to the trap faster and in greater numbers than would curiosity alone (Swingle et al. 1970). Traps were generally deployed in pairs, with a 4-6 m length of line joining the two. A second line was secured to the terminal trap and extended to the surface float.

Upper reef fish were collected by SCUBA divers using 2.1 m (7 ft) hand pole spears. Typically one or two buddy teams would swim around a relatively small area on top of the coral reef or around the platform to spear the required reef fish species. Dive sites over the coral reef were temporarily marked by a small anchor and bouy at the surface where a

Zodiac inflatable boat and tender would stand-by during the dive. The anchor was moved away from live coral at the beginning of each dive to prevent significant damage to living coral heads and facilitate retrieval.

Fish occupying soft bottom habitats were collected for Work Unit B3, Histopathology, by otter trawling. The trawl was a standard 12.2 m, shrimp otter trawl and tows ranged between 10 min and 1 h in duration. Samples were taken around the platform, between the platform and the reefs, and between the reefs. Independently, we recorded fish catch composition but quantitative data regarding catch were not obtained.

Numbers and types of samples obtained and provided to other work units, excluding fish samples, appear in Table 3-1. A total of 3413 sample units were provided at an overall success rate of 102% based on a total number of 3354 sample units scheduled for collection, excluding fish for Work Unit A4 (Bioprofiles). Sample goals for the Bioprofiles work unit were not quantified beyond a request for the maximum number of fish which could be dedicated for that study. A total of 3068 fish were provided to the Bioprofiles work unit. Table 3-2 lists all fish samples provided to Bioprofiles and other work units.

Table 3-1. Samples provided to other work units (excluding fish, Table 3-2).

	Phase I				Phase II			
	Cruise #				Cruise #			
Work Unit	1	2	3	4	5	6	7	8
A3 - Ichthyoplankton (# net samples)	26[1]	18[1]	65[1]	37	86	102	34	72
B2 - Benthos[2] (box cores)	140	65	135	135	90	105	25	60[1]
B4 - Water Microbiology	40	21	39	38	NOT FUNDED[3]			
B4 - Sediment Microbiology	135	65	140	140	NOT FUNDED[3]			

[1]Samples also processed by LGL personnel on vessel.
[2]Samples for total organic carbon and sediment grain size were collected from box core #2 and #4 at each station.
[3]Work Unit B4 was terminated prematurely after Phase I due to a reduction in funding requiring reprogramming of the project.

Table 3-2. Fish samples provided to other work units.

Work Unit	Phase I Cruise # 1	2	3	4	Phase II Cruise # 5	6	7	8
A4 - Bioprofiles	318	210	316	294	649	393	485[1]	403[1]
B3 - Histopathology	112	84	152	173	108	161	139	157
B4 - Microbiology	117	133	91[1]	173[1]	NOT FUNDED[2]			

[1]Samples also processed by LGL personnel on vessel.

[2]Work Unit B4 was terminated prematurely after Phase I due to a reduction in funding requiring reprogramming of the project.

OCEANOGRAPHIC SAMPLING

Under subcontract to LGL (Dr. J.M. Brooks), a representative of Texas A&M University's Oceanography Department participated in each of the eight scheduled cruises for purposes of supervising the collection of hydrographic data. Samples and measurements obtained during each cruise were either processed on the vessel or taken back to the chemical oceanography facilities on campus in College Station, Texas for analysis. Four hydrographic parameters were measured; temperature, salinity, dissolved oxygen, and transmissometry. We also provided Sigma-t density values for all stations and depths sampled. Sigma-t is a calculated measure of seawater density taking both temperature and salinity into account.

The hydrographic sampling array consisted of 22 profiles. During Phase I, when the study platform (PLA) was near the West Flower Gardens eight profiles were located around each bank, one on top of each bank, one (CNA) between West Flower Gardens and the drilling platform PLA, one between the banks (BRC), and one each up- and down-current of the platform (Fig. 3-1). Beginning with Cruise 5, the sampling array was changed to reflect the shift of the study emphasis to the new Mobil Platform (PLB) on the southeast side of the East Flower Garden Bank. Whereas the total number of profiles remained the same, the number of stations at the West Flower Gardens were reduced to two (Fig. 3-2), and eight new stations were

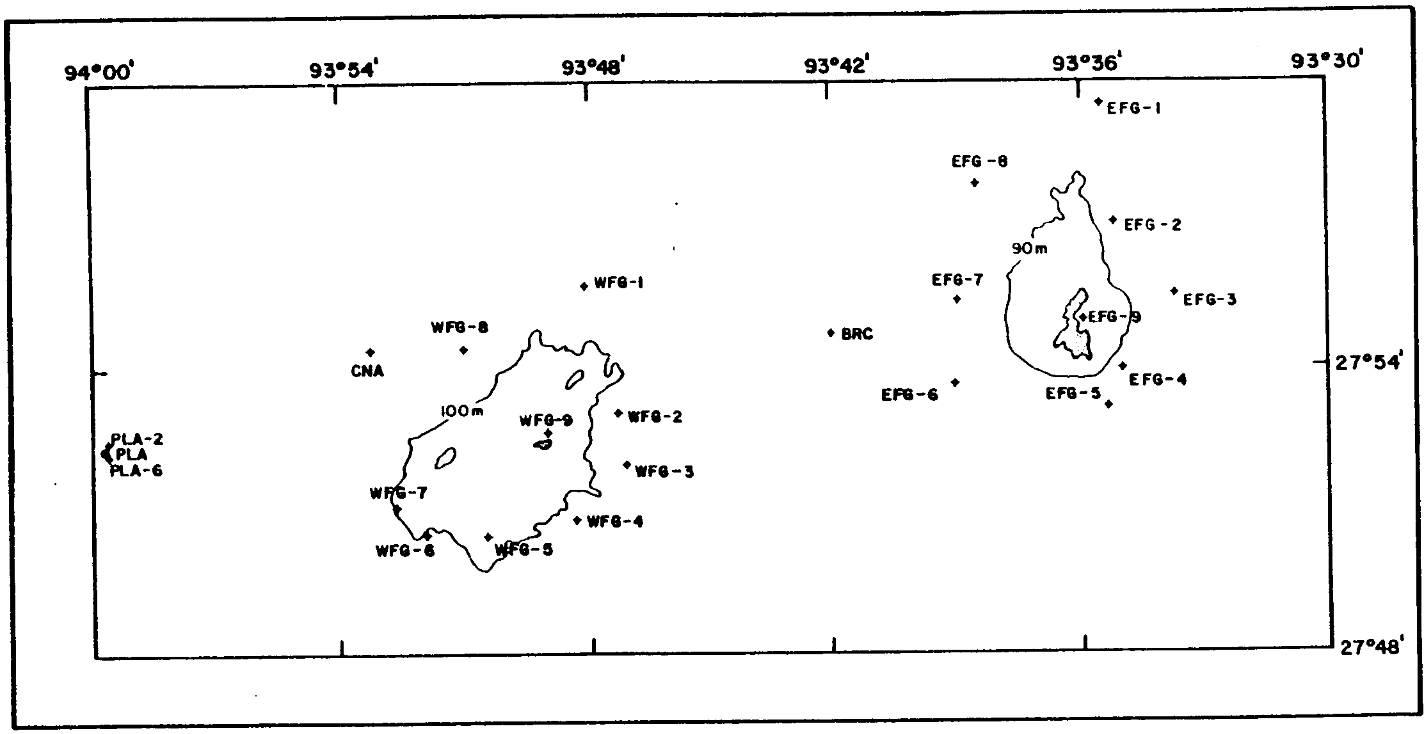


Fig. 3-1. Hydrographic sampling stations, Phase I, Cruises 1-4.

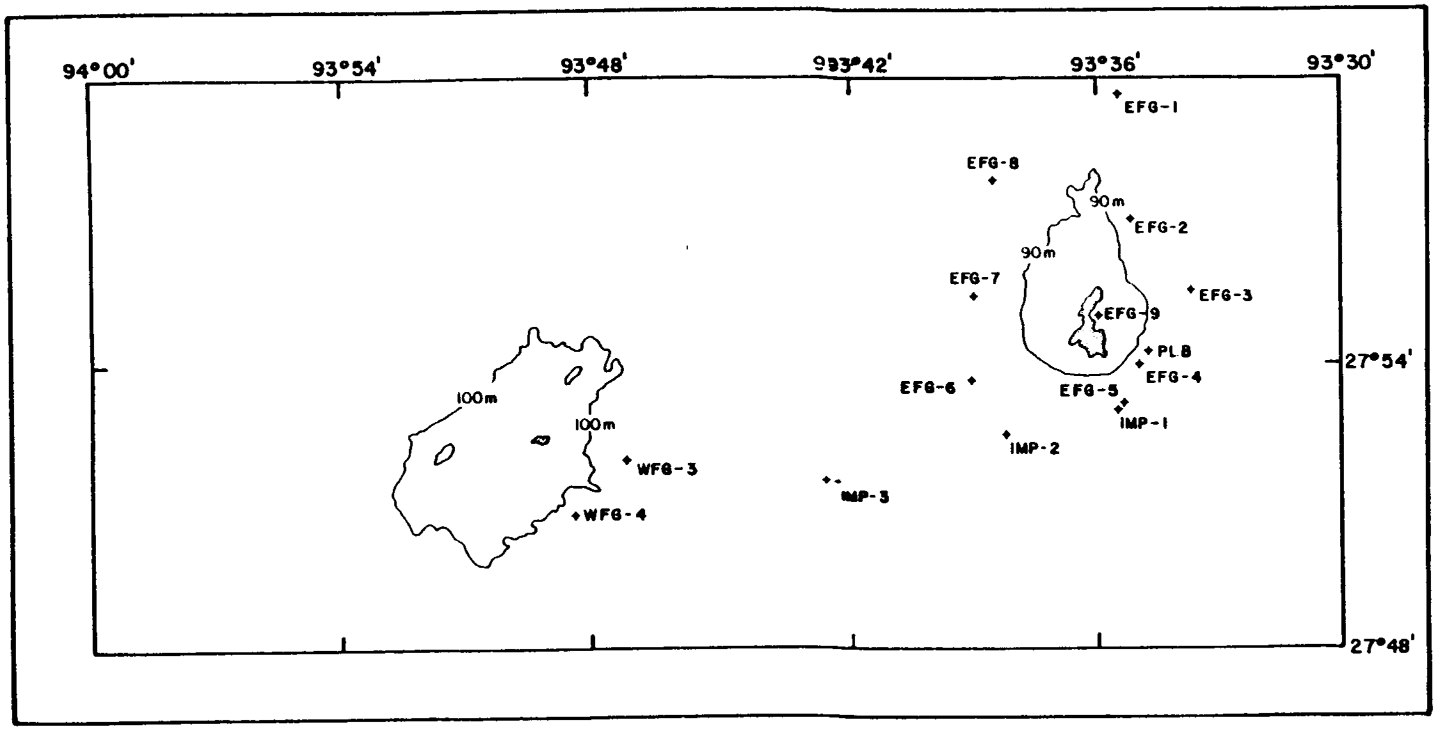


Fig. 3-2. Hydrographic sampling stations, Phase II, Cruises 5-8.

created around PLB (Fig. 3-3). Additionally, three "impact" stations (IMP) were added in place of the original PLA platform stations and control (Fig. 3-2).

Temperature

A pair of oceanographic reversing thermometers were attached to Nansen bottles to obtain extremely accurate temperature measurements in duplicate. Nansen bottles were attached to the hydrowire at 10-m depth increments. After reaching the last depth they were allowed to equilibrate at least 5 min before tripping. The thermometers from the Texas A&M University, Department of Oceanography collection which were used, had long histories of very accurate calibration to ±0.005°C. All thermometers were allowed to equilibrate before reading, and were read in duplicate by separate observers.

Salinity

Water samples for both salinity and dissolved oxygen were obtained from reversing Nansen bottles at the surface and at 10-m depth increments. Salinity samples were collected into 300-ml bottles which had been previously rinsed with sample water. When capped, these bottles were airtight. They were then transported to College Station for analysis on a Plessey Environmental Systems Model 6230N Laboratory Salinometer. This system utilized an inductively-coupled conductivity sensor to establish a conductivity ratio between an unknown sample and a standard at approximately 35 ppt salinity. A dual-element platinum thermometer and its associated circuitry sensed the temperature of the sample and applied the appropriate compensation. The specifications of the system were as follows:

Range:	0 to 51 ppt
Accuracy:	±0.003 ppt
Temperature Compensation:	±0.0007 ppt/°C

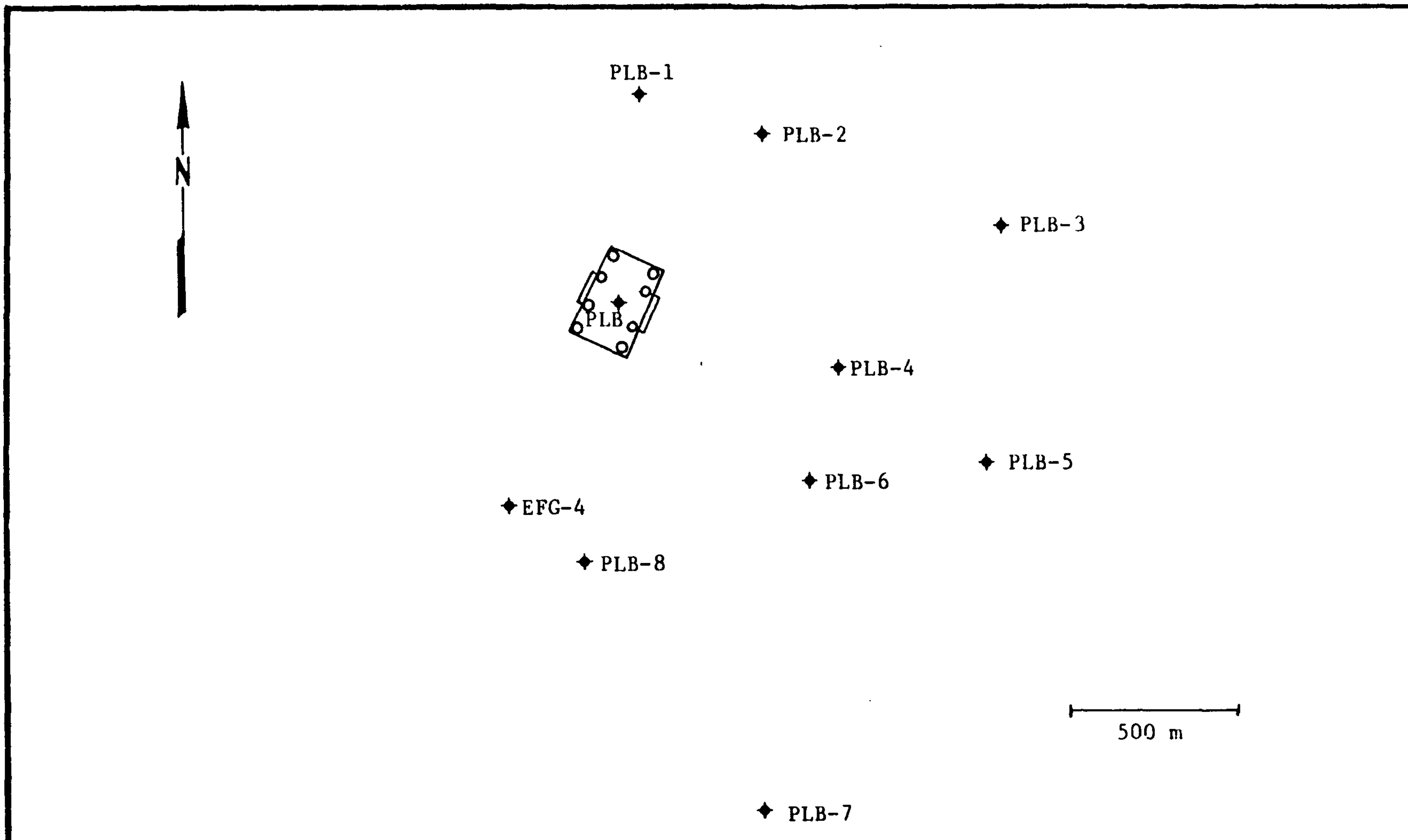


Fig. 3-3. Hydrographic sampling stations around study platform PLB (MO-HI-A389-A), Phase II, Cruises 5-8.

Oxygen

Oxygen samples were always the first to be drawn from a Nansen bottle cast and were drawn as soon as possible. The samples were taken using a length of tygon tubing with the tip of the tube near the bottom of the flask so that it could be filled slowly without agitation. The flask was rinsed and air bubbles were removed from the tubing with a small amount of sample before the flask was filled. The flask was overflowed and the stopper inserted to avoid trapping air bubbles.

The modified Winkler technique of Carpenter (1965) for analysis of oxygen was used. All oxygen analyses were performed on the vessel.

Transmissometry

Transmissometry was provided by an XMS in situ transmissometer system manufactured by Martek Instruments, Inc., equipped with its own temperature probe and depth sensor. A photocell sensor measured the percentage of light that reached the photocell surface after passing through an optical light path of 1 m from the light source. The percent light transmittance versus depth was traced on an X-Y recorder.

MARK-RELEASE-RECAPTURE

Collection of fish for mark and recapture purposes was accomplished by means of trapping with fundered traps (Swingle et al. 1969) and hook-and-line sampling, both procedures which had been reported in the literature to be effective for taking red snapper (see Gulf of Mexico Fishery Management Council 1980 for a review). Typically, traps were set during one day and retrieved the next day. Trapped fish were the subjects for the underwater tagging procedures. After the traps were set, the balance of the daylight hours was typically used for sampling for other work units or conducting remote sensing surveys using the underwater video system. At night, the boat was anchored and hook-and-line sampling was conducted to obtain fish for other work units or for tagging. All fish sampling, whatever the reason, constituted the recapture effort. The on-deck and underwater tagging and release procedures are described below.

On-deck Fish Tagging

All fish caught and raised to the surface for the purpose of marking and release were measured to the nearest mm of fork length on a measuring board and then weighed to the nearest gram. Hanging scales of various weight ranges were best suited for at-sea conditions and performed better than top loading types. The fish were then tagged with a Floy Mark II, long tagging gun and 15-cm anchor-type tags. The tags were specifically designed for high visibility *in situ* for possible observations by the underwater video cameras by divers or by the submersible assessment efforts (Work Unit A2, ultimately not funded). Several tag colors were tried but white proved to have the highest visibility underwater. All tags had an imprinted legend: "Reward LGL 1410 Cavitt Bryan TX 77801" with a tag number preceding or following the legend. All rewards given were for $10 except for one of $5.

Once processed and tagged, fish were either released directly at the surface or returned to the bottom and released using a release basket apparatus opened near the bottom by a remote trip line (Fig. 3-4). Often the catch rate combined with the time required to lower and raise the release mechanism necessitated the holding of tagged fish on deck in tanks filled with fresh seawater.

The major advantage of the release basket was that it enabled us to recompress fish suffering from gas expansion problems by lowering them to the bottom prior to their release. Most species caught at depth and raised to the surface were usually positively buoyant to the degree that they could not easily return to the bottom due to gas bladder expansion. The release basket overcame this problem as the fish had been recompressed at the time of release. Further, using this method of release we were able to reintroduce fish into the same habitat type near the bottom where they had been captured. Using this approach, the risk of a tagged fish being taken by predators was theoretically lessened.

There were, however, some serious drawbacks to the technique, problems which ultimately advocated its discontinuance. For many species, there was a direct correlation between holding time on deck and survival. This was likely due to a number of factors including elevated holding tank water temperature, reduced dissolved oxygen and possibly embolism or other

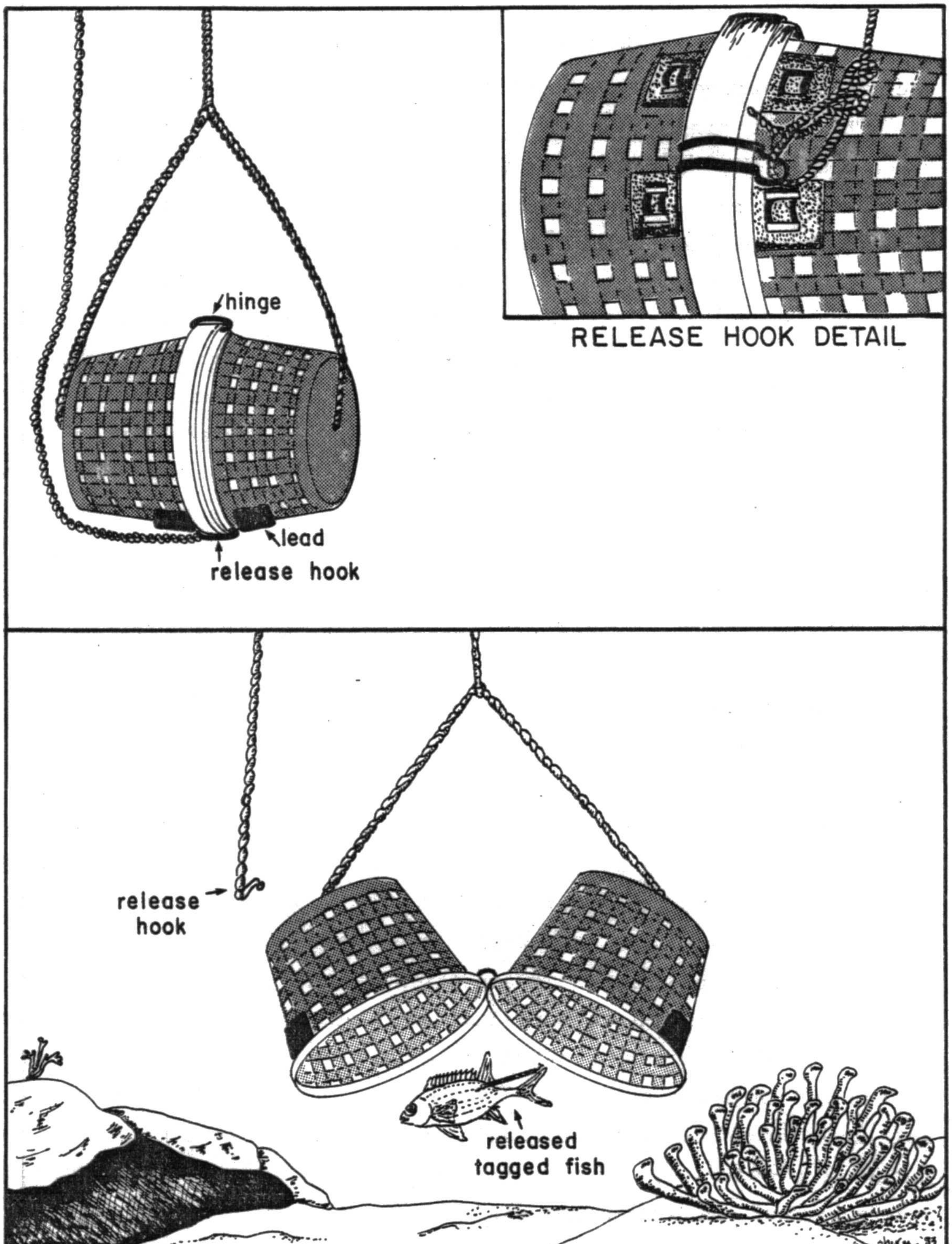


Fig. 3-4. Release basket mechanism for lowering tagged fish to bottom.

gas expansion problems experienced by the fish. The release mechanism required approximately 5 minutes to lower and raise. When fish were caught and tagged when the release basket was already in operation, the additional holding time often proved fatal.

The most significant problem, however, was the attraction of predators to the release basket per se. Instead of protecting the tagged fish from the most common predator (the amberjack, Seriola dumerili), the baskets appeared to attract large amberjack to the release point above the bottom. We observed amberjacks to have been consistently and rapidly attracted to any structures placed in the water. Klima and Wickham (1971) also described rapid and repeated attraction of jacks to artificial structures suspended in the water column. Large jacks were frequently seen by divers during mid-water tagging experiments and during the tag mortality experiments, when both the video frame and attached trap were suspended off the bottom. At one point, the echo sounder used during video transects was utilized to observe the release basket mechanism underwater. Surprisingly, the echos of several large fish were repeatedly seen following the echo trace of the release basket all the way to the bottom.

Given the above, it was the opinion of the fisheries biologists on board that most tagged fish had the best chance of survival when released at the surface as soon as possible after capture and tagging. These fish were believed to have had the greatest energy reserves to overcome slight positive buoyancy, and it was also believed that they were better able to escape predation as individual small targets swimming down in unpredictable directions than when slowly lowered in a basket of a size known to attract predators. An exception to this general release approach was red snapper which was particularly susceptible to gas expansion problems, becoming very buoyant. The release basket was necessary for release of this species as they were buoyant to the point of not being able to swim to the bottom on their own. Attempts were made to relieve internal pressure by puncturing the swim bladder of this species and others without significant success.

Three experiments were conducted to observe the effects of tagging on fish. During Cruise 1 five tagged cottonwick were placed into a trap secured to the video support frame. The frame and trap was then lowered to the bottom and the fish observed over a period of about one hour. This experiment was essentially repeated on a special supplementary cruise aboard the Oregon II between the usual legs of Cruise 7. In addition to observing four tagged fish, five untagged fish were included in a totally enclosed mesh trap secured to the video frame. Each set of fish were in a separate enclosed section of the cage. This experiment continued for 24 hours with observations recorded on videotape for a minimum of five minutes every hour. A third experiment was also conducted during this cruise. Seven tagged fish and seven untagged fish were placed into a single trap, lowered to the bottom and observed for 10 hours.

Underwater Tagging Stations

Considerable effort was expended developing techniques and designing and constructing equipment enabling us to perform mid-water fish tagging; thereby avoiding in large part the problems associated with swim bladder damage or rupture in physoclistic fish species caught at depth and raised to the surface.

A mid-water tagging platform (Fig. 3-5) was designed for the purpose of intercepting trapped fish at depth where they could be tagged and released without being subjected to the pressure changes which would have been experienced between the depth of the tagging platform and the surface. The tagging station also served as an anti-shark cage for the protection of the taggers. The aluminum cage (constructed by a company specializing in animal cages) weighed 204 kilograms and was about 2.1 m high, 1.5 m long and 1.1 m wide. The cage was large enough to accommodate all of the team of three divers which was used to conduct mid-water tagging operations. The cage was equipped with incompressible buoyancy tanks in the form of six lengths of PVC pipe 15.2 cm (6 in) in diameter secured to the sides of the cage. These provided 34 kg of buoyancy to the cage in the water if ballast weights were dropped (Fig. 3-5). Two SCUBA buoyancy compensator vests with independent air supplies were attached to the top of the cage. These units provided an additional 34 kg of buoyancy when inflated if required. Three supplementary air cylinders with separate regulators were provided for emergency breathing. A detachable tagging and measuring table was located above the tanks. A release basket

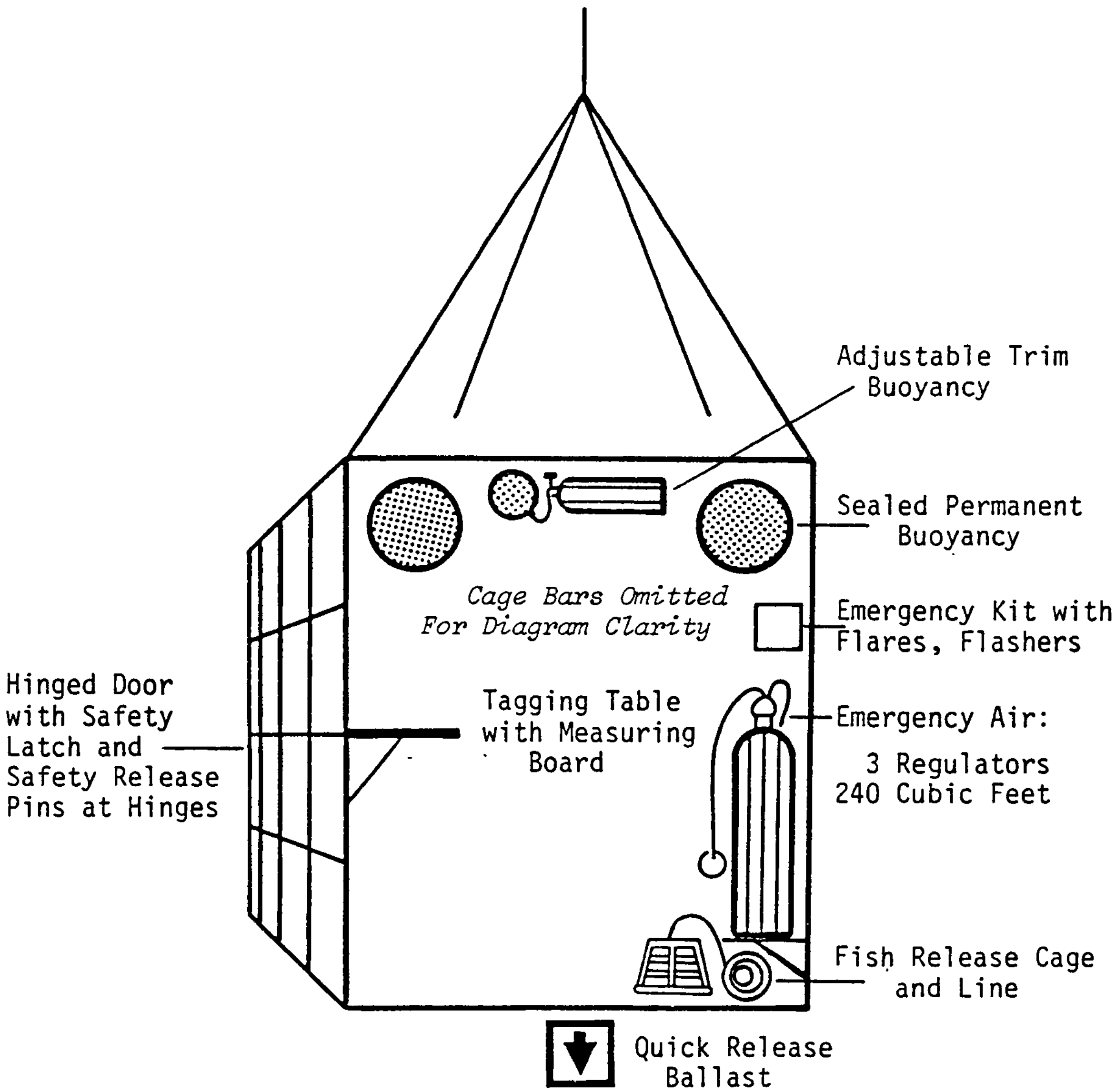


Fig. 3-5. Schematic illustration of midwater tagging station.

and line were located inside the cage for lowering tagged fish to the bottom, if desired when predators were present.

The optimum sequence of events developed for mid-water tagging using standard rigid wire traps were as follows. At some period of time before a tagging operation was to take place, several sets of fish traps were deployed in a promising area. Usually the next morning, the research vessel maneuvered to pick up a flag buoy attached to one set of traps. Once it was secured and slack removed, the ship would drop anchor to prevent drift away from the capture site. Both the tagging platform and video camera frame were then placed in the water and lowered to the depth where the tagging operations were to occur. The video camera frame was used to observe all operations so that the movements of the traps and the cage in the water column could be managed from the ship under the direction of the divers. A depth of about 20 m was determined to represent the best compromise between no-decompression dive time limits and water pressure differential between the working depth and surface.

After entering the water and approaching the cage, divers first secured the buoy line extending to the traps (still on the bottom) through a hook attached to the cage. This enabled the traps to be winched up from the research vessel to a point directly below the tagging platform. Once raised, the traps were attached to the side of the cage by the divers for operational convenience. If a trap was found empty, it was passed around the line hook and the next trap was raised to the level of the tagging cage using the winch on the research vessel.

When fish were present in a trap, the first step was to administer Quinaldine, an anaesthetic (Gibson 1967). A stock solution of 20-30% Quinaldine using alcohol as the carrier solvent was used to anaesthesize the fish. The mixture was transported in 1000 ml plastic squeeze bottles and administered by the divers. Once the fish were anaesthetized, one diver removed the fish and took it to a second diver standing inside the cage where it was measured and tagged. The third diver maintained watch on the operation as a safety measure and assisted as necessary. The same Floy Mark II SS long tagging guns and anchor tags used for surface fish tagging were used for mid-water tagging. Fork length was measured to the nearest mm on the tagging table, which had a tape measure attached to its surface. Lengths were then recorded next to the appropriate tag numbers which had previously been recorded on an underwater slate before each tagging dive. After tagging, each fish was placed into a holding basket or a release basket mechanism and allowed to recover. Depending on the water depth and predator situation, the tagged fish could then be lowered to the bottom and released by a remote trip line as described previously. In the absence of predators, fish were allowed to swim freely out of the holding basket and to the bottom after recovery from the anaesthetic.

The rigid traps were difficult to handle and harvest at depth. The most efficient trap type we used in mid-water tagging operations proved to be a collapsible mesh trap which enabled the diver to consolidate fish into a small area. Using this approach, the fish could be restrained without the use of an anaesthetic and could be tagged and measured before removal from the trap. A clear measuring stick was held up to the individual fish inside the mesh trap and fork lengths measured while looking through the clear plastic. This style of trap and underwater tagging technique was used extensively by LGL divers in the Buccaneer Gas and Oil Field study using fyke nets (Gallaway et al. 1981). The ability to localize and restrain captured fish while still inside the trap greatly facilitated the tagging operation. A similar concept was used for tagging at depth by Tong (1978) who marked and measured fish in the cod end of trawls.

REMOTE SENSING

Quantitative assessment of reef fish populations has always been a formidable task. There are basically two categories of active, non-destructive methods for estimating reef fish populations by remote sensing: (1) direct visual or photographic measurements, or (2) measurements made using hydroacoustic devices. Several problems exist in current hydroacoustic technology, including not being able to make species identifications with the records obtained and the lack of acoustic resolution when fish are close together or near the bottom (Barans 1982). Both of these difficulties precluded using hydroacoustics to assess Flower Garden reef fish communities.

Visual methods for assessing reef fish populations include making observations from submersibles, using towed or drifted remote cameras, and by means of scientific divers (Uzmann et al. 1977, Powels and Barans 1980). Benthic camera sleds are capable of censusing a known bottom area but cannot be used on high relief benthic environments for the same reason that trawls cannot be used successfully. Survey techniques for rough topography requires that the point of observation be able to move over and around obstructions. Submersibles and divers have this capability as do underwater video systems which can be raised and lowered as they move or are moved along a transect. The use of highly trained scientific divers can have many advantages in study of shallow reef areas, but depth restrictions severely limit their usefulness in areas such as the Gulf of Mexico shelf-edge banks. Submersibles also allow for making direct observations and have greater depth capabilities than divers alone. However, their tremendous expense has restricted their extensive use.

The method used in this study was transecting by underwater television. This method has no significant depth limitations, logistics time involved is minimal and expense is relatively low as compared to submersibles. As with other direct observation techniques, underwater television has the distinct advantage of real-time feedback (Uzmann et al. 1977). Reactions of fish species to the cameras can be observed and judgements made concerning any probable bias. Television transects are videotaped creating a permanent record of fish and habitat. Extensive observer training (which is necessary for divers) is not required and greater accuracy in identifying and counting fish is possible during analysis in the laboratory.

The method of deployment of underwater television systems includes many options. Busby Associates (1979) described 180 different remotely-operated vehicles. The basic categories are tethered, free-swimming, bottom-crawling, towed and untethered vehicles. Obviously, bottom-crawling is not practical on a coral reef. In 1979, the only known operational untethered vehicles were located at the Applied Physics Laboratory at the University of Washington. The technology of the field was best described as "emerging".

Remotely-operated tethered vehicles (ROVs) were utilized by CSA (1982) and found to have major drawbacks in performing fisheries assessments. Divers were required to rescue the ROVs on numerous occasions for many different reasons. Other problems included navigation and "station-keeping", which were described as inherent difficulties with all tethered free-swimming vehicles available at the time. CSA (1982) recommended that ROVs observations only be made while the ship and ROV were stationary, thereby greatly restricting their utility in surveying large areas.

In our studies, we used an underwater television-system which was suspended by a line from the research vessel to a point near the bottom. The surveys were conducted by simply allowing the research vessel to either drift or be slowly powered, maintaining vertical position of the cameras near the bottom by raising or lowering the system using the ship's winch.

Apparatus and Deployment

The principal components of the stereo video system were twin Sub-Sea Systems Model CM-8 underwater black-and-white television cameras with Ultricon camera tubes, and the Sub-Sea Systems Model ST-1000 stereo control console with multiplexer. Only two other systems were in existence at the time LGL acquired their system. Of these, the only one in use was located at the Oak Ridge Nuclear Laboratories in Tennessee.

Black-and-white cameras were chosen because of their enhanced contrast and superior sensitivity in low light conditions typical of underwater habitats. More than three times the light needed by these cameras would be required for an equivalent color picture, and artificial light would be required at all times to obtain a color picture. The RCA Ultricon black-and-white camera tube was utilized as the best compromise between sensitivity and resolution. The Ultricon tube is approximately four times more sensitive to light than a standard 2/3" (17 mm) Vidicon tube, and has 60,000 times the burn resistence. Camera tubes with low burn resistence will be permanently damaged and leave marks on recordings if exposed to a bright source of light, especially the sun. Another option was the Silicon Intensified Target (SIT) Vidicon tube which is significantly more sensitive to light than the Ultricon tube, but also costs at least five times as much. The SIT Vidicon type of camera was used in a reef fish study by CSA (1982) who found that the expensive SIT low-light level camera did not provide superior results compared to conventional cameras. Suitable observations were obtained 10-15 minutes beyond the time existing light became insufficient for a standard camera. For this Flower Gardens study, observations near sunset were intentionally avoided to prevent significant biases of fish counts during crepuscular periods (Starck and Davis 1966, Collette and Talbot 1972).

Both camera signals were transmitted through a dual coaxial cable where video multiplexing circuitry allowed both right and left camera signals to be viewed on a single monitor as well as recorded on a portable Panasonic VHS single-channel, video tape recorder (Model NV-8410). Each 1/2" tape cassette would record two hours of observations.

Auxillary light was provided by a Sub-Sea Systems 400 watt mercury vapor lamp. The blue-green spectral output of a mercury vapor arc bulb is well matched to the maximum spectral transmission of seawater and therefore, particularly efficient for black-and-white video. Both the cameras and light were attached to a Sub-Sea Systems Model A50 pan and tilt motor capable of a 340° pan axis and 180° tilt axis. The pan and tilt motor was attached to the center of a steel pipe tripod or "camera frame" which provided protection of the lamp and cameras. The tripod also provided a stable support structure for working while resting on the substrate and could be easily towed. The trailing edge of the tripod frame supported a large vertical stabilization fin which reduced twisting movements and enabled a consistent orientation during a transect drift.

The camera tripod was lowered on an oceanographic hydrographic cable ("hydro-wire") off the side of the research vessel. Electronic cables were attached to the hydro-wire at appropriate intervals. The available laboratory space for monitoring and recording equipment was located below deck at some distance from the winch operator. A public address amplifer system was used to communicate directly with the winch operator from the location of the video monitor in order to maintain minimum response time. Minimum response time was especially critical when passing over deep drowned reef structures given that a few seconds delay in raising the frame would result in a collision and possible entanglement.

An auxillary SIMRAD Model EY-M Echo Sounder with the transducer mounted at the surface directly over the camera frame was used to obtain precise depth information and to maintain a relatively consistent position of the system above the bottom during a transect (Fig. 3-6). The

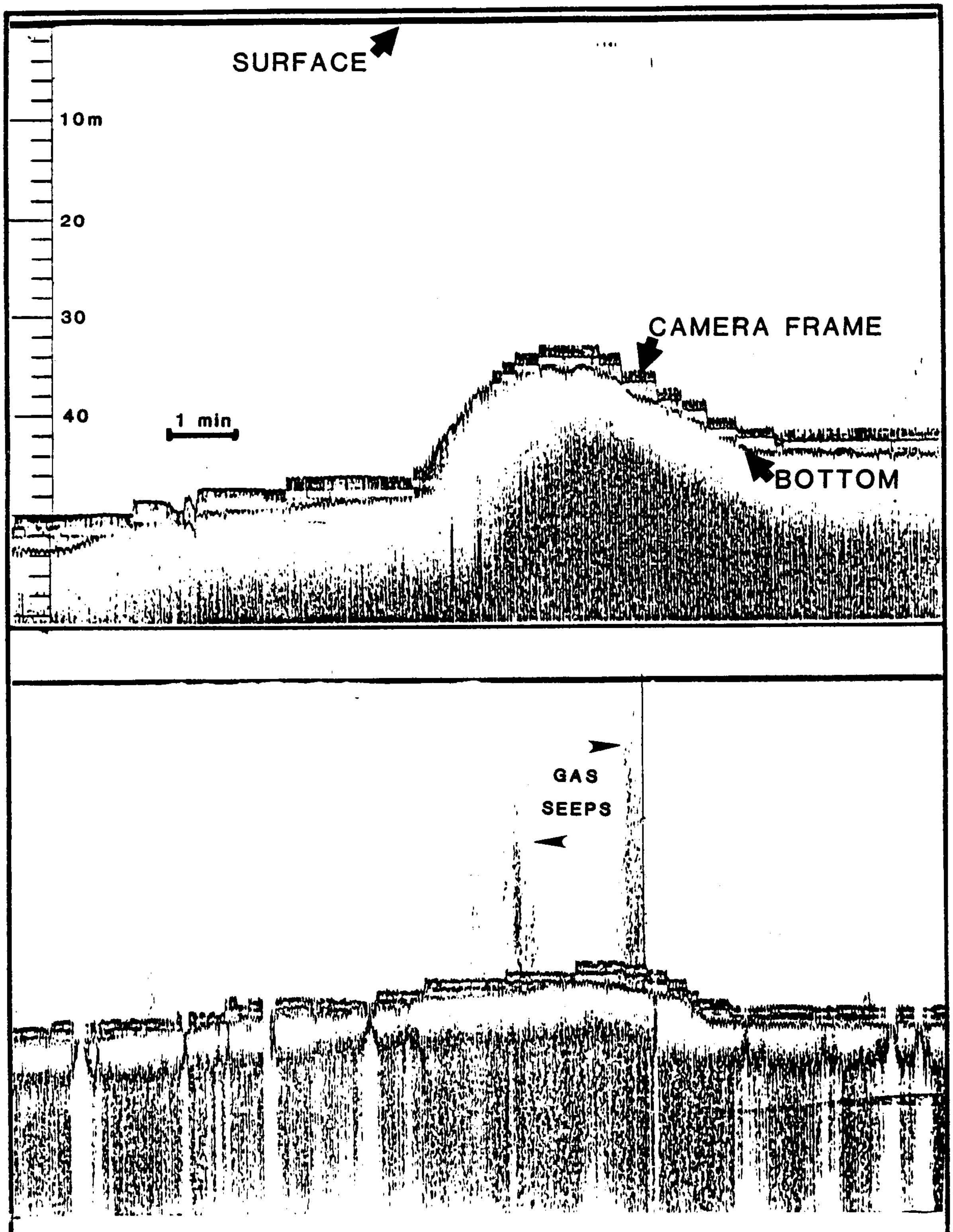


Fig. 3-6. Echo sounder records depicting elevation of video camera during transect over reef outcrop and echo returns from gas seeps.

returning transducer signals also gave some advance warning of oncoming obstructions under turbid water situations.

Options for retrieval of a snagged and lost video frame are numerous but most always very expensive. Acoustic releases and buoyancy systems were investigated for this program but the cost for such a system exceeded the value of the cameras and other equipment attached to the frame. Further, if cable separation occurred due to entangling an obstruction, there was no guarantee that positive buoyancy would free the frame from entanglement. Pingers and locators were also quite expensive, and finding the equipment would only solve the problem if the lost system was located in shallow water within diving depths. The majority of transecting at the Flower Garden Banks was performed below 40 m in depth, outside safe diving depths.

The recovery system designed for the LGL video frame was very simple and inexpensive, and was never used in 357 project hours of operation. The approach was to have a 19 mm nylon safety line with buoy separately attached to the frame which would enable both its location and recovery should it be entangled. This line was secured to the hydro-wire along with the video cables as the frame was lowered. Attached to the surface end of the line was a #A-5 Polyform Norweigian buoy, 70 cm in diameter with a buoyancy of 180 kg. If the frame snagged on the bottom and the hydro-wire parted, the remaining line and buoy would be thrown overboard. The buoy would be capable of supporting the cable which would probably be flooded at any rate. The 19 mm safety line had a break strength of 6441 kilograms and was believed to be adequate for freeing and retrieving the snagged frame.

Measurement Technique

The measurement technique for determining size of objects being viewed was similar to that described by Boyce (1964) and used by Klimly (1981) but differed in that we used double video images as opposed to still photographs. The two video cameras were mounted with their optical axes parallel to each other and separated by a distance of 210 mm. This distance corresponded to the existing support arm attachment points and was similar to lengths of several of the dominant reef fish species encountered. The relatively close placement also resulted in the visual near field overlap of the camera optics (area viewed by both cameras), to be very close to the cameras, actually inside the support frame.

The majority of transect recording time utilized only one video camera. When both cameras were switched on simultaneously to obtain measurements, the video image was degraded somewhat because of the characteristics of video multiplexing; i.e. each camera shared one-half of the available scan lines on the monitor. For this reason, it was important that a minimum amount of time be spent in the multiplexed mode, just long enough to obtain several seconds of split double image which was analyzed at a later date in the laboratory. Real-time feedback was important for recording detailed voice information and decision-making in the field, but another important aspect of the video technique was to obtain a permanent record which allowed the majority of analyses to be done in the laboratory.

The measurements were taken from the image on a monitor screen. For this study a 48.3 cm (19") television screen was used. We believed this size represented the optimum compromise between a larger screen which would have provided a larger image and smaller screen which would have provided better clarity of image due to compression of scan lines.

Figure 3-7 illustrates a frame of the dual video camera's image as represented on the monitor screen in the multiplex mode. The most critical factor for accurate measurement of a fish length was the orientation of the free-swimming fish to the cameras. Accurate measurements could only be taken when the fish or other object was exactly or very nearly perpendicular to the optical plane of the cameras. Other positions would result in artificially short length determinations.

Only two measurements were required from the image on the monitor screen: (1) the length of the object (e.g. L_1 fork length) which could be measured from either image (Fig. 3-7) and (2) the degree of separation between the split video images (S_1) which could be measured on the screen at any common point on both images. Any point of high contrast (e.g. the nose or a tip of the caudal fin) all worked equally well. The equation derived by Van Sciver (1972):

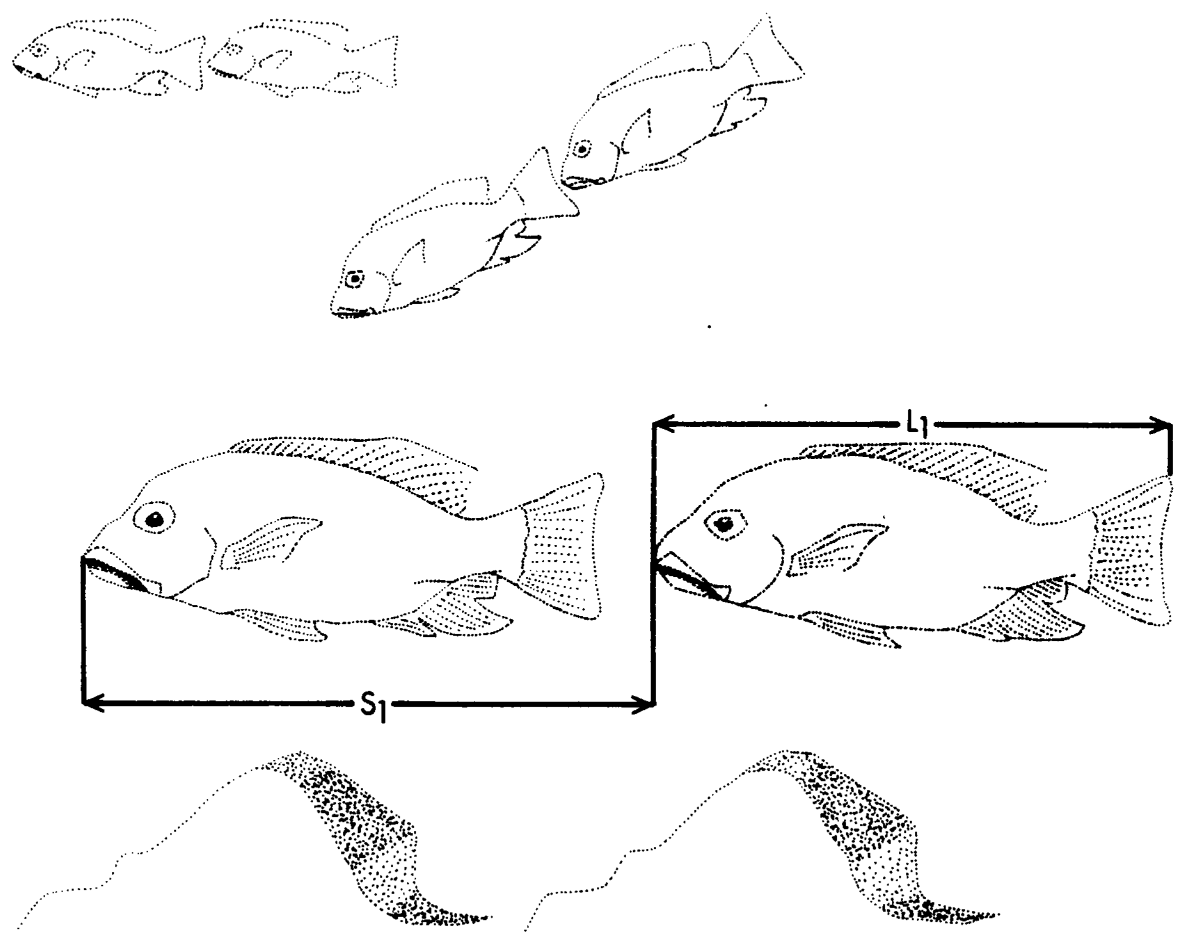


Fig. 3-7. Double video image used in determination of actual fish lengths. Measurement of image separation, S_1 can be taken at any common point on the object being measured L_1 = fork length.

$$L = \frac{L_1 S}{S_1} \quad (1)$$

was used to determine actual length (L, in this case fork length). In this equation, S is the physical separation of the twin video cameras, S_1 is the separation of the two images measured from the monitor screen between any common point on both images, and L_1 is the image length on the screen. Using video tape records instead of still camera photographs eliminates the possibility of errors due to film advance mechanisms or photographic printing variations.

Quality control or calibration of the measurements were made *in situ* by viewing a portion of the video frame. During transects, the camera operator would position the cameras such that the front vertical leg of the support frame was in the middle of the monitor screen and then trip the stereo switch to record a short segment of double image. Calculated measurements of the pipe diameter were obtained from the monitor screen and then compared to the known dimension of the pipe. Calculated diameter was usually within ± 1% of the known diameter, and determination of fish lengths were not made if the quality check was in error more than 5%. Error in measurement indicated the camera alignment had been altered. In instances when error was greater than 5%, adjustments in camera alignment were made prior to making the next transect.

Determination of Lengths and Widths of Transects

The transects were typically conducted from the top of the reef in clear water down and into soft bottom habitats having turbid waters (Fig. 3-8). The term transect in this case refers to the period between lowering and raising the cameras from the bottom regardless of distance traveled. During the sampling, the camera tripod was maintained between 1/2 and 1 m above the bottom enabling us to view fish in the horizontal plane which enhanced the ability to identify and measure the fish or other objects being observed. Fish were considered outside the transect if they occurred more than about 5 m above the bottom or if they were observed behind a line through the camera which crossed the direction of travel at a 90° angle (Fig. 3-9).

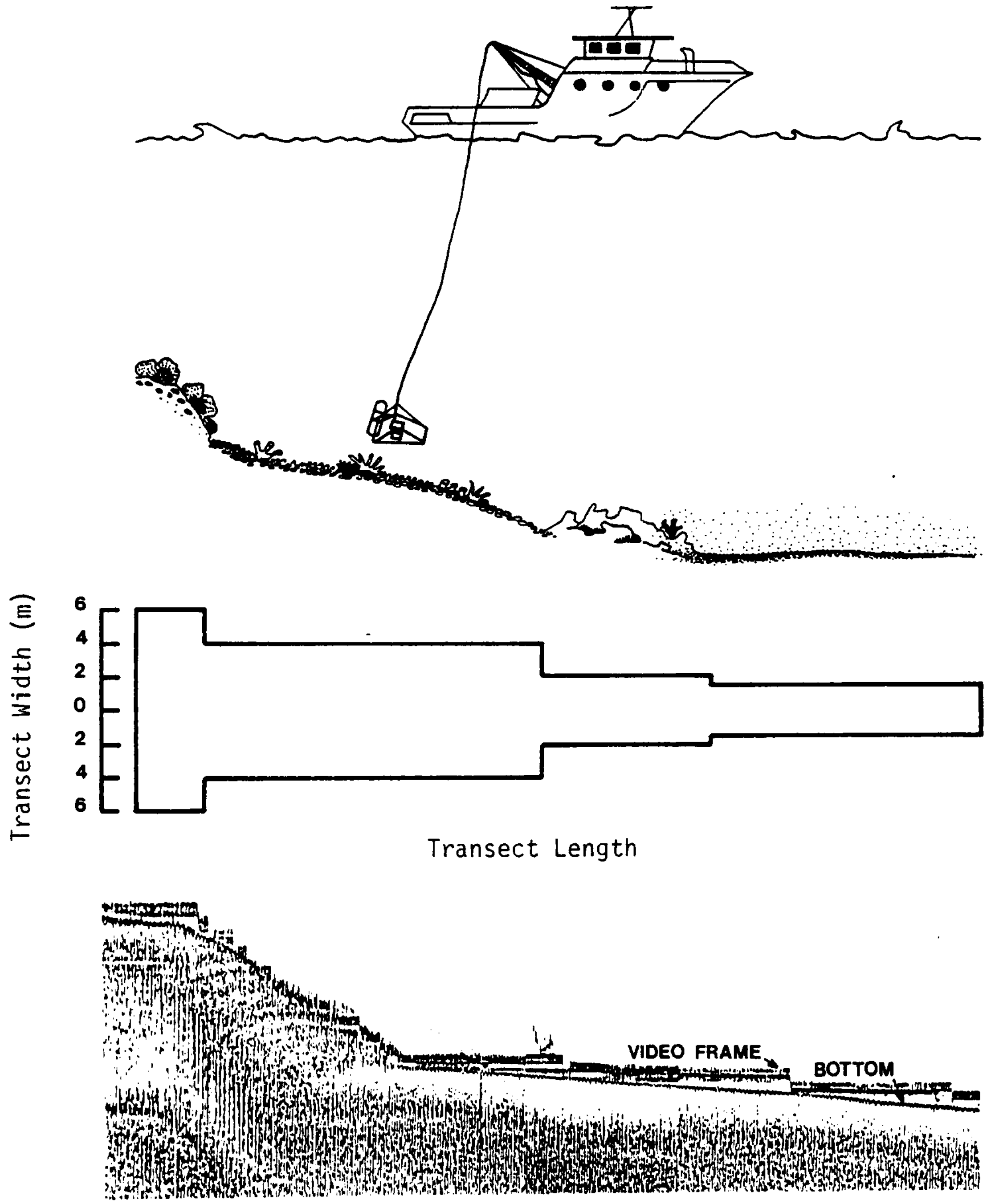


Fig. 3-8. Representation of a typical transect drift over Flower Garden coral reef including actual echo sounder record.

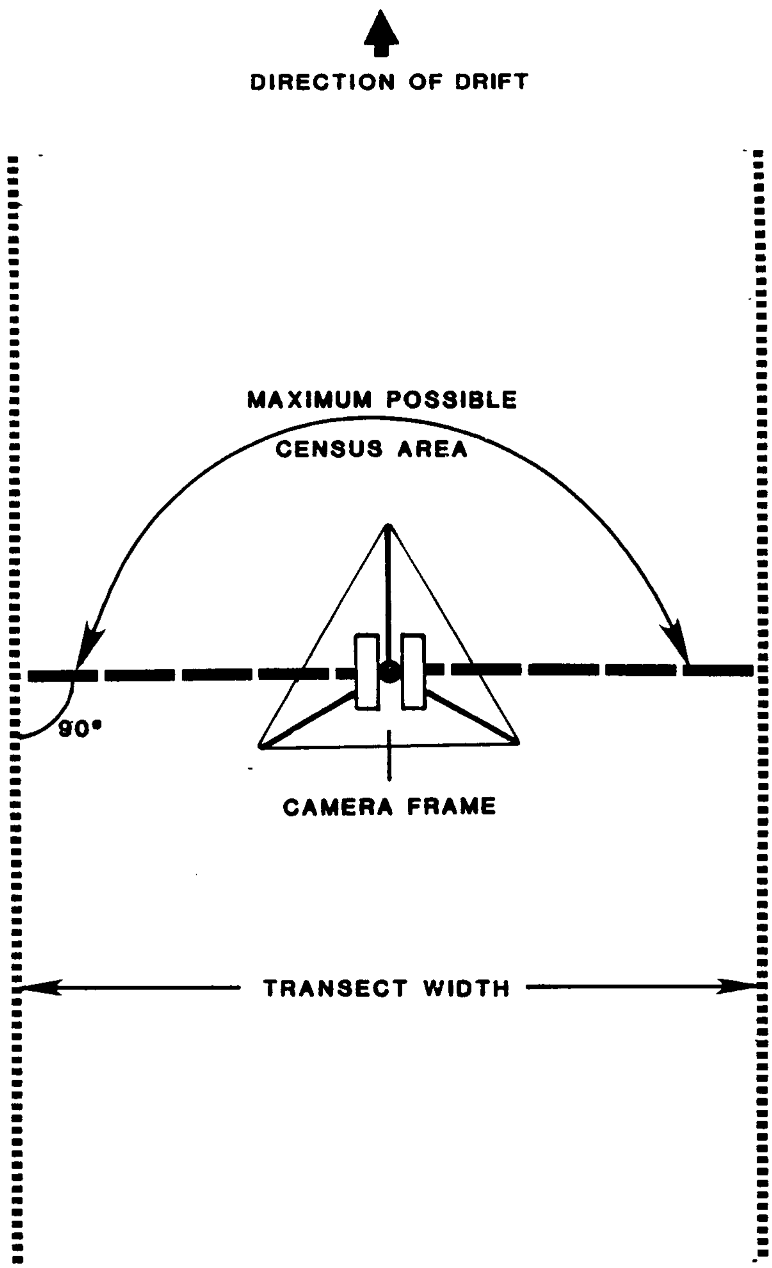


Fig. 3-9. Representation of boundaries for maximum possible area of video census.

Length of the transect was determined using LORAN C in conjunction with ranges and bearings to permanent (at least over the course of this study) offshore structures and detailed bathymetry maps. As shown by Fig. 3-8, the width of the transect varied primarily as a function of depth-related water clarity. Determination of transect width was based upon distance-image separation relationship. The relationship was derived using divers to extend a measured line away from the camera frame which was then viewed in the stereo mode producing a split image on the monitor screen (Fig. 3-10). The measurements of S_1, the image separtion, were recorded at 1-m intervals away from the cameras. The measurement width of the image separation decreases in direct proportion to the distance of the object from the cameras. During a transect, periodic stereo "flashes" of fixed objects perpendicular to the transect drift duration were taken, enabling us to estimate transect width with reasonable accuracy, both in the field and in the laboratory.

All analyses presented in this report are based on numbers of fish per surface area of habitat as opposed to water volume because of the direct correlation of reef fish to habitat area. Numbers of biomass per unit area is characteristic in the literature (Sale 1980, Brock 1954, Russell 1977, Bardach 1959, Goldman and Talbot 1976).

Habitat Delineations

Habitat types represented on the banks were delineated and mapped based upon side-scan sonar mosiacs prepared by Texas A&M University (McGrail et al. 1982). Major modifications to the original chart included:

1. Combining areas classified by McGrail et al. (1982) as high and low diversity upper coral reef into a single type since we could not identify individual coral species.

2. Consolidating patches of hundreds of tightly-spaced, small drowned reef outcrops into a contiguous habitat type.

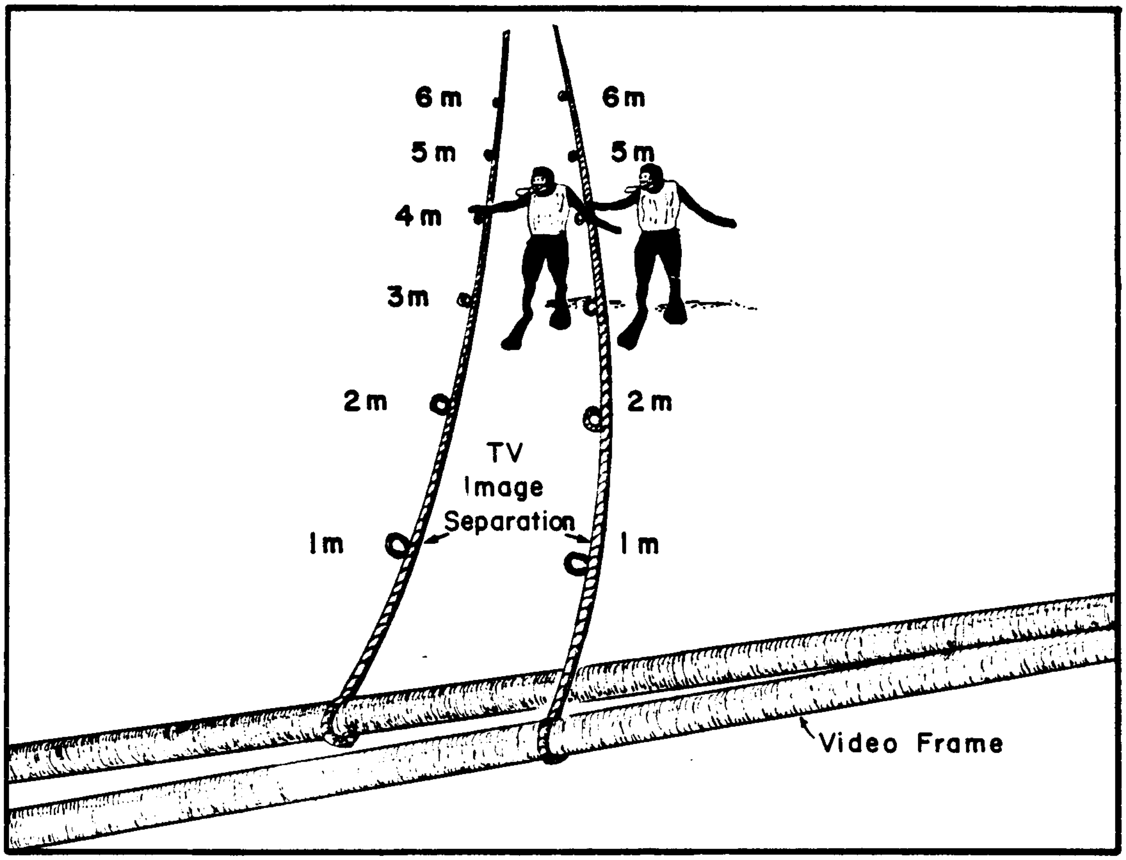


Fig. 3-10. Double image of measured line extending away from video camera frame as it appears on television monitor.

Basically, as described above in the INTRODUCTION section, we grouped all the five delineations of habitat types into five major habitat types.

Type 1 Upper Coral Reef
Type 3 Algal-Nodule Sponge Zone
Type 72 Shallow Drowned Reef
Type 7 Deep Drowned Reef
Type 6 Soft Bottoms

Appendix 3-1 contains a listing of all the other habitat types and subtypes which were delineated, most of which were not presented as a separate entity because of the small areas they represented, and the resulting small sample sizes. Exceptions to this generalization include Type 2 Coral Detritus Zone (includes the "carbonate sand and rubble" zone of McGrail et al. 1982), Type 4 Shallow Transition Zone and Type 5 Deep Transition Zone all of which are included (but not delineated) on the maps and in most of the analyses as part of the Algal-Nodule Zone. These types represent a transition between the upper coral reef (Types 2 and 4) and the Algal-Nodule Zone, and between the Algal-Nodule Zone and soft bottom habitats (Type 5). Structurally, all of these transition types are similar to the Algal-Nodule Zone, even though some were visually distinctive. Data in the above transition zones were analyzed separately to evaluate any differential use of specific areas lumped within our Algal-Nodule Zone habitat type.

Area calculations by habitat were facilitated by digitizing the habitat contours from the base map prepared by Texas A&M University, Department of Oceanography (in McGrail et al. 1982) using a Hewlett Packard HP9874A digitizer. Areas were calculated from the contours using a modified trapezoid rule following Loomis (1975).

Analysis of Videotapes

Videotape analysis was a laborious and time-consuming task due to the wealth of information contained on the visual records. Tapes were viewed in the laboratory using a video tape player and television monitor screen with capabilities for freeze-frame, variable slow motion, double-speed

(2x) viewing and 9x-speed forward and reverse search mode with picture. These features saved considerable time in analysis. The double-speed viewing was used over habitats of very low fish densities. Visual search capabilities aided in passing over segments of off-transect video records or backing up to review segments which required multiple observations. Often a short segment of tape had to be reversed and reviewed up to 10 separate times in order to record the numbers of all fish species present inside the transect. Single-frame capability was necessary for determinations of fish lengths and transect widths as described earlier.

The identification of fish was determined visually by the senior author with identifications confirmed by other LGL biologists and a consultant to the project, Dr. Thomas J. Bright of Texas A&M University. Dr. Bright is considered an authority on reef fish. Fish were identified to the lowest taxon possible and each identification was assigned a quality index ranging from 1-5. A score of 5 was used to indicate that there was virtually no doubt about the identification, a 1 implied that even though a taxon had been assigned, there was a high degree of uncertainty concerning the identification. Quantitative analyses were based on taxa having an index scores of 3-5. The taxa codes and index scores used in this study are described in Appendix 3-2.

Data from each videotape was transcribed onto pre-printed forms having columns for types and numbers of fish observed, depth of each observation, video recorder counter number and time of day. Data were not directly transcribed onto computer forms because of the detailed interpolations, calculations and chart measurements which had to be performed on the preliminary observations before they could be formatted. Other observations of interest were also transcribed and included events such as unusual animal sightings (e.g. sea turtles), animal behavior and geological information such as brine pools and gas seeps.

Once the transcription process was completed for an entire transect, data gaps of depth and time were determined and recorded where voice records were not obtained. Continuous depth information was available from the SIMRAD echo sounder chart records. Using periodic time marks on the echo record and known chart speed, bottom depths were recorded for each minute of transect time. Gaps in time of day records were determined using the video recorder counter numbers. A table was prepared prior to the analyses, listing the counter number and elapsed minute for the two full hour duration of a video cassette. Using this table, the exact time could be interpolated for any counter number using the previously voice-recorded time checks made in the field.

The next step in the analysis was to map the transect. One of the thirty habitat types (Appendix 3-1) was assigned to each segment of the transect. Each transect was individually plotted onto a clear plastic overlay of a detailed bathymetric chart of the appropriate bank using the LORAN C fixes which had been taken at 5- or 10-min intervals on the ship's bridge during the cruise. Radar ranges and bearings to the Mobil platform had also been taken during each time interval and were used as a quality control check for position in case of LORAN shift. The total transect was divided into individual habitat segments using known times along the transect and the start and end times for each habitat.

The latitude and longitude was measured and recorded for each habitat start and end point along the transect. The transect length of each habitat type crossed was determined from the chart by calipers using the map scale of 1 inch (25.4 mm) = 1000 ft (304.8 m). The width of each habitat segment was then determined from the dual image calculations as previously described. Actual width calculations and operator comments were recorded on the transcripts.

Other information recorded on data sheets included depth of individual observations, minimum and maximum depth ranges for each habitat type, identification quality index and quadrat number. The quadrat system (Fig. 3-11) was developed for use in comparing densities of fish in specific habitats in "control" and "affected" areas around the platform. Each quadrat was essentially a segment of a circle having the center point on the top of the East Flower Garden coral reef. Two circular bands of five segments each were formed, dividing as closely as possible to two bands on either side of the major break in benthic communities around 80-85 m (Fig. 3-11). The Mobil drilling platform (PLB) was located in the middle of the center segment (#3) in the outer band of quadrats.

Once the data transcript was completed all data were recorded on computer coding forms. As a result of analyses by time and area, the data set included a great deal of information, including a transect size for

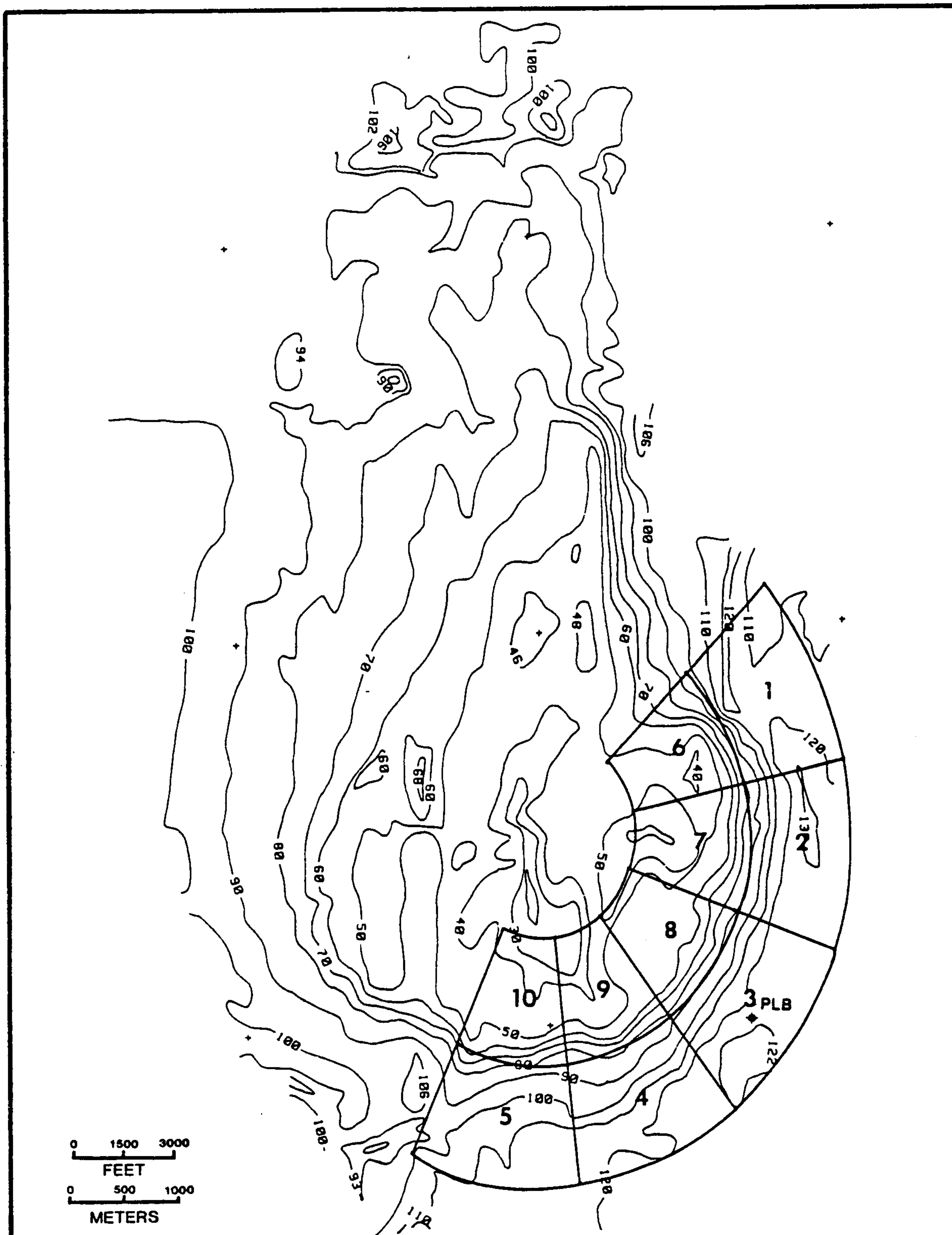


Fig. 3-11. Location of sampling quadrats #1-10, East Flower Garden Bank. (Some distortion resulting from conversion of sphericial coordinates to linear coordinates for plotting purposes.)

each minute of observation time with corresponding data describing fish density, depth and specific habitat type.

DATA MANAGEMENT AND ANALYSES

All data collected by LGL as part of this project were submitted to the Project Data Manager (Mr. Jack Foreman, NOAA/EDIS, Washington, D.C.) on tape No. B19250. The data tape is an unlabeled 9-track tape with 1600 bpi. The blank-filled logical record size is 80 and the fixed block size is 6160. The data are organized into 12 files containing a total of 38,429 records. Documentation for each file format was provided at the time of data submittal. Data loading forms are provided in Appendix 3-3.

Data Management

Data were recorded on computer coding forms and on a Tri-Data Flexifile 21 Data Entry/Maintenance System before being transferred to project designated data files on Texas A&M University's Amdahl system. This not only saved costs in terms of data entry and storage on the mainframe, but also provided a temporary back-up data disc. Hard-copy printouts of the data files were obtained via an NEC Spinwriter (printer) and were keypunch-verified for entry errors. Following correction of any keypunch errors, revised hard-copy printouts were obtained and provided to project investigators for validation. Errors noted were corrected on the data files and the data were considered ready for analyses. Any subsequent errors discovered during the analyses were corrected such that at time of submission to the project Data Manager, errors remaining on the tapes, if any, were considered to be minimal.

Density Calculations

In order to compare and describe raw abundance of fish over habitats and depths, counts were converted to density per 1000 m^2. As was detailed in the videotape analysis section, the depth was recorded for each fish encountered. To compute the area transected at given depths the average depth of a minute of transect time was computed on the basis of fish observed in that minute. The area transected for that minute was then accrued to the average depth. For the majority of transected minutes, the depths of encountered fish were constant and thus the average depth was an exact measure of depth within that minute.

In some habitats having relatively low fish density (e.g. soft bottom, algal nodule zone, etc.) entire minutes of transect time were devoid of fish and thus the technique of averaging depth was not useful. In this case, the depth of that minute was estimated by interpolating between depths of adjacent minutes. Overall, this approach for determining area transected over depth increments, while not as accurate as continuous measurement of depth, yielded quite reasonable depth density estimates.

In an effort to eliminate the high variability in the depth density distributions, and to reflect the intuitive feeling that density of fish as a function of depth was smooth, a three point moving average was performed on the depth density distributions. This smoothing process appears in the graphics of raw density by depth only.

Statistical Models

Most of the reef fish population data which were collected on this project consisted of minute-by-minute counts of fish within a total transect area which was subdivided by habitat type and depth of observation. Count data typically require some transformation prior to any comparative statistical analyses in order to normalize variance. The type of transformation which is appropriate depends upon the type of statistical model or distribution represented by the data. Additionally, knowing the appropriate distribution of the abundance data was critical to being able to estimate population sizes with reasonable confidence. Thus, the first step in the analysis of the fish abundance data was to critically examine the data in order to determine the appropriate statistical model or distributional form of the abundance data.

A range of distributional forms for fish abundance patterns are possible due not only to the heterogeneity in abundance patterns across different habitat types, but also due to local differences in environmental factors (e.g. temperature, salinity, prey abundance, etc.)

within a given habitat type. The video assessment methodology provided a unique opportunity to observe and measure patterns of fish abundance and spatial variability in these patterns.

Many indices have been proposed for use as diagnostics to determine the statistical models represented (see Ripley 1981). Of these, we chose two, following Douglas (1975):

(1) Index of Cluster Size (ICS) = $(s^2/\bar{x})-1$

(2) Index of Cluster Frequency (ICF) = $\bar{x}[(s^2/\bar{x})-1]^{-1}$

where $\bar{x}$ and s^2 represent the sample mean and variance of the number of fish for quadrats of equal size, respectively. The use of the sample variance to mean ratio as an index of clustering has a long history dating to Fisher et al. (1922).

The diagnostic ICS was used to differentiate gross features in spatial variability assuming that

(1) if ICS<0, then individuals were regularly spaced
(2) if ICS = 0, then individuals were randomly spaced
(3) if ICS>0, then individuals were clustered or clumped

following Ripley (1981).

Given that ICS was negative only once out of 500 trials, the possibility for a distribution of regularly-spaced individuals was ignored. The Poisson process (see Pielou 1977) was selected as the appropriate stochastic model in instances where the ICS value of zero indicated a spatially random distribution, again following Ripley (1981).

There are several distinct, stochastic models for clumped or clustered distributions which are indicated by large (positive) values of ICS. We, following general custom, made the tacit assumption that a large value of ICS indicated a negative binomial distribution and restricted our clumped or clustered models to those yielding a negative binomial distribution.

The two models of this kind which yield negative binomial distributions are the Rate Varying Poisson Process and the Clustered

Poisson Process. The former is a simple adaptation of the Poisson process. It assumes that the distribution of individuals is spatially random but that the rate of the Poisson process is a random variable assumed to have a gamma distribution. This allows for the possibility that individuals are present in higher density in some areas than in others; i.e. the rate varies from area to area. Because of the generality of this model, it fits a large portion of the data. This model has wide application in many fields (see Ripley 1981) and its application to video census of reef fish was made by Gazey (1983).

The clustered Poisson process is a model appropriate for distributions which are strongly clustered or grouped as, for example, in the case of the "clouds" of small tropical reef fish in the vicinity of certain bottom features. A clustered Poisson process assumes that there are clusters of fish randomly distributed in space with the centers of each cluster positioned in space according to a Poisson process. Additionally the number of fish in each cluster is assumed to follow a log series distribution. As noted, this also yields a negative binomial distribution for counts. However, the parameterization procedure for this model is different than that for the rate varying Poisson model (see Appendix 3-4). Therefore, this model had to be identified and treated separately for the parameter estimation procedure.

The statistic ICF can be used in conjunction with ICS to distinquish between the two models yielding negative binomial distributions (Ripley 1981). The varying rate Poisson process can be identified when

$$ICS \approx W/p$$

and

$$ICF \approx k$$

where W = quadrat size, p = gamma scale parameter and k = gamma shape parameter; and the clustered Poisson process can be identified when

$$ICS \approx \alpha/(1-\alpha)$$

and

$$ICF \approx W\lambda/[-\log(1-\alpha)]$$

where W = quadrat size; α = log series parameter and λ = Poisson rate. In other words, when ICF is constant and ICS is proportional to quadrat size, then the rate varying Poisson model is indicated. When ICS is constant and ICF is proportional to quadrat size, then the clustered Poisson model is indicated. Thus, when ICS and ICF were calculated for a range of quadrat sizes, the joint behavior of the two indices with respect to quadrat size could be used to discriminate between the two models. It should be noted that more complex models might have been more appropriate than the ones which were used. However, the three models given (Poisson, rate varying Poisson and clustered Poisson) appeared to describe a major portion of the fish distribution patterns observed.

For computation of the diagnostics, two aspects of the data were critical to the analyses. One aspect was that relatively large samples of similar sized quadrats be available, and the other was that a variety of quadrat sizes were also available in order to examine the variability of the diagnostics with respect to quadrat size as described above. These criteria were achieved in that for each habitat encountered, a strip transect of constant width could be constructed and divided into replicates of equal size using the minute records (see above section on videotape analysis). Because the habitats encountered along a strip transect varied in length depending upon where the habitat was encountered and in width depending upon water clarity, a large array of quadrat sizes were thus available for analysis.

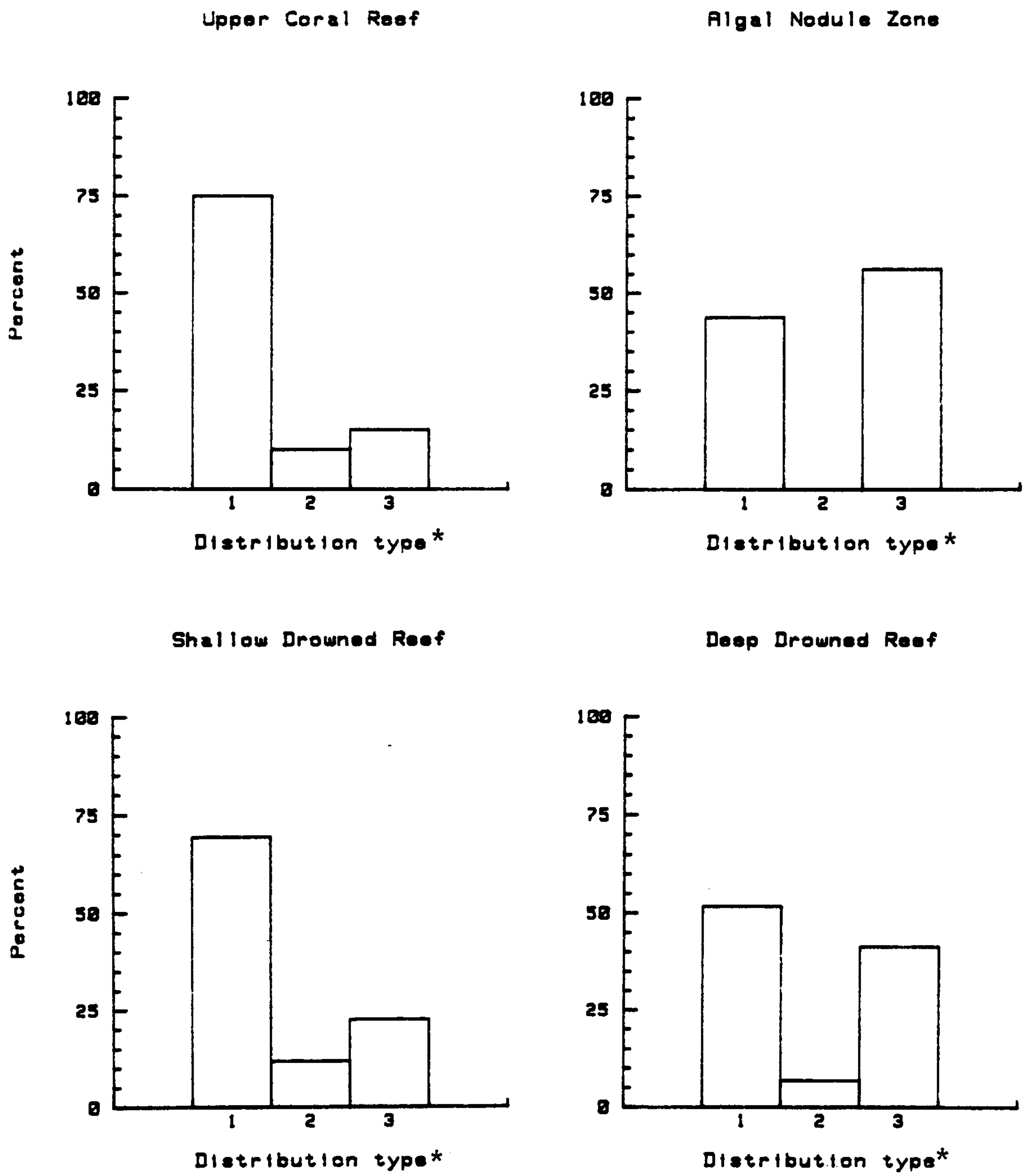
In practice, a chi-square test for ICS = 0 ($P \leq 0.01$) was used initially to separate Poisson distributions from negative binomial distributions. The distributions indicated as being Poisson were then further tested to determine if the rates varied significantly among transects using a likelihood ratio test for equality of rates (derived following Rao 1973), again using $P \leq 0.01$. This test enabled delineation of transects having a negative binomial distribution resulting from the rate-varying Poisson model. For the distributions initially classified as having a negative binomial distribution, a Kendalls tau test was completed for ICS versus quadrat size, and ICF versus quadrat size. In cases where ICS was more correlated with quadrat size than was ICF, a random rate Poisson model was indicated; and in the opposite case, a clustered Poisson model was indicated. Examples of the model identification process follow.

The first set of examples represent data for the bigeye (Priacanthus arenatus) taken in Shallow and Deep Drowned Reef Habitats during Cruise 5. A total of 54 replicates were obtained for Shallow Drowned Reef Habitats with the area of the strip transects ranging between 200 and 13,309 m^2 in size and having density values ranging between 0 and 0.01 fish/m^2. In the Deep Drowned Reef 11 replicates were obtained with the replicates ranging in size from 160 to 4340 m^2 with the associated density rates ranging between 0 and 0.035 fish/m^2. In each case, ICS was not significantly different from 0 indicating a Poisson model. For Shallow Drowned Reef Habitat, the chi-square statistic for the likelihood ratio test for equality of intensities (densities) was 74.125, which was not significant at the $P \leq 0.01$ level given 53 d.f., thus confirming the Poisson model.

However, the chi-square statistic for data from Deep Drowned Reef Habitat was 115.481 (significant at $P \leq 0.01$ and 10 d.f.) suggesting that the appropriate model for these data was a rate varying Poisson process. A different statistical model was suggested for the same species but in different habitats.

Data for the creole-fish (Paranthias furcifer) and brown and blue chromis (Chromis spp.) taken on Cruise 6 in the Upper Coral Reef Habitat each had ICS values significantly greater than 0, suggesting a negative binomial model. ICS values for the creole-fish were significantly correlated with quadrat size (Kendall's tau = 0.3142) but the ICF values were not (Kendall's tau = -0.142) suggesting the rate varying Poisson model for the negative binomial distribution was appropriate. The converse was true for Chromis spp. (Kendall's tau for ICS to quadrat size was -0.1212 whereas for ICF the value was 0.409, significant at $P \leq 0.011$) suggesting the cluster Poisson model.

Data for a total of 134 species-habitat-cruise combinations were analyzed to determine the appropriate model represented. The results of these classification tests were of interest in themselves and are depicted by Fig. 3-12. Spatial distributions of fish in the Upper Coral Reef and Shallow Drowned ReefH habitats were strongly clumped, typically following a rate varying Poisson Process. In contrast to these two high-relief habitats, spatial distributions of fish in the low-relief Algal-Nodule Zone were of a Poisson type over 50% of the time, indicating a comparative reduction in clumped distributions. In the Deep Drowned Reef Zone, both



*Distribution types: 1) Negative Binomial (Rate varying Poisson process)
2) Negative Binomial (Clustered Poisson process)
3) Poisson (Poisson process)

Fig. 3-12. Relative frequency of three distribution types for 134 species/habitat/cruise combinations (four major habitat types), Cruises 5-8, East Flower Garden Bank.

Negative Binomial and Poisson distributions were observed with Negative Binomial distributions representing about 59% of the total cases. What these data show are that clumped distributions are associated with high-relief habitats whereas the distributions over low-relief habitats are more random in nature.

Cluster Analyses

The cluster analysis consisted of three distinct steps. They were (1) taxa deletion, (2) clustering and inverse analyses and (3) nodal analyses. Typically, a large number of taxa were observed for each set of classifications (depths, habitats, etc.). In an effort to reduce the number of taxa to a manageable yet descriptive set, very rare taxa were deleted. The approach to taxa deletion was through the use of a rarefaction curve (Fig. 3-13). The rarefaction curve was computed by counting the number of taxa remaining after deletion of those taxa having a total density over all classifications less than a given percent of the density for all taxa. For example, at deletion level 0%, all taxa would be retained in the analysis, whereas at 100% deletion no taxa would be used. The choice of an appropriate deletion level was made on the basis of a desire to retain most of the data, but to restrict the analysis to a "reasonable" number of taxa. The selected deletion levels chosen appear in figure titles of each dendogram presented. The deletion level ranged between 0.0004 and 0.0005%.

Cluster analysis and the corresponding inverse analysis was performed on three major combinations of cruises to obtain overall community descriptions and to define relationships of classifications to temporal and spatial dispersions of species. Fish density was the attribute used for all clustering, i.e. the density of a given species with a particular classification (depth, habitat and cruise) was used as a replicate for that classification. Because of its demonstrated utility, a Bray-Curtis metric with a complete linkage algorithm was used for clustering. The Bray-Curtis metric is a particular distance measure for determining the similarity of two classifications. Complete linkage refers to the technique of determining the similarity of two classification clusters as a function of their least similar entities.

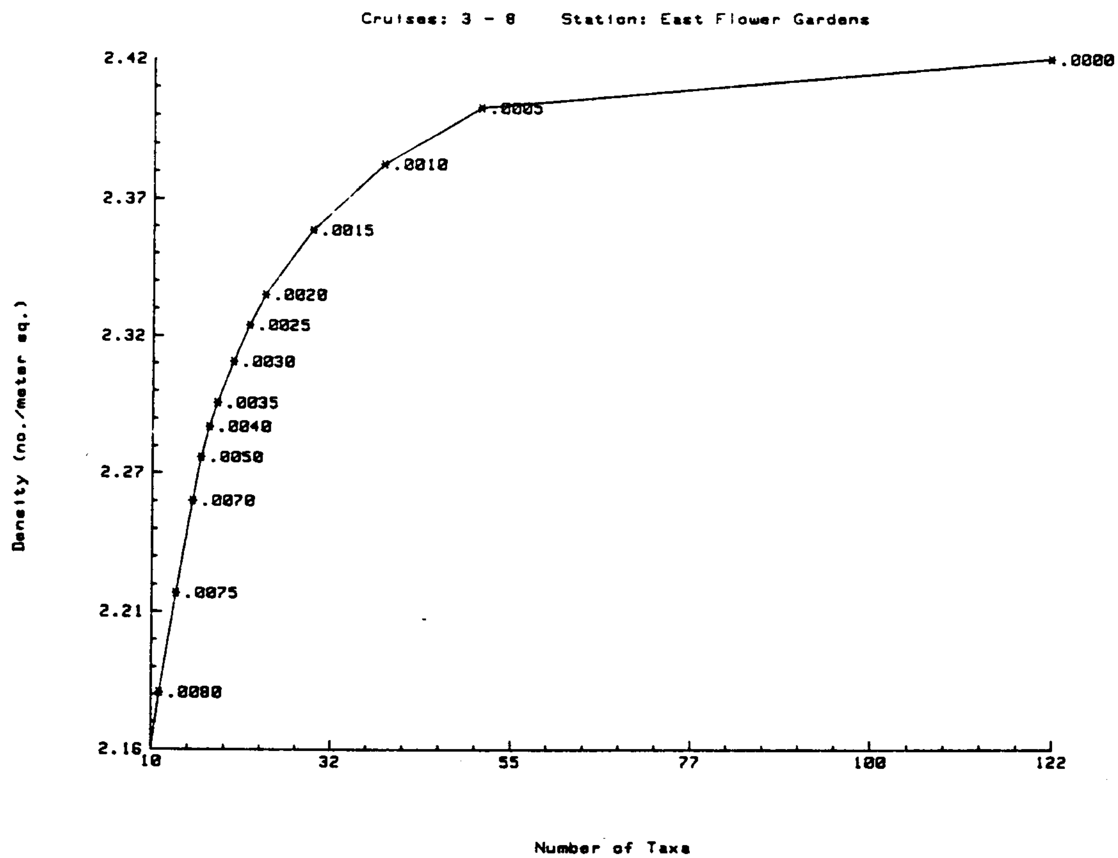


Fig. 3-13. Example of species rarefaction curve for species density by depth, Cruises 3-8 East Flower Garden Bank.

As an aid to interpretation of the clustering of both classifications (depths, habitats etc.) and species, a two-way nodal analysis was performed (Boesch 1977). This analysis consisted of three, two-way tables. First was the standard two-way coincidence table indicating only the presence or absence of a particular species in a given classification or a "contingency table". After the selection of major clusters for classifications and species was made, two more tables were generated. They consisted of measures of species constancy and fidelity within classification clusters.

Constancy is a measure of the proportion of the number of species in a species cluster that appeared in a classification cluster, to the total possible number of such occurrences. That is, to what extent did all of a given set of species occur in a set of classifications. The computation formula for constancy is given in Boesch (1977).

Similarily a two-way table of fidelity was generated. Fidelity of a species is a measure or indication of the degree to which a given species group "selects" for a given classification, habitat for example. A simple measure of fidelity is relative constancy; i.e. the constancy for a particular classification compared to the constancy over all classification groups. Again the computational formula may be found in Boesch (1977).

Community Summary Statistics

Community summary statistics were computed by depth and within habitat types on a cruise-by-cruise basis. These indices included

1. total numbers of taxa,
2. total numbers of individuals,
3. density as numbers of individuals per 1000 m^2,
4. diversity ($\hat{H}'$) as the maximum likelihood estimate of the diversity function (H') defined by Pielou (1977), and
5. evenness ($\hat{V}'$) as the maximum likelihood estimate of the evenness function (V') defined by Fager (1972).

Diversity ($\hat{H}'$) and evenness ($\hat{V}'$) were computed for each cruise or each habitat type using density in numbers/1000 m^2 (rather than absolute abundance) to normalize values and to minimize the effects of unequal areas transected. In order to compare $\hat{H}'$ and $\hat{V}'$ within habitat types between cruises, replicates were assumed to be segments of the same habitat type within individual transects. For example, if on a transect Habitat Types 1, 3, 4, 3, and 6 were encountered in sequence, Habitat Type 3 would be considered to have been represented by two replicates and the other habitat types by one replicate. All replicates of the same habitat type were then pooled within cruises to give a total number of replicates of each habitat type per cruise (Table 3-3). The potential weakness of this procedure is that an estimate of density (or derivative indices) is, in fact, less informative when based upon small areas or numbers of replicates than upon large areas or numbers of replicates (e.g. 1 fish/100 m^2 vs. 100 fish/10,000 m^2 both yield the same density estimate of 10 fish/1000 m^2). However, habitat types were sufficiently discontinuous throughout the lengths of the transects that the number of replicates of each habitat type was positively correlated with the area transected, indicating that this working definition of replicates was reasonable. Where the number of replicates was inadequate for an estimation of $\hat{H}'$ or $\hat{V}'$ for comparison purposes, they were not included in either the nonparametric main-effects analysis [Kruskal-Wallis ANOVA (Kruskal and Wallis 1952)] or the multiple range test [Nemenyi procedure on average ranks (Barnett and Wolfsen 1983)].

Community summary statistics are provided only for Cruises 3-8 (Table 3-3). On Cruise 1, the video survey techniques were being developed, and the data collected on that cruise are qualitative only. On Cruise 2, only the West Flower Garden Bank was surveyed.

Population Estimates

One of the objectives of the model selection procedure detailed above was to enable correct parameterization of the abundance distributions in order to estimate standing stock levels and confidence intervals for the estimates. Because of the desire for efficient estimates (small variance), the approach to estimation was by means of maximum likelihood.

Table 3-3. Total number of transect replicates by cruise* and habitat type.

Habitat Type	3E	3W	4E	4W	5E	6E	7E	8E
1	67	23	68	36	142	184	188	150
2	6	4	1	0	7	0	0	1
3	10	48	9	58	130	138	180	145
4	14	5	39	6	34	76	43	42
5	10	12	3	9	20	12	26	23
6	11	47	20	56	126	105	100	79
7	1	43	0	42	42	39	35	29
72	2	34	19	44	146	173	220	196

*E = East Flower Garden, Cruises 3-8; W = West Flower Garden, Cruises 3,4.

Maximum likelihood estimation has several features which make it very attractive. First, maximum likelihood estimates are typically consistent; i.e., they tend to yield the correct values when they are based upon large sample sizes. Second, when based upon large sample sizes they are fully efficient estimates (i.e. they have the smallest variance among the class of unbiased estimators). Since 1-minute counts represented replicates and a large number of minutes were available on a cruise-by-cruise basis, maximum likelihood estimation should generate good accuracy and precision.

Maximum likelihood estimation procedures are mathematically complex. Because of this, the estimation procedures are not presented here, but are defined fully in Appendix 3-4. Of the three models used, the Poisson has a closed form estimate whereas the other models are not closed form. The latter therefore require numerical maximization. Despite the complexity of these procedures, the resulting improvements in the accuracy and precision of the estimates as compared to those obtained by simpler methods certainly warrant their use. Replicates for the maximum likelihood estimates of standing stock were provided by the minute records (detailed in the videotape analysis section). To reduce the amount of correlation between replicates, 5-minute blocks of counts were used, which approximates random sampling of transects.

Data Transformations and ANOVAS

Parametric ANOVA's were used to compare fish densities in time and space with a view towards determining the effects of the discharges of drill muds and cuttings. In a theoretical context, it can be shown that the mean density of fish for a large sample size is normal (see Serfling 1980) with the mean and variance dependent on the underlying distribution of fish. To allow for a comparison of mean density, it is required that the variance not depend on the value of the mean. Because this does occur for the underlying distributions observed prior to analyses of this data, an appropriate transformation for each underlying distribution was applied. For data showing a Negative Binomial distribution, the (applied transformation was $\log_e$ (density + 1). Data having a Poisson distribution were transformed using $2\sqrt{\text{Density}}$. To allow for comparisons among cruises which were characterized by data having different distributional forms (a situation that seldom occurred), a single distribution was obtained by a re-analysis of the model diagnostic using the aggregate of data for all cruises within each species-habitat combinations.

To reduce the data to a manageable number of replicates (for Cruises 5 through 8 there were in excess of 2500 minutes for each cruise) and to reduce the possible correlation between replicates in the rate-varying Poisson model, 5-minute blocks were used as replicates for all comparison procedures. The use of 1-minute and 5-minute blocks are equivalent to random sampling of transects in cases of the Poisson and clustered Poisson models due to the properties of those models [independence of the number of fish in disjoint areas (Pielou 1977)]. In the case of the rate-varying Poisson model, the lumping of 1-minute blocks reduces the effect of local fluctuations in the rate and thus reduces correlation between replicates which approximates random sampling.

In addition to the main effect tests, Duncan's multiple comparison procedures and sets of orthogonal contrasts were used to determine specific differences among cruises, seasons and quadrats.

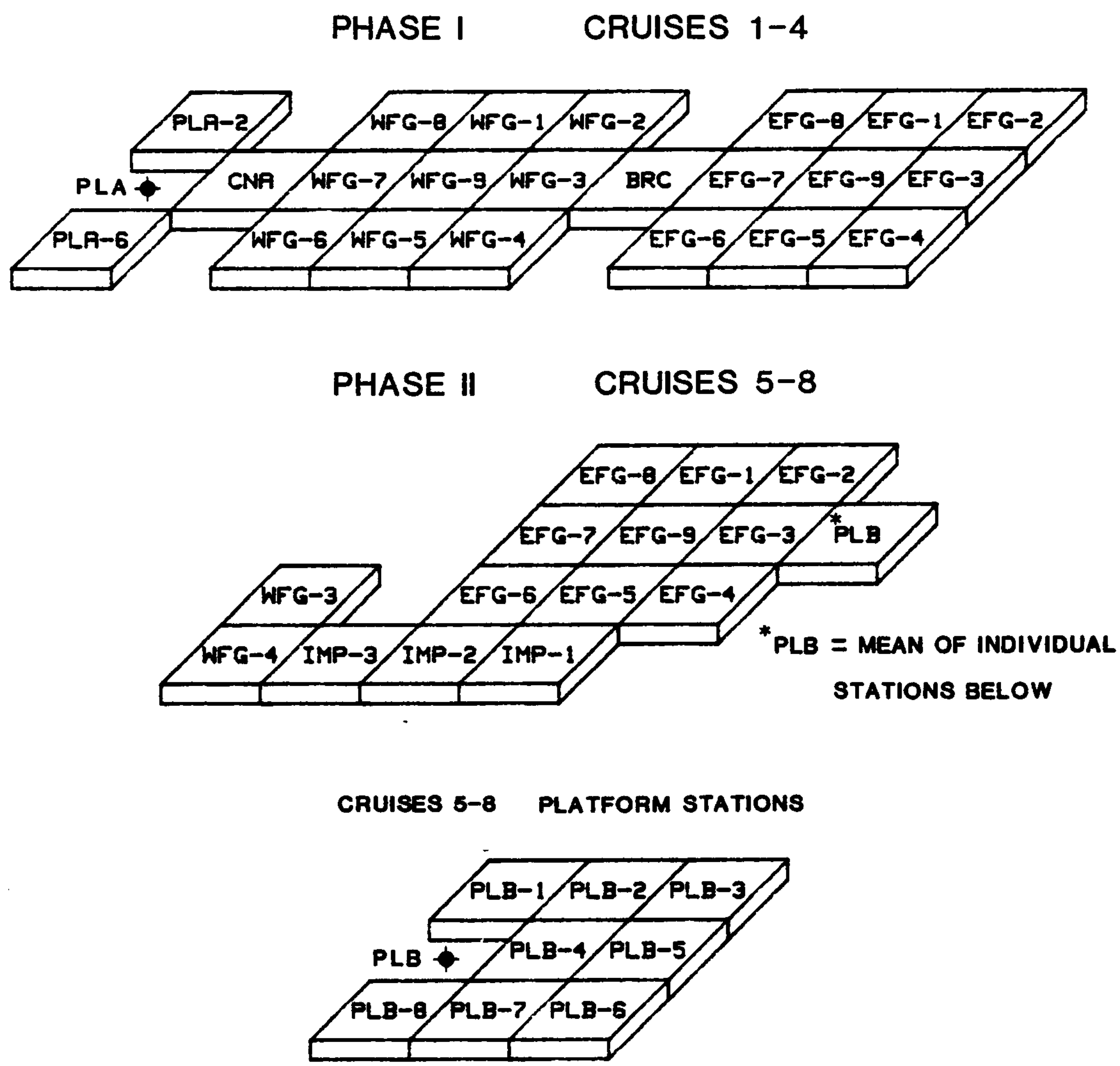
SECTION 4

OCEANOGRAPHY RESULTS AND DISCUSSION

GENERAL INTRODUCTION AND FIGURE DESCRIPTION

Complete hydrographic data from this project have been stored on magnetic tape in a standardized format with the Project Data Manager at NOAA/EDIS. In the interest of brevity, these data have not been included in this report. Rather, a quantitative set of synoptic, graphical summaries have been provided for each parameter measured. Each figure has been designed to present a very large amount of information in compact, easily interpreted form that allows immediate, simultaneous visual comparisons between measurements at different locations at the same depth, and between depths. Following a description of the graphics, the results are summarized in narrative form for each parameter, describing some of the trends and patterns evident in the figures.

Each stack of graphics represents a set of complete vertical profiles from one cruise. Figures showing several stacks thus contain information from several cruises. The number of vertical profiles in each stack varies depending on the scale of the illustration. Each square within every level of a stack is symbolic of a single depth at a single sampling station. Depths are given along the left edge of each stack. The sampling array has been reduced to a Cartesian grid designed to place squares in positions roughly corresponding to the spatial orientation of the stations which they represent vis a vis one another (see Figs. 3-1 to 3-3 for station maps). Figure 4-1 is a key to the illustrations, showing which squares pertain to which stations. Within each square, increasing density of shading indicates increasing values of the parameter being illustrated, and the scale at the bottom of each figure shows the values to which the shading equates. Asterisks within squares indicate that no data were collected for that depth at that station. For example, the central squares of both nine-square arrays on the two banks only show data down to a depth of 20 m, below which the coral reefs on top of the banks were encountered. Consequently, an asterisks may mean either that data were



Key

PLA - Platform A MO-HI-A595-D
PLB - Platform B MO-HI-A389-A
EFG - East Flower Garden Bank
WFG - West Flower Garden Bank
CNA - Control (between platform A and WFG)
BRC - Between reef control
IMP - Impact

Fig. 4-1. Schematic station legend for all hydrographic figures (see Figs. 3-1, 3-2 and 3-3 for actual positions).

missing or suspect for some reason (e.g. equipment failure), or that a limiting depth was reached at a shallower level.

For each parameter measured (temperature, salinity, density, dissolved oxygen, and transmissivity, respectively), schematic drawings are presented in the following sequence:

1. The entire sampling array for Cruises 1-4, on which nine East Flower Garden stations (EFG 1-9), nine West Flower Garden stations (WFG 1-9), two stations near Platform A (PLA 2 and PLA 6), the station between the banks (BRC), and the station (CNA) between the PLA and WFG stations were sampled;

2. The sampling array for Cruises 5-8, i.e. the nine East Flower Gardens stations (EFG 1-9), a single block representing Platform B (PLB, summarizing averaged values from eight stations very near the platform), three "Impact" stations (IMP 1-2), and two West Flower Garden stations (WFG 3-4); and

3. The eight sampling stations adjacent to Platform B (PLB 1-8) that were sampled on Cruises 5-8, and which are represented together as a single square described in 2).

Temperature

On the first cruise (fall), water temperatures were fairly uniform from one station to the next at the same depth level over the entire study area (Figs. 4-2). A thick mixed layer extended downward to a thermocline at about 60-70 m, below which temperatures dropped slowly at the deeper stations. One station (EFG 5, located to the south of the East Flower Garden Bank) showed anomalously high temperatures near the bottom (100-120 m) despite lower temperatures in shallower water (e.g. at 90 m). Table 4-1 summarizes overall means by depth and cruise.

On Cruise 2 (winter), the water column appeared well mixed from surface to bottom at most stations surveyed (the West Flower Gardens

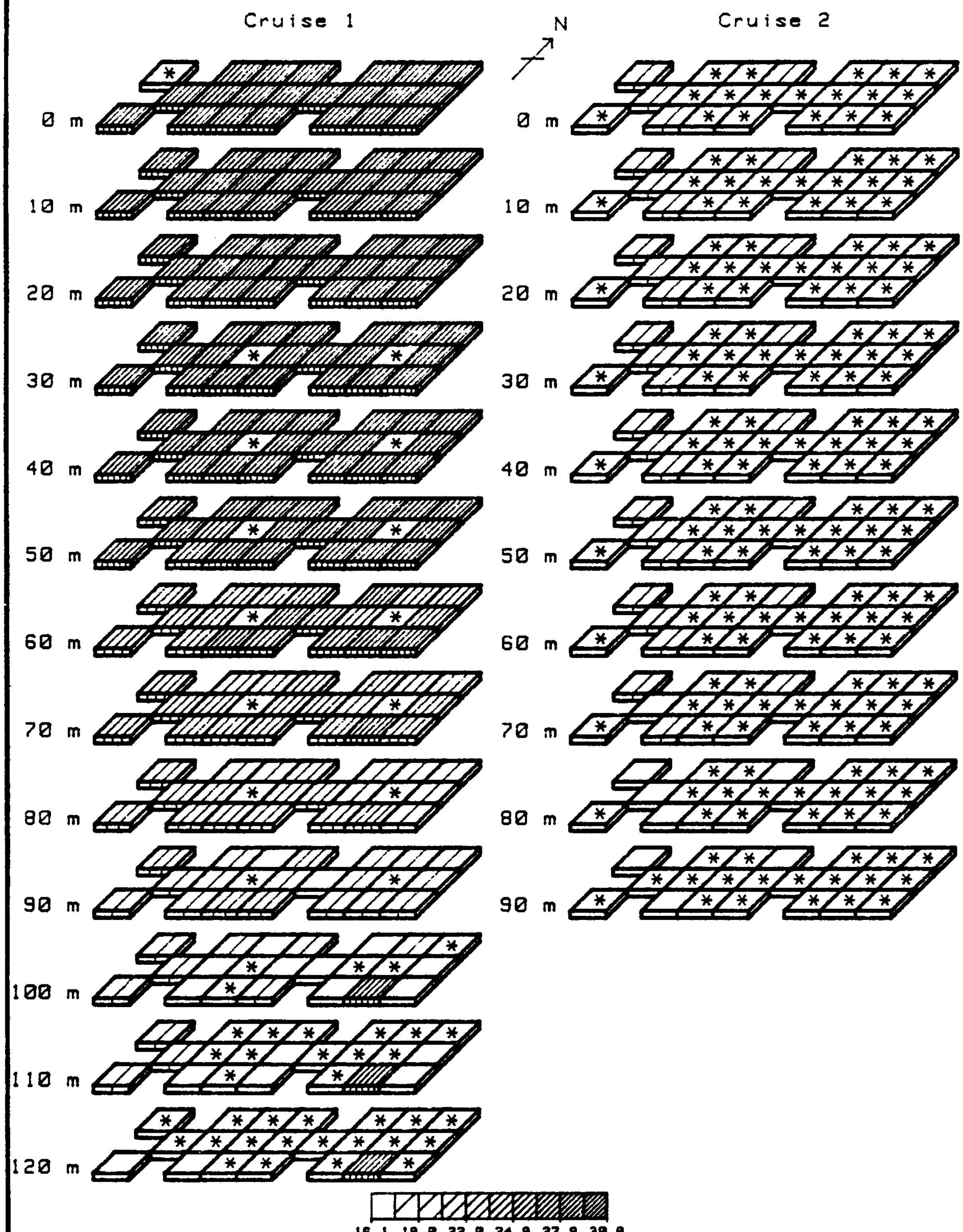


Fig. 4-2a. Temperature (°C) for Phase 1 stations by depth, Cruises 1 and 2 (*: no data).

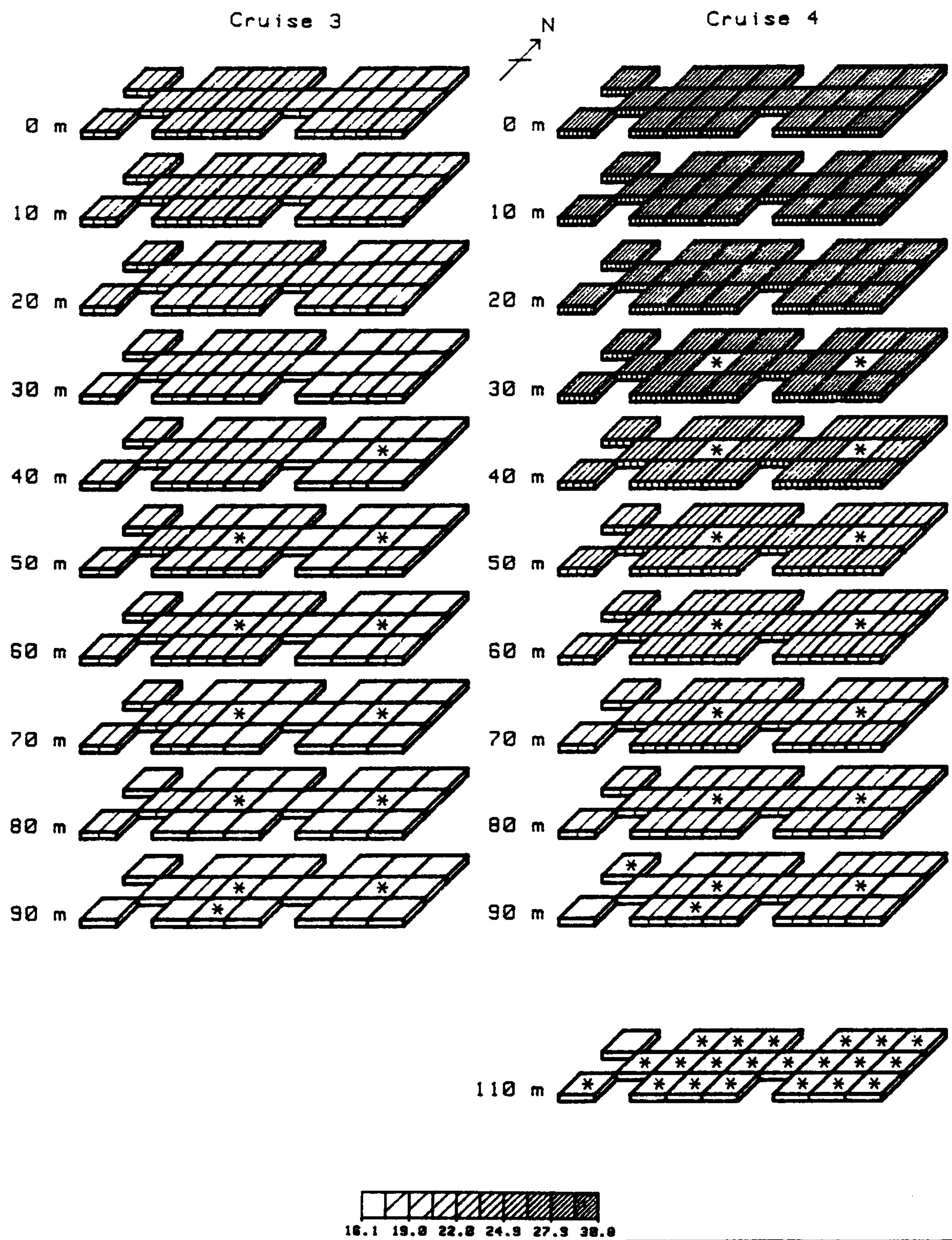


Fig. 4-2b. Temperature (°C) for Phase 1 stations by depth, Cruises 3 and 4. (*: no data).

Table 4-1. Temperature (°C) means by cruise and depth, for all stations together.

	Cruise							
	Phase I				Phase II			
Depth (m)	1	2	3	4	5	6	7	8
0	26.75	20.61	21.07	30.07	25.61	25.36	28.91	26.76
10	26.82	20.54	20.78	29.92	25.58	24.91	28.91	26.77
20	26.82	20.44	20.32	29.64	25.64	23.60	28.29	26.75
30	26.75	20.34	19.75	28.69	25.69	22.15	23.69	26.72
40	26.71	20.18	19.47	25.42	25.51	21.11	21.71	26.60
50	26.36	19.95	19.42	23.01	23.72	20.32	20.54	22.97
60	24.80	19.76	19.18	21.81	22.06	19.67	19.76	21.38
70	23.02	19.29	18.84	20.98	20.95	18.80	18.97	20.60
80	21.27	18.59	18.51	20.22	18.94	18.05	17.36	19.87
90	20.13	18.29	18.14	19.43	18.79	17.33	15.65	18.87
100	19.79	-	-	-	-	-	-	-
110	19.59	-	-	18.03	21.45	-	-	-
120	21.20	-	-	-	-	-	-	-

mainly), though there were many missing data points. Temperatures were much lower at corresponding depths in the upper water column than on the previous (fall) cruise. Unfortunately, sampling did not extend below 90 m on this and subsequent cruises in the region of EFG 5, so it was not possible to determine if the high-temperature zone discovered on the first cruise was persistent in time.

On Cruise 3 (spring), a warming trend was evident in surface waters, with a shallow thermocline at about 20-30 m. The West Flower Garden Bank (especially the western edge and the area around Platform A and the CNA site) had somewhat warmer temperatures than did the East Flower Garden Bank at most depths.

On Cruise 4 (summer), strong thermal stratification was evident throughout the area, with a thermocline located at about 40-50 m. Below this depth, temperatures dropped steadily near the bottom. The slightly warmer temperatures encountered during Cruise 3 in the western portions of the study area were not obvious during Cruise 4.

On Cruise 5 (fall), (Fig. 4-3) strong thermal stratification was still present, with surface waters well mixed to a depth of about 50-60 m at all stations but one. The thermocline in the fall had thus moved farther downward than its summer position on Cruise 4. The thermocline was depressed to a depth of about 80-90 m at the western end of the study grid (at WFG 3), where temperatures above those at other stations were recorded all the way to the bottom (110 m). Below the thermocline, water temperatures were fairly constant at all recording stations with the exception of WFG 3, where warmer temperatures persisted. The eight PLB stations surrounding Platform B (Figure 4-4) had very similar temperatures at comparable depths, with a thermocline in the 60-70 m range at most stations. Slight differences were seen between stations below the thermocline, with the northwestern and southeastern stations (PLB 1 and PLB 6) being somewhat warmer.

On Cruise 6 (spring), the mixed layer was once again restricted to fairly shallow water. Below a thermocline at about 30 m, temperatures were a bit lower at the two western-most stations (WFG 3-4) at comparable depths than at other stations, unlike the situation on Cruise 5. Temperatures at the eight PLB stations were relatively homogeneous at

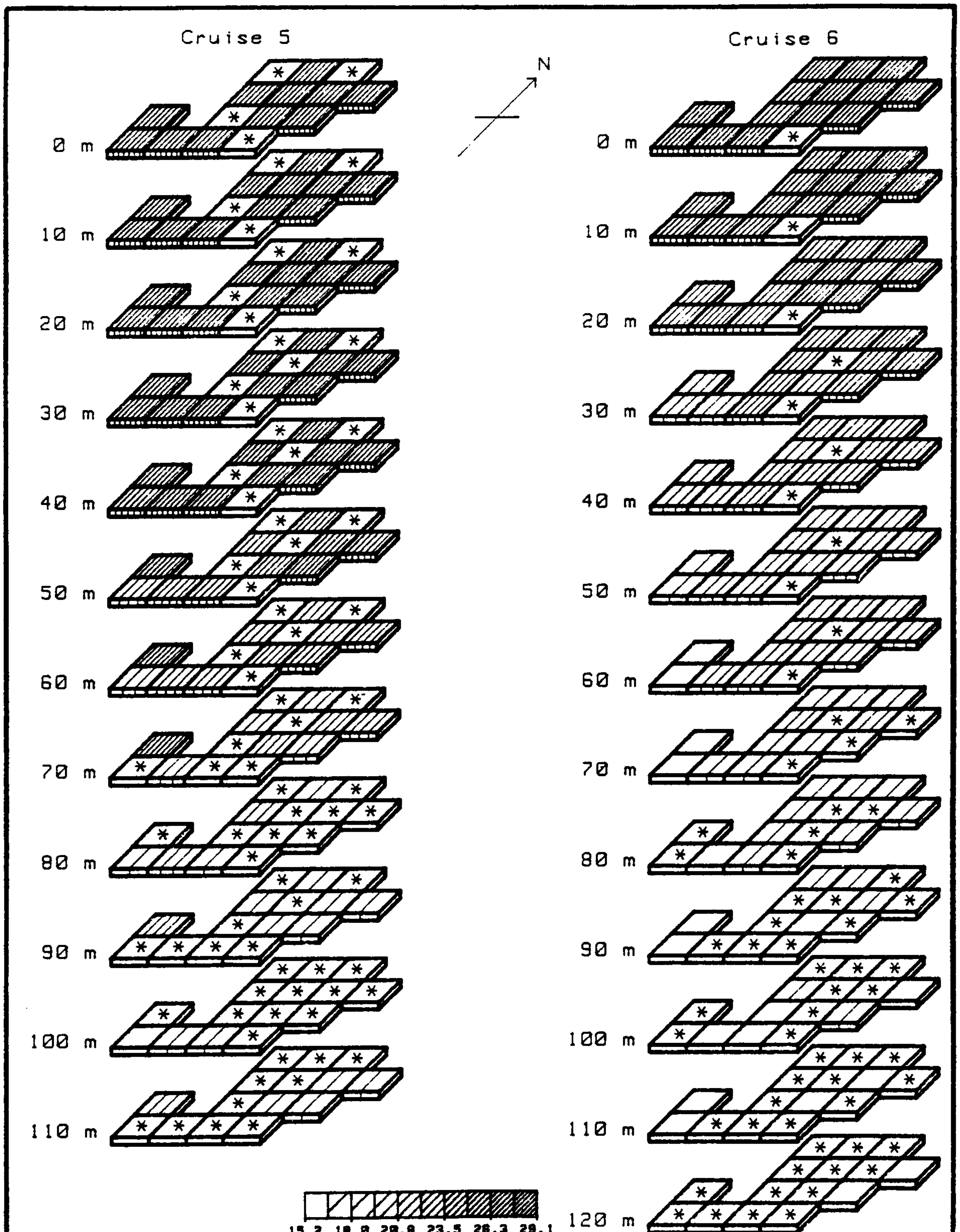


Fig. 4-3a. Temperature (°C) for Phase II stations by depth, Cruises 5 and 6. (*: no data)

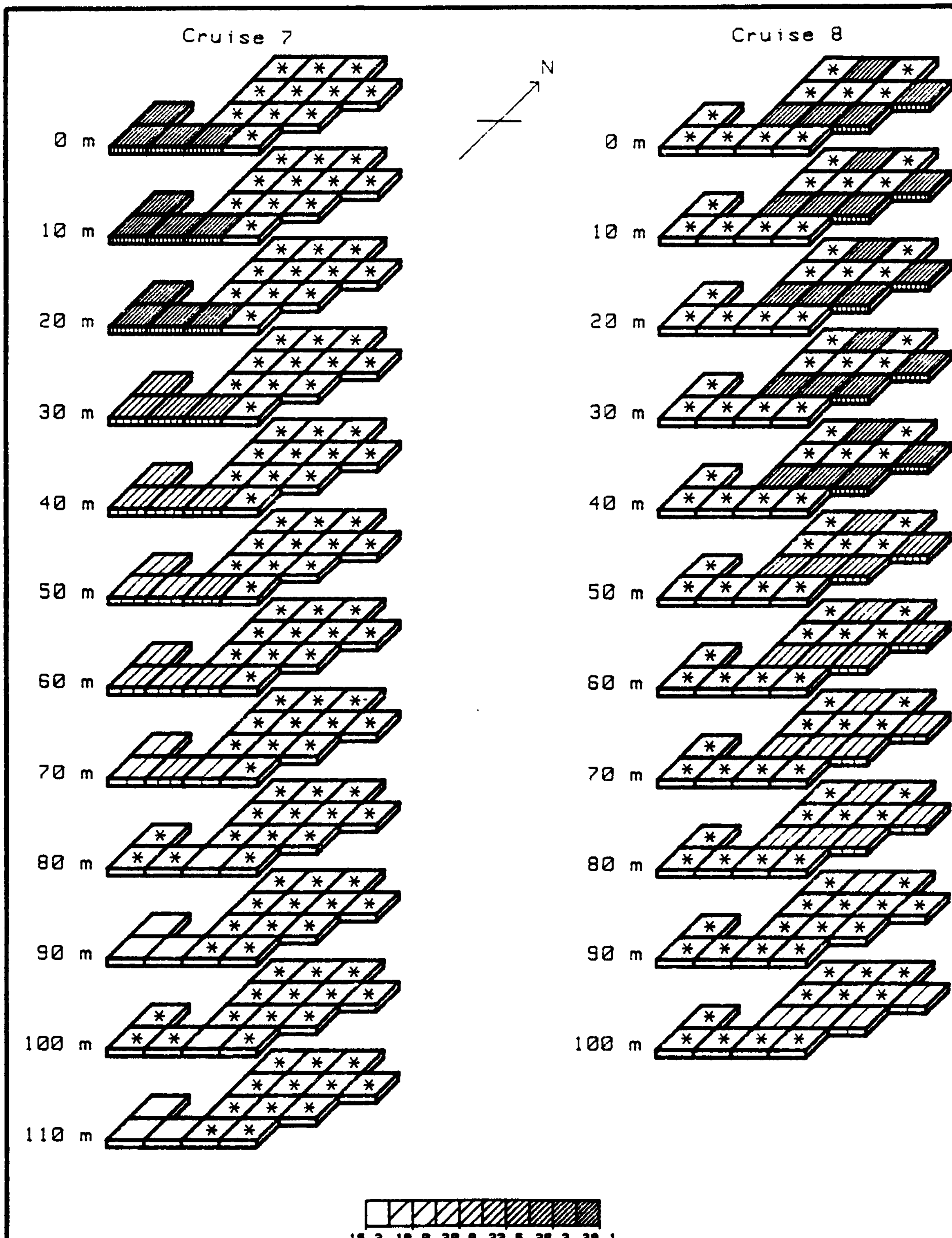


Fig. 4-3b. Temperature (°C) for Phase II stations by depth, Cruises 7 and 8. (*: no data)

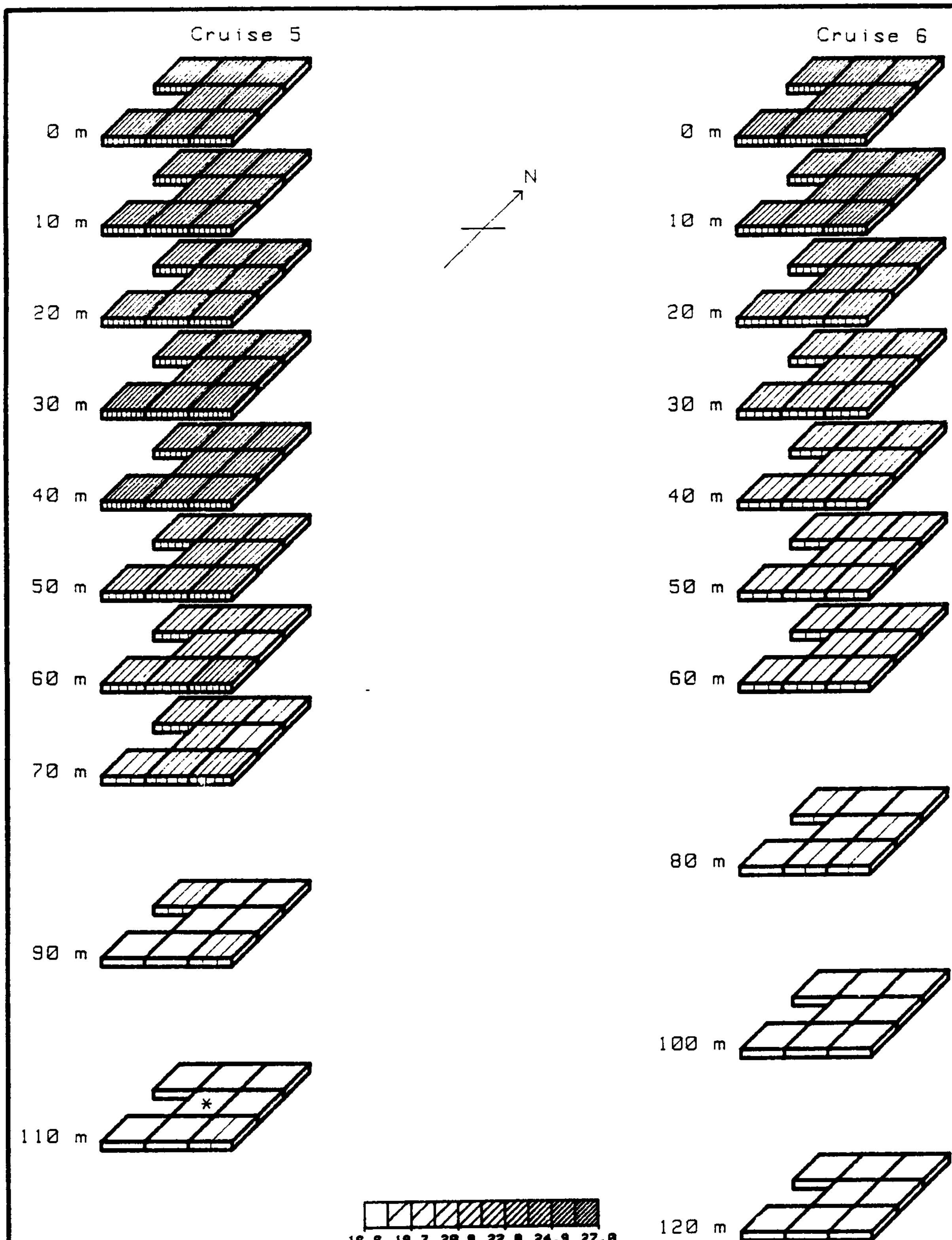


Fig. 4-4a. Temperature (°C) for individual Phase II platform stations (PLB) by depth, Cruises 5 and 6. (*: no data)

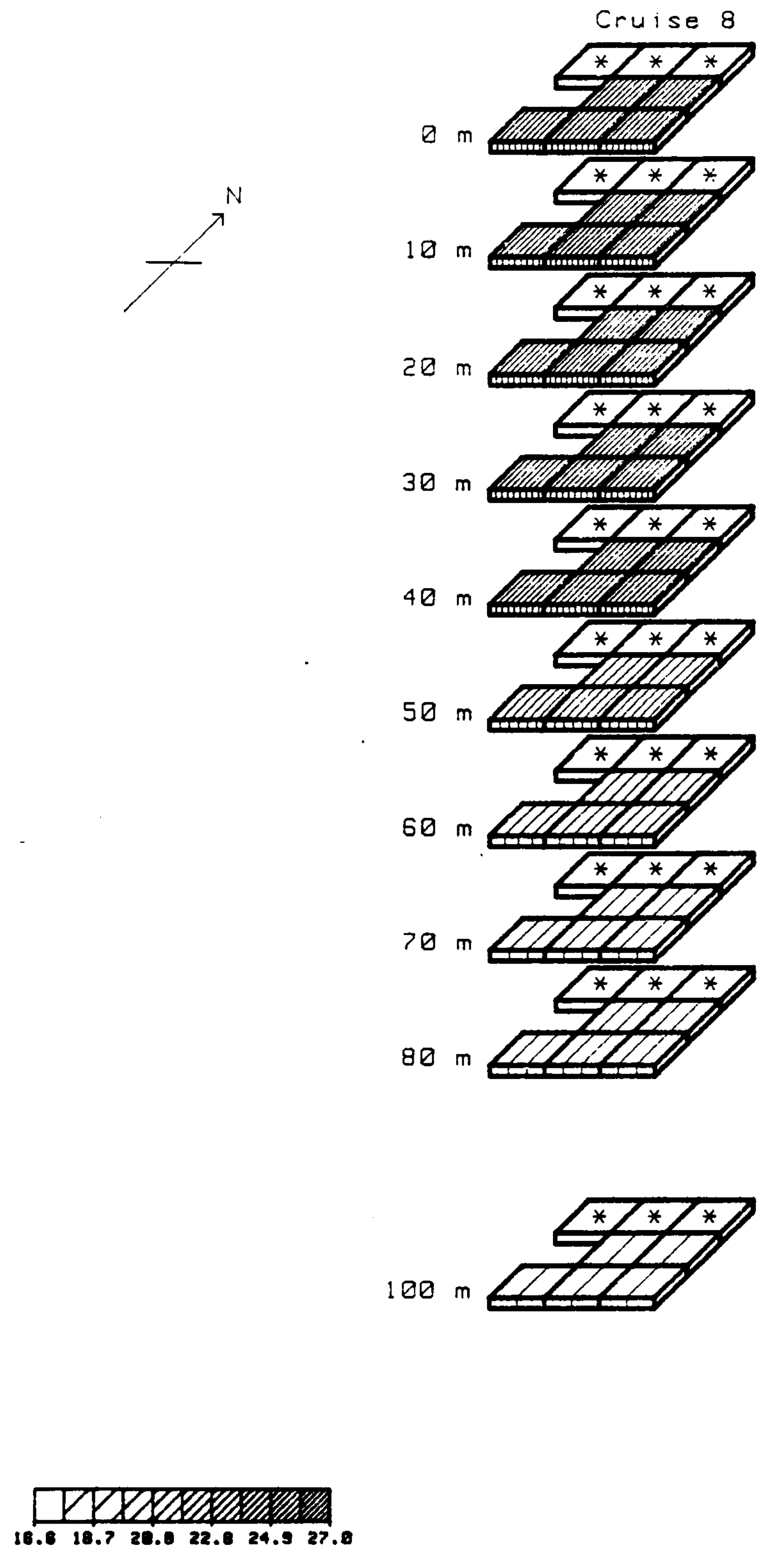


Fig. 4-4b. Temperature (°C) for individual Phase II platform stations (PLB) by depth, Cruise 8. (*: no data)

equivalent depths, not differing substantially from any of the other nearby stations (e.g. EFG 2-4).

Data from the seventh and eighth cruises suffer from many missing values. No temperatures were recorded for any of the East Flower Garden stations (including the PLB stations) on Cruise 7. However, those stations that were sampled on Cruise 7 (IMP 2-3, WFG 3-4) showed a summer thermocline at about 30-40 m, and a rapid decline below 70 m. On Cruise 8, the thermocline was near 50 m (i.e. lowering in the fall), with uniform temperatures in the mixed layer, and below the mixed layer and falling to minimum values below 90-100 m. Temperatures at PLB 1-8 were homogeneous between stations and similar to temperatures recorded at other nearby East Flower Garden stations, EFG 3, 4 and 5.

Salinity

On Cruise 1, salinity was relatively constant over all stations and at all depths (Figs. 4-5 to 4-7), Table 4-2. There was no evidence of any distinct halocline.

On Cruise 2, the large number of missing data points (e.g. the entire East Flower Garden Bank) precludes drawing any area-wide conclusions, but for the stations sampled, salinity was virtually homogeneous at all stations from the surface to the deepest collections (100 m).

On Cruise 3, as on the previous two cruises, salinity was relatively invariant between stations and depths.

On Cruise 4, lowered surface salinities in the upper 20 m are evident with minimum values on the northern edge of the East Flower Garden Bank. Below 30 m, fairly uniform mixing was suggested by the lack of substantial differences from station to station.

On Cruise 5, slightly lower salinity values were recorded at some stations above 40 m but no sharp halocline was present, and salinity was quite uniform between stations. The eight PLB stations also reflected this uniformity.

On Cruise 6, water above 30-40 m was considerably less saline than water below this depth. Vertical stratification was striking. Surface values were much lower than salinities below 40 m. The discontinuity may be seen on a area-wide basis as well as for the eight PLB stations. It is

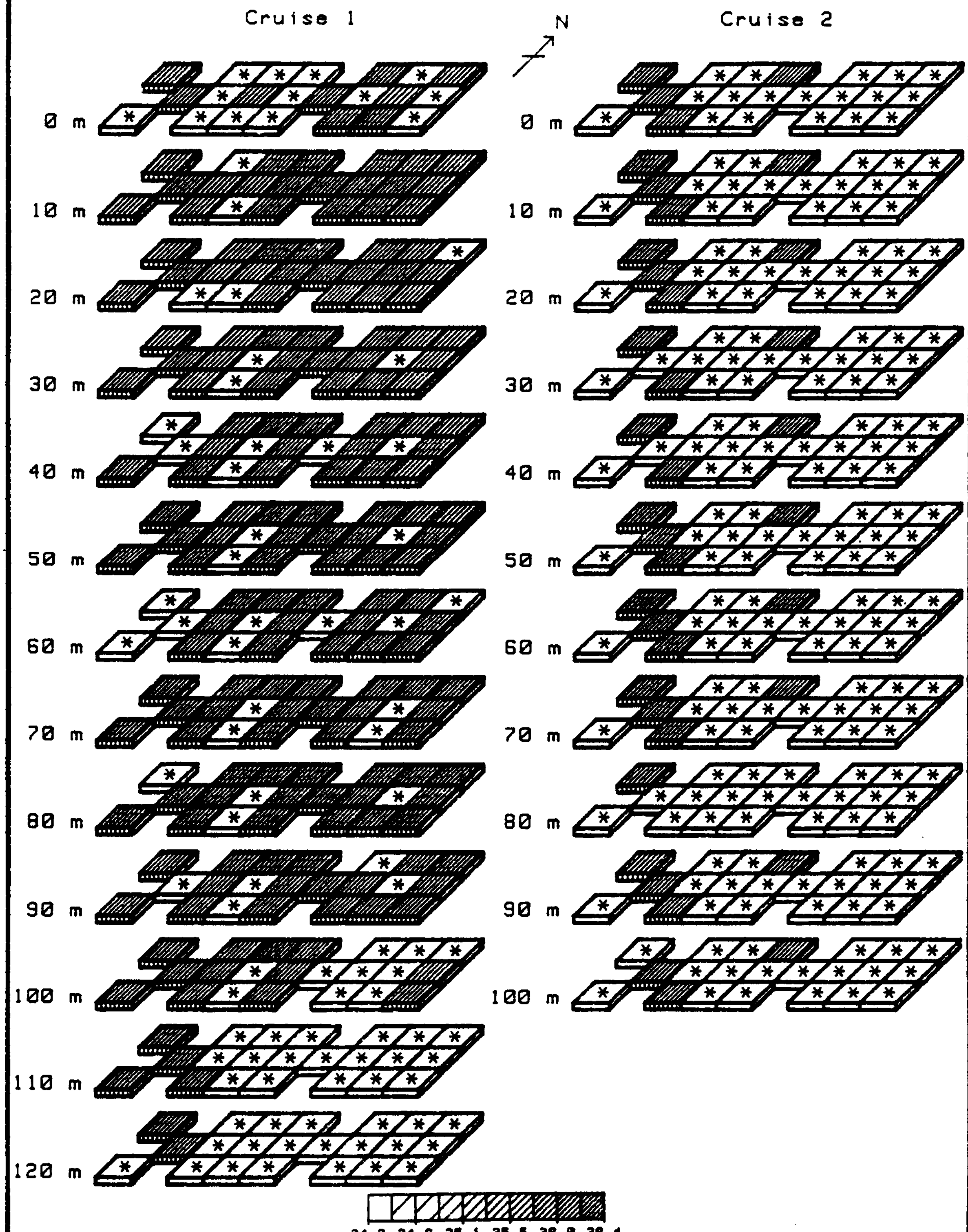


Fig. 4-5a. Salinity (ppt) for Phase I stations by depth, Cruises 1 and 2. (*: no data)

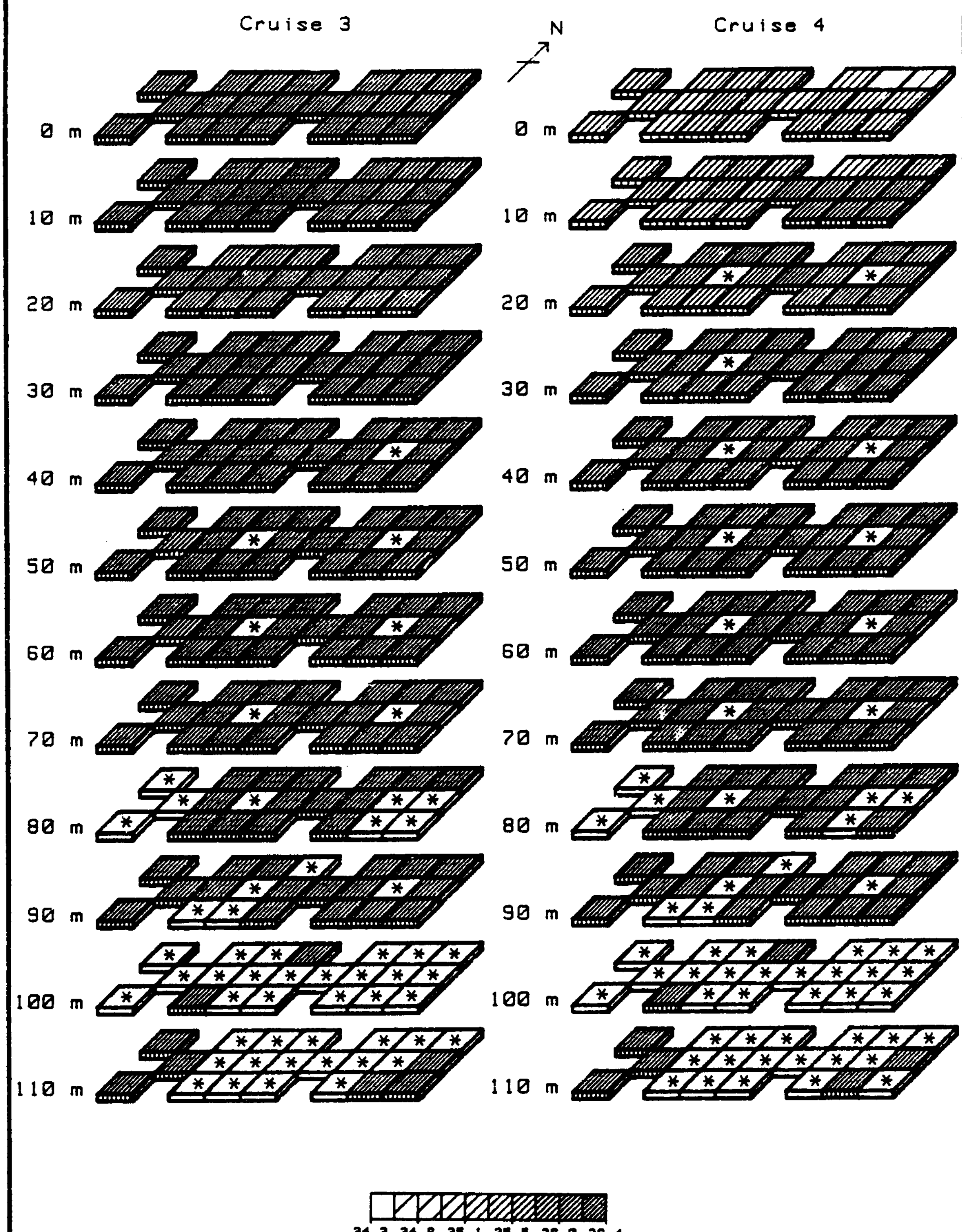


Fig. 4-5b. Salinity (ppt) for Phase I stations by depth, Cruises 3 and 4. (*: no data)

Fig. 4-6a. Salinity (ppt) for Phase II stations by depth, Cruises 5 and 6. (*: no data)

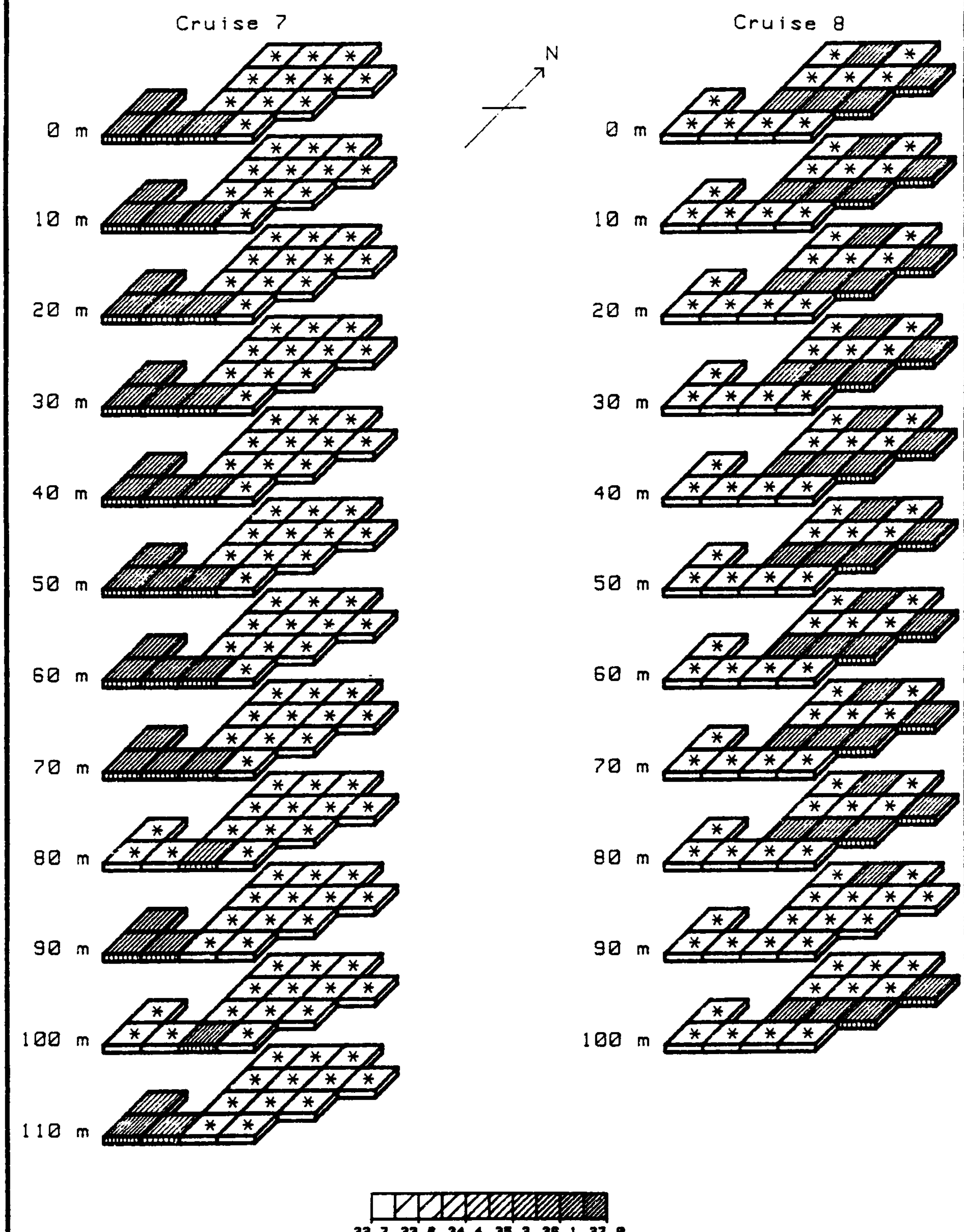


Fig. 4-6b. Salinity (ppt) for Phase II stations by depth, Cruises 7 and 8. (*: no data)

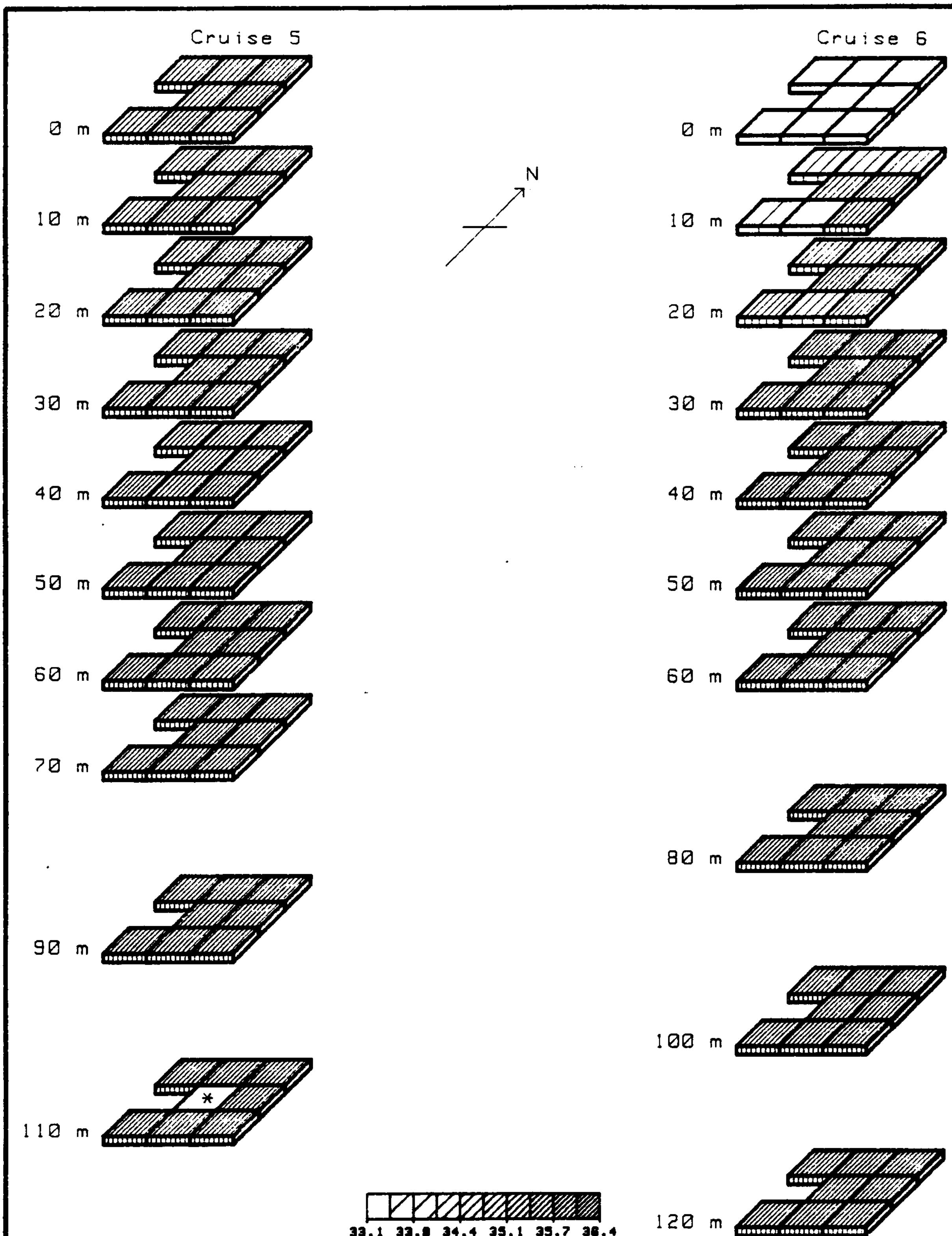


Fig. 4-7a. Salinity (ppt) for individual Phase II platform stations (PLB) by depth, Cruises 5 and 6. (*: no data)

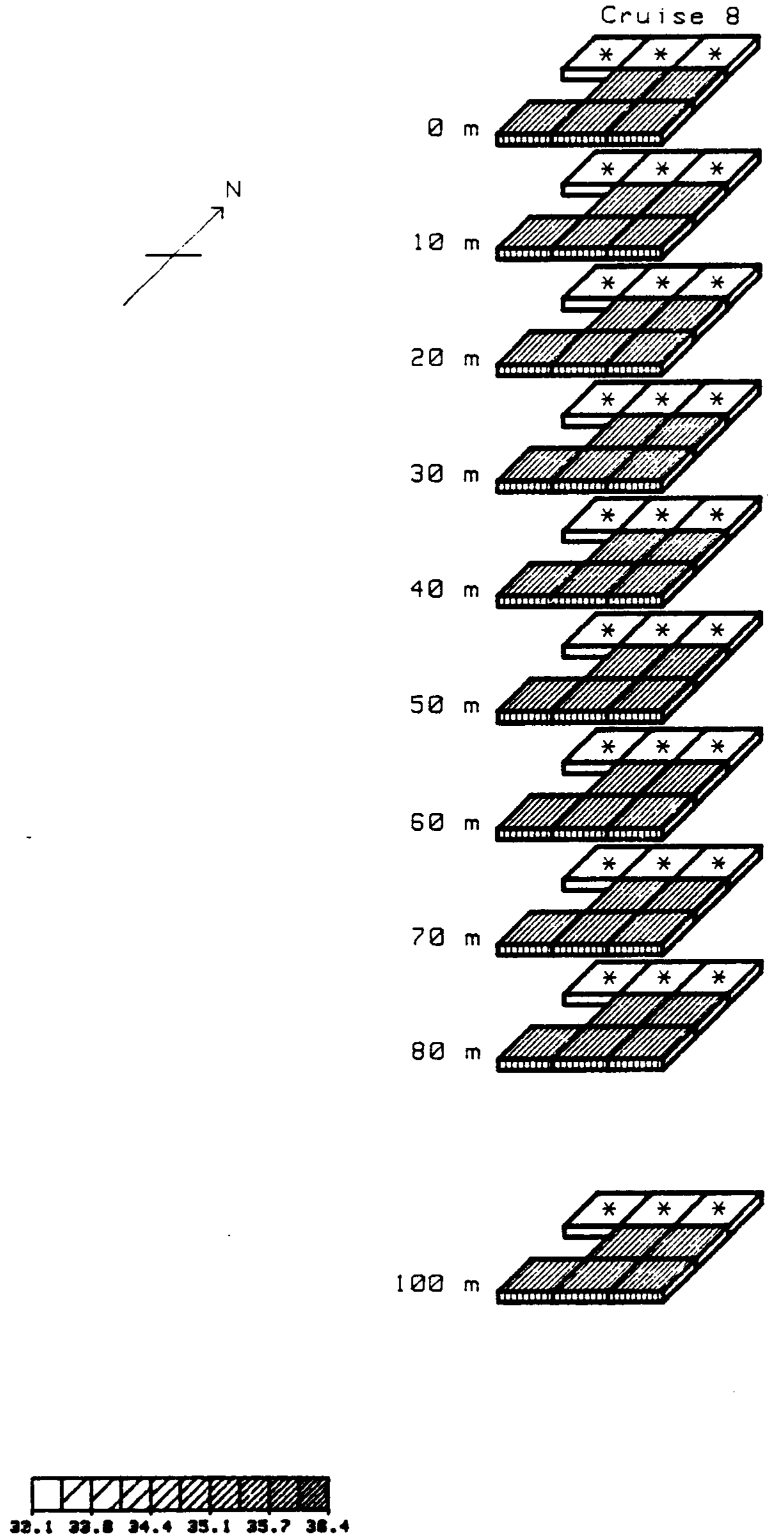


Fig. 4-7b. Salinity (ppt) for individual Phase II platform stations (PLB) by depth, Cruise 8. (*: no data)

Table 4-2. Salinity means (ppt) by cruise and depth, for all stations together.

	Cruise							
	Phase I				Phase II			
Depth (m)	1	2	3	4	5	6	7	8
0	36.14	36.33	36.20	35.48	35.75	33.24	36.16	36.17
10	36.16	36.33	36.21	35.78	35.77	34.35	36.19	36.16
20	36.37	36.33	36.22	36.09	35.81	35.36	36.17	36.16
30	36.18	36.34	36.26	36.21	35.86	36.15	36.23	36.16
40	36.44	32.98	36.27	36.17	35.96	36.26	36.23	36.18
50	36.24	36.33	36.27	36.27	36.26	36.28	36.25	36.31
60	36.72	36.34	36.29	36.30	36.29	36.27	36.29	36.33
70	36.43	36.34	36.29	36.32	36.31	36.26	36.29	36.36
80	36.25	36.30	36.30	36.32	36.35	36.26	36.09	36.39
90	36.31	36.25	36.30	36.34	36.29	36.26	36.23	36.41
100	36.33	36.28	36.31	36.33	36.30	36.24	36.94	36.39
110	36.39	-	36.30	36.31	36.29	36.24	36.47	-
120	36.33	-	-	-	-	36.21	-	-

likely that either heavy rain offshore, or unusually high river runoff onshore (or a combination of both factors) was responsible for the low salinity values. The near-surface transmissivity measurements for Cruise 6 were lower than for other cruises, also suggesting the presence of suspended matter that might have been derived from terrestrial runoff. However, the source of the fresh water responsible for lowered salinities and Sigma-t values on Cruise 6 has not been determined.

Cruises 7 and 8 are missing many data points, so generalizations are restricted to those few stations that were surveyed. Neither the data from the seventh nor from the eighth cruise showed the existence of any haloclines, and values from the five PLB stations studied on Cruise 8 (but not on Cruise 7) were concordant with those from other nearby East Flower Garden stations (EFG 3, 4, and 5).

Density (Sigma-t)

On the first cruise, Sigma-t values increased with depth (Fig.4-8), largely in response to the thermal stratification visible in Figures 4-2 rather than to salinity differences (which were minor) (Fig. 4-5). The pattern of Sigma-t values is almost the inverse of the pattern of temperature values with depth. A deep pycnocline (about 70-80 m) marked a rather abrupt boundary between high and low Sigma-t values (Table 4-3)

On Cruise 2, Sigma-t values could only be computed for a few stations (WFG 2 and WFG 6, CNA, and PLA 2). Density between stations at equivalent depths were essentially identical, and there was a gradual trend of slightly increasing density with depth but there were no distinct, sharp pycnoclines.

On Cruise 3, as on Cruise 2, Sigma-t gradually increased with depth, but surface readings differed little from bottom readings. Horizontal differences between stations at equivalent depths were minor.

On Cruise 4, surface water was markedly less dense than deeper waters, with a pycnocline at about 40-50 m. Values were fairly uniform between stations at equivalent depths. The low density of surface water could be attributed to the combined influence of low salinity and high temperature above 40 m (Figs. 4-2 and 4-5).

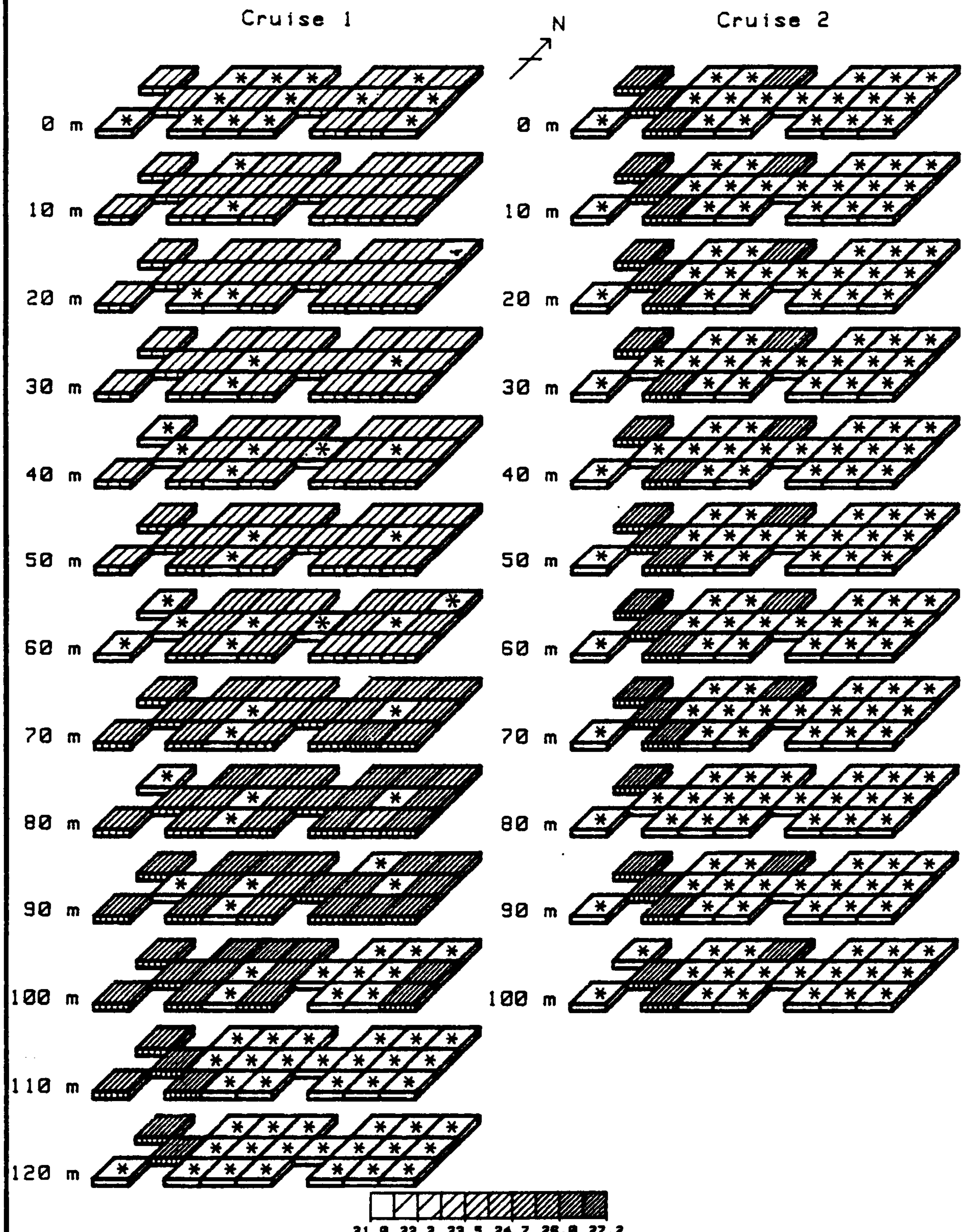


Fig. 4-8a. Density (Sigma-t) for Phase I stations by depth, Cruises 1 and 2. (*: no data)

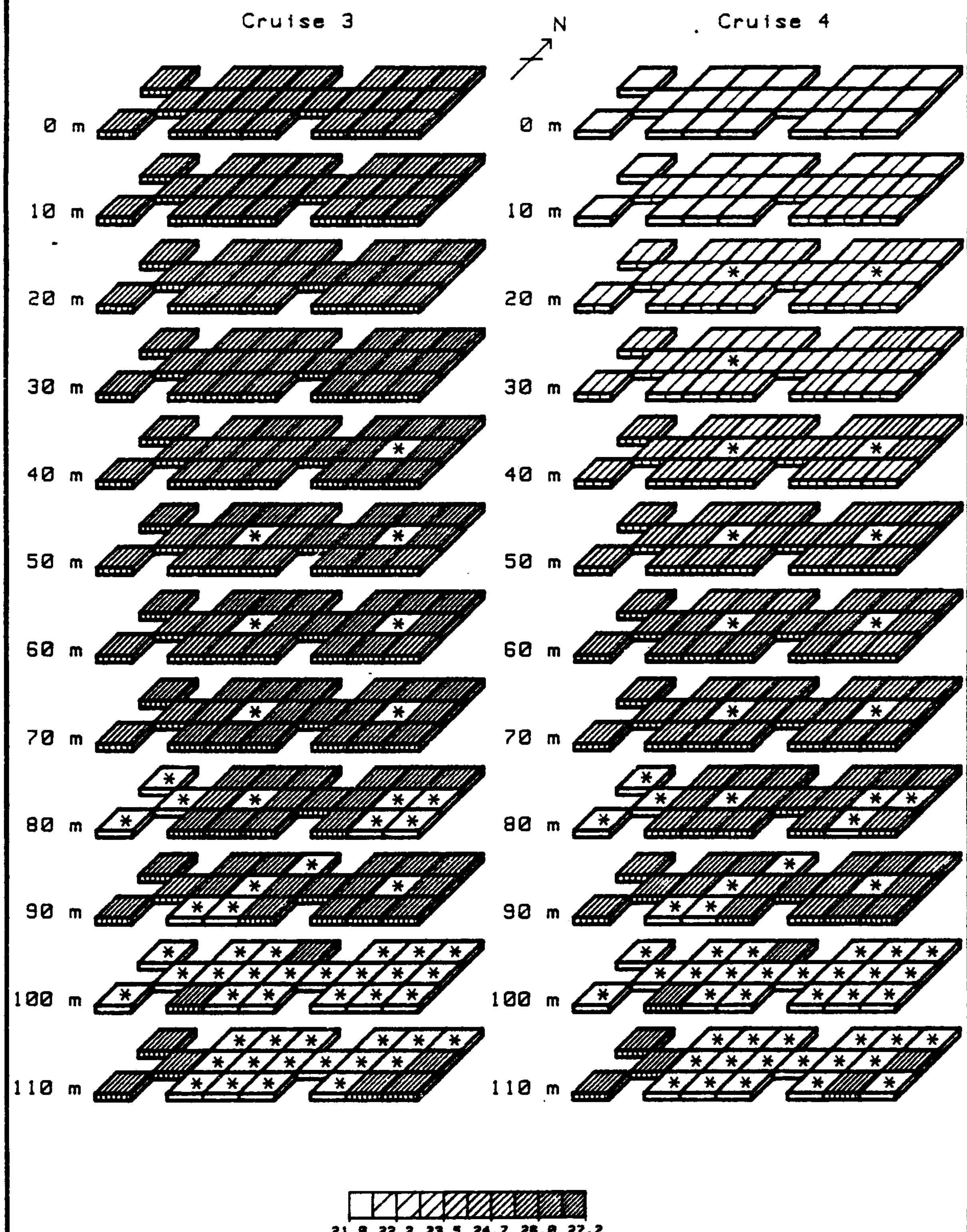


Fig. 4-8b. Density (Sigma-t) for Phase I stations by depth, Cruises 3 and 4. (*: no data)

Table 4-3. Density means (Sigma-t) by cruise and depth for all stations together.

	Cruise							
	Phase I				Phase II			
Depth (m)	1	2	3	4	5	6	7	8
0	23.31	25.62	25.39	22.07	23.73	21.90	22.97	23.68
10	23.33	25.64	25.48	22.35	23.75	22.88	23.00	23.68
20	23.50	25.66	25.61	22.66	23.76	24.04	23.19	23.68
30	23.36	25.68	25.79	23.08	23.78	25.07	24.67	23.69
40	23.55	25.71	25.88	24.10	23.92	25.43	25.24	23.74
50	23.48	25.79	25.89	24.90	24.68	25.66	25.58	24.94
60	24.28	25.84	25.96	25.27	25.18	25.81	25.82	25.41
70	24.65	25.91	26.06	25.51	25.47	25.97	26.03	25.64
80	25.01	26.07	26.18	25.68	25.99	26.07	26.12	25.86
90	25.47	26.10	26.18	25.85	26.08	26.27	26.41	26.07
100	25.76	26.19	26.29	25.93	26.25	26.22	26.40	26.13
110	25.84	-	26.20	26.22	26.22	26.45	26.62	-
120	26.29	-	-	-	-	26.43	-	-

Sigma-t values for Cruise 5 increased monotonically with depth. There was a mild pycnocline about 40-50 m deep (Fig. 4-9). Sigma-t appeared to be influenced primarily by temperature decreases with depth (Figs. 4-3), rather than by salinity, which was fairly constant with depth (Fig. 4-6). For the most part, water densities were similar between stations at equivalent depths, though PLA 2 (to the north of Platform A) had an apparent depression of isopleths to at least 70 m. Sigma-t values at the eight PLB stations had similar features to those nearby on the East Flower Garden Bank: inter-station homogeneity, well-mixed surface water, a mild pycnocline at about 40-50 m, and a gradual increase in density with depth (Fig. 4-10).

On Cruise 6, a sharp pycnocline at about 20-30 m separated an upper mixed layer from denser water at depth. Little difference was noted between stations at equivalent depths. The eight PLB stations also showed a pycnocline at about 20-30 m, and were very similar to one another at equivalent depths. The density differences were due to a combination of low surface salinities and high surface temperatures (Figs. 4-3 to 4-6).

Only four adjacent stations on the southwestern edge of the grid were surveyed on Cruise 7. These stations, which had quite homogeneous Sigma-t values within depths, had low-density shallow water overlying higher-density deeper water and a pycnocline at about 20-30 m. The density differences were a result of thermal stratification rather than salinity changes with depth.

On Cruise 8, a mild pycnocline at about 40-50 m was evident at the four East Flower Garden Bank stations surveyed, with uniform values below this depth (Fig. 4-10). There were no substantial inter-station differences at equivalent depths. The five PLB stations that were surveyed were very similar in Sigma-t values at equivalent depths, and the water column structure closely resembled that of the four East Flower Garden stations. The lowered mixed layer density can be attributed to high surface temperatures, rather than to salinity (which was constant throughout the depth range) (Figs. 4-4 to 4-7).

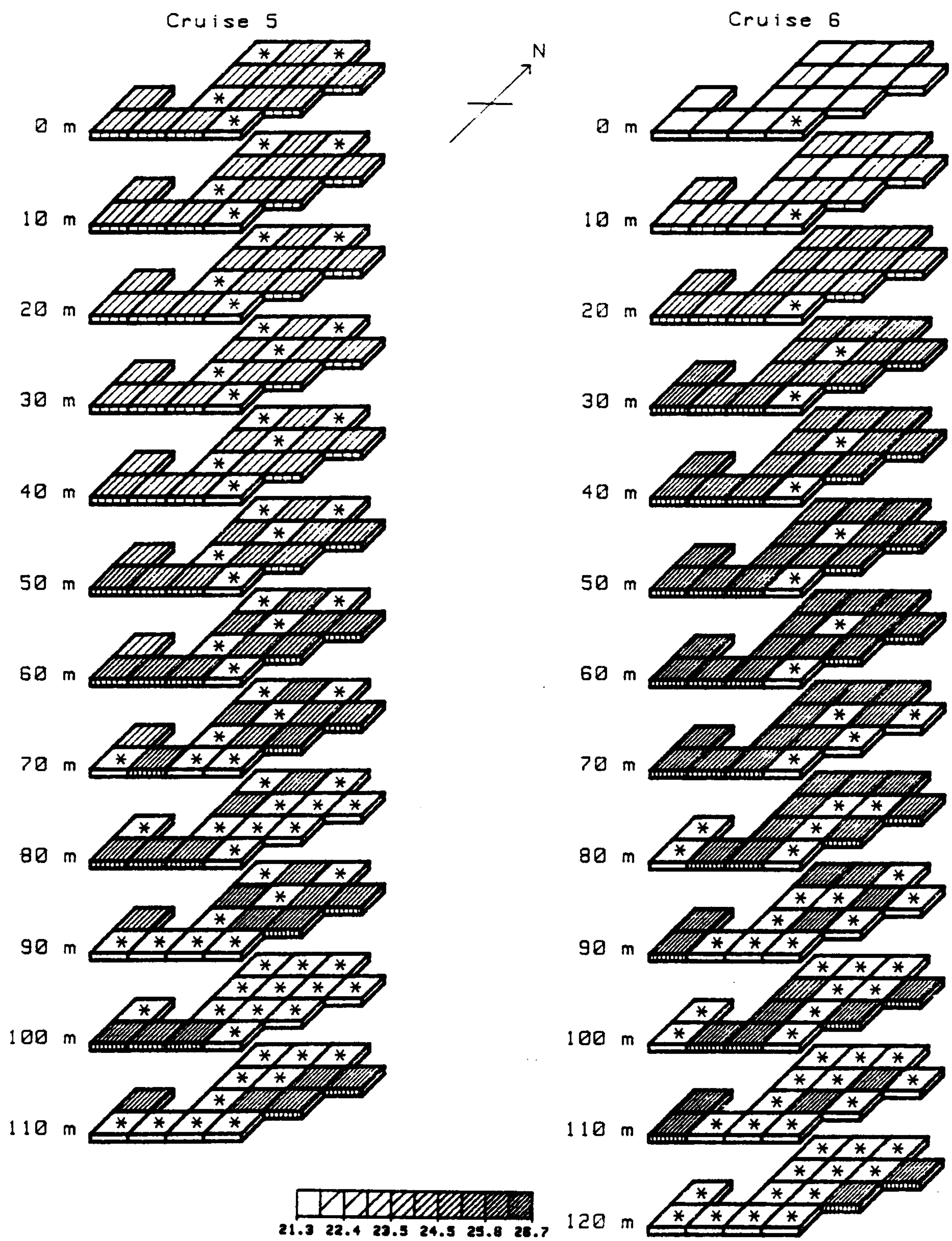


Fig. 4-9a. Density (Sigma-t) for Phase II stations by depth, Cruises 5 and 6. (*: no data)

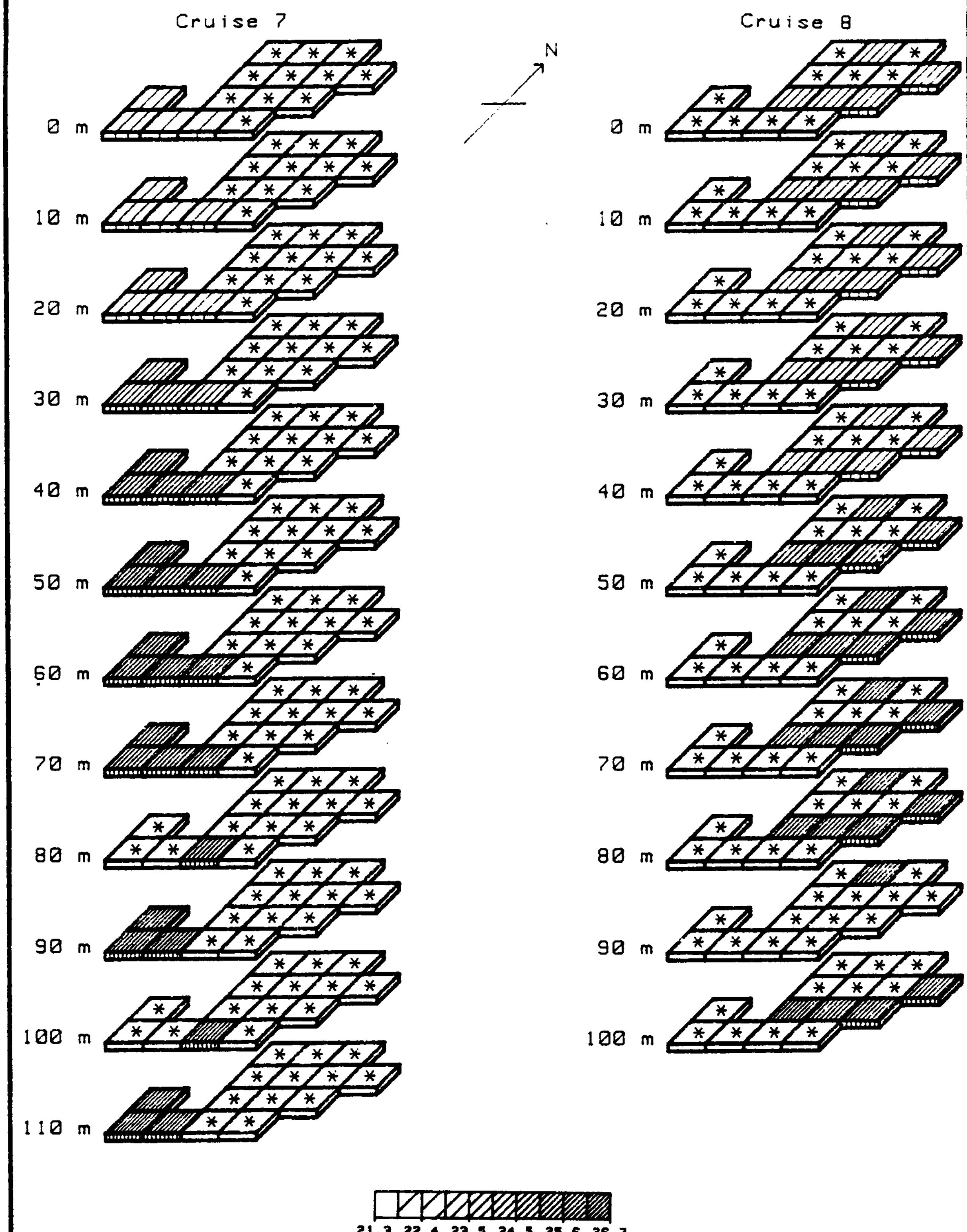


Fig. 4-9b. Density (Sigma-t) for Phase II stations by depth, Cruises 7 and 8. (*: no data)

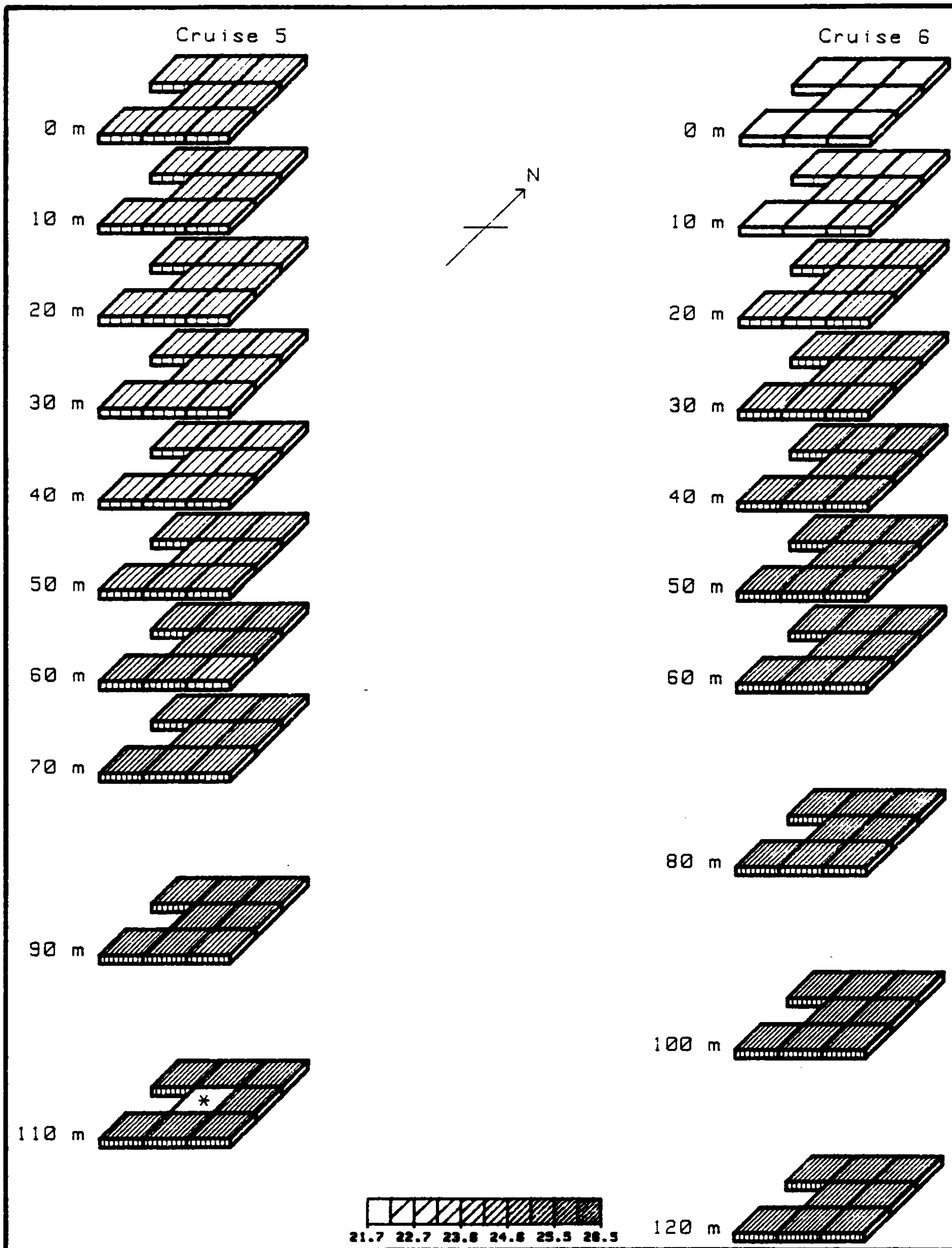


Fig. 4-10a. Density (Sigma-t) for individual Phase II platform stations (PLB) by depth, Cruises 5 and 6. (*: no data)

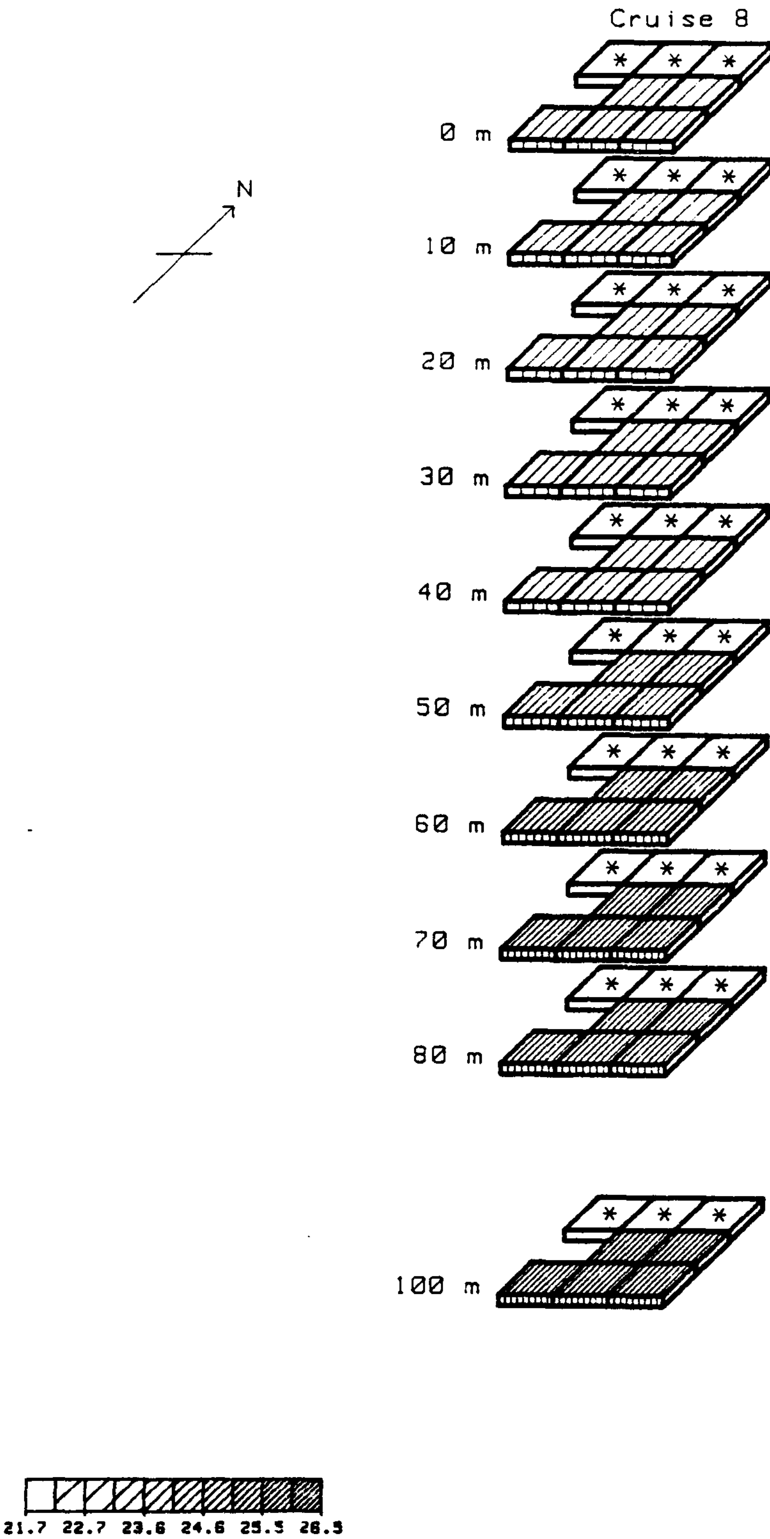


Fig. 4-10b. Density (Sigma-t) for individual Phase II platform stations (PLB) by depth, Cruise 8. (*: no data.)

Dissolved Oxygen

On the first cruise, dissolved oxygen (DO) levels were rather uniform between stations down to a depth of about 80 m (Fig. 4-11, Table 4-4). At and below 80 m, DO decreased markedly at many stations (though not at all) to values approaching hypoxic biological conditions (i.e. 2-3 ml/l). This decrease was not associated with increased water temperatures (which can result in lower saturation maxima), since temperatures in this depth range decreased relative to shallower waters that had higher DO.

On Cruise 2, many missing data points preclude an area-wide discussion of DO, but these stations that were surveyed had similar values at equivalent depths, with some mid-depth mesoscale fluctuations recorded. No abrupt decrease with depth was noted.

On Cruise 3, most stations did not differ greatly in DO values at equivalent depths. Dissolved oxygen was fairly constant with depth. Immediately above the bottom (which varied in depth depending on the station), several stations showed decreased DO (e.g. WFG 2 at 80 m, EFG 1-3 at 90 m, and WFG 6 at 100 m.

On Cruise 4, the influence of higher water temperatures in the mixed layer (to 30-40 m) was seen in lowered DO values. Dissolved oxygen levels were very similar at equivalent depths between stations, except immediately above the bottom (as on Cruise 3), where some (but not all stations had significantly lower DO.

On Cruise 5, DO values were fairly uniform to a depth of about 60-70 m, below which prominent declines were seen at nearly all stations except for WFG 3 (Fig. 4-12). Again, lowered DO values were accompanied by lowered temperatures beneath a thermocline at about 50-60 m. The eight PLB stations had reduced DO levels below 70 m, and hypoxic values below 90 m.

On Cruise 6, the pattern was very similar to that seen for Cruise 5, except that the westernmost stations (WFG 3-4) had lower than average DO values compared to other stations at equivalent depths below 50 m, the reverse of the Cruise 5 situation in which higher DO values were recorded in WFG 3.

On Cruise 7, DO samples were taken only on the southwestern edge of the grid, at IMP 2-3 and WFG 3-4, so it is not possible to make area-wide

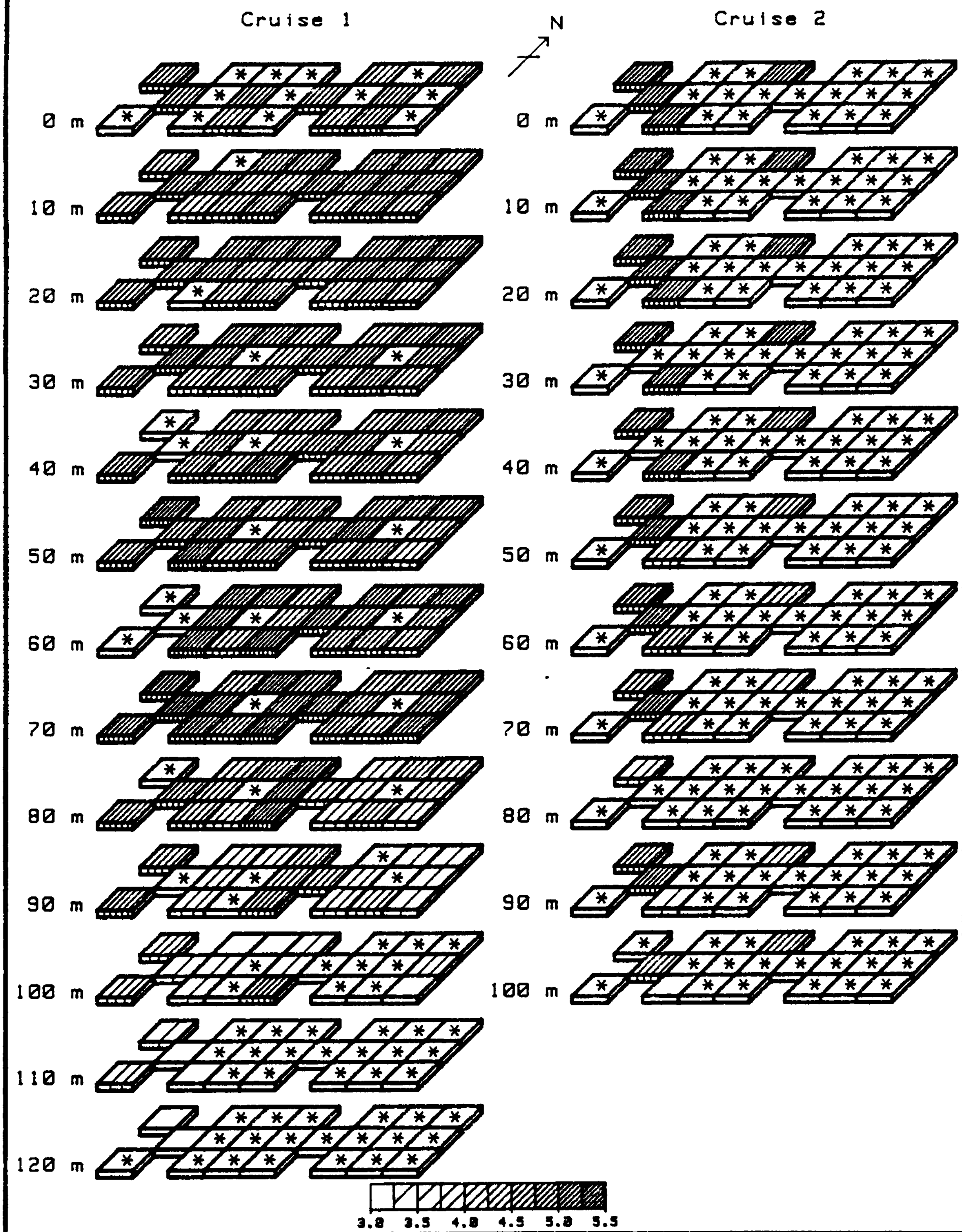


Fig. 4-11a. Oxygen (ml/l) for Phase I stations by depth, Cruises 1 and 2. (*: no data)

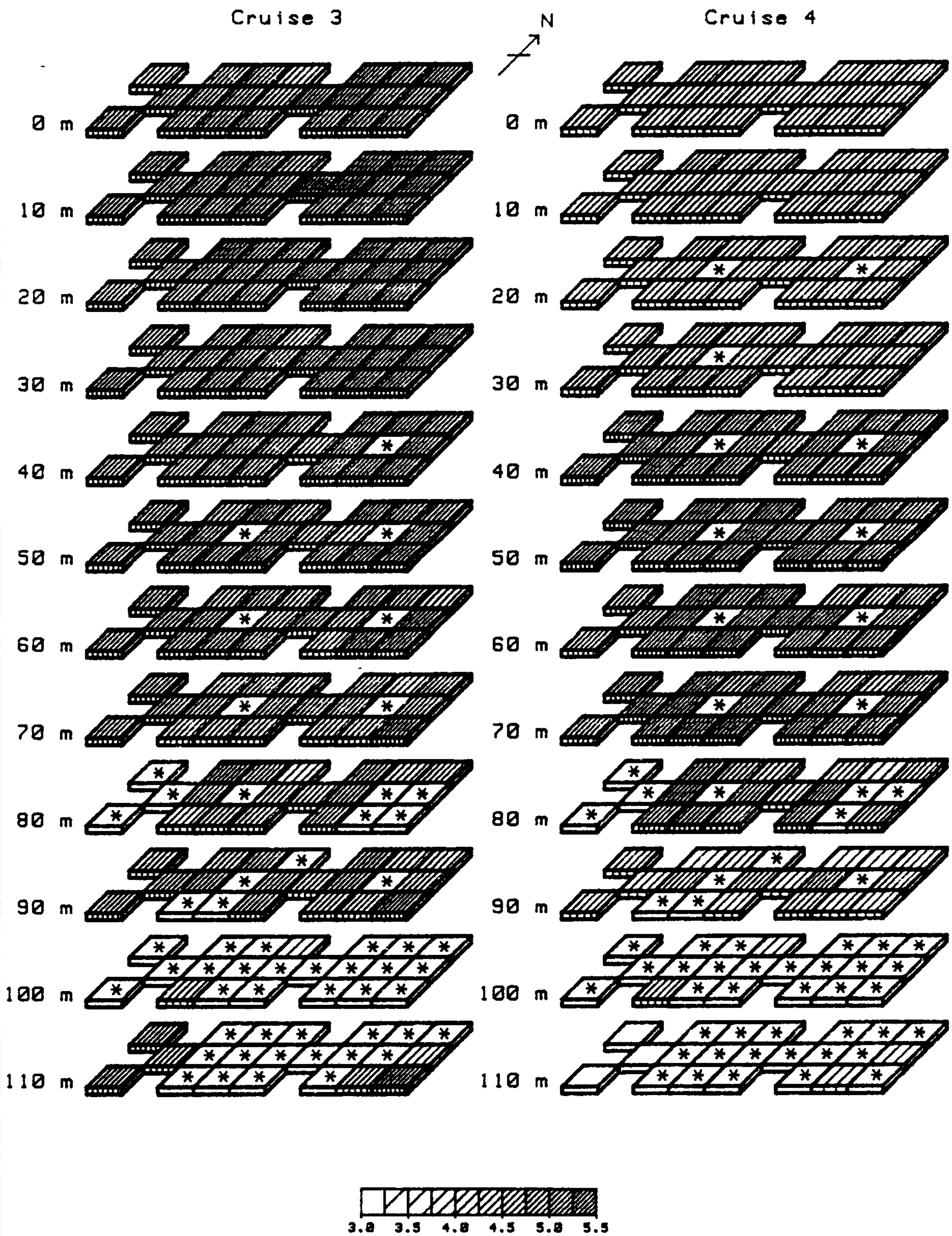


Fig. 4-11b. Oxygen (ml/l) for Phase I stations by depth, Cruises 3 and 4. (*: no depth)

Table 4-4. Dissolved oxygen means (ml/l) by cruise and depth, for all stations together.

	Cruise							
	Phase I				Phase II			
Depth (m)	1	2	3	4	5	6	7	8
0	4.70	5.16	5.07	4.48	4.70	5.00	4.22	4.20
10	4.69	5.15	5.16	4.51	4.70	5.04	3.99	4.18
20	4.68	5.16	5.22	4.56	4.69	5.13	4.35	4.23
30	4.67	5.05	5.22	4.62	4.58	5.07	4.79	4.17
40	4.66	4.98	5.18	5.10	4.65	4.97	4.60	4.13
50	4.75	4.68	5.11	5.18	4.82	5.01	4.16	4.45
60	4.88	4.58	5.03	5.18	4.48	4.82	3.43	4.11
70	4.90	4.38	4.97	5.10	4.12	4.32	3.12	3.76
80	4.48	3.93	4.84	4.85	3.48	4.07	2.88	3.23
90	4.14	4.44	4.93	4.38	3.42	3.52	2.62	2.87
100	3.81	4.06	4.25	4.10	3.19	3.35	2.67	2.90
110	3.58	-	4.88	3.51	3.29	3.14	2.58	-
120	3.04	-	-	-	-	3.05	-	-

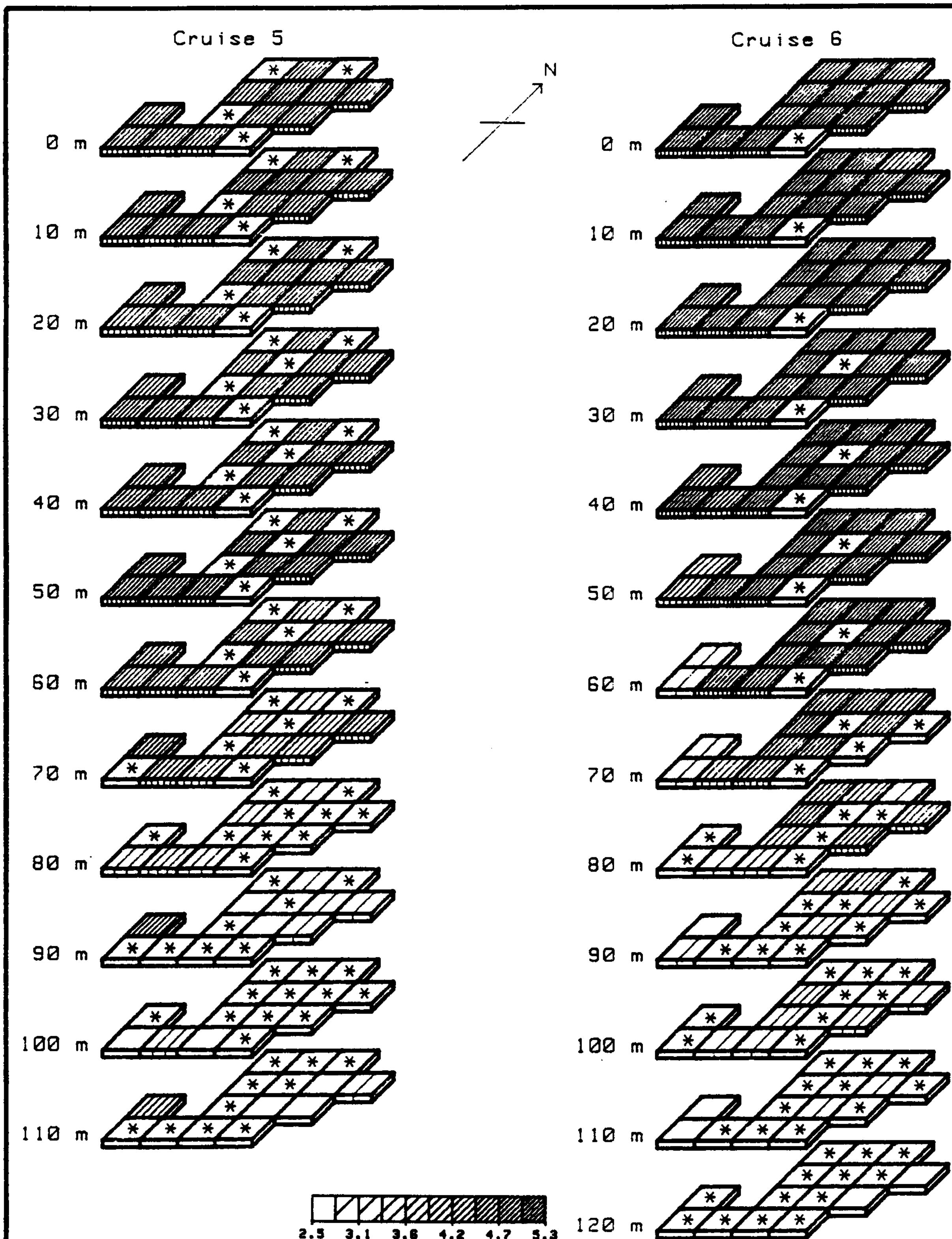


Fig. 4-12a. Oxygen (ml/l) for Phase II stations by depth, Cruises 5 and 6. (*: no data)

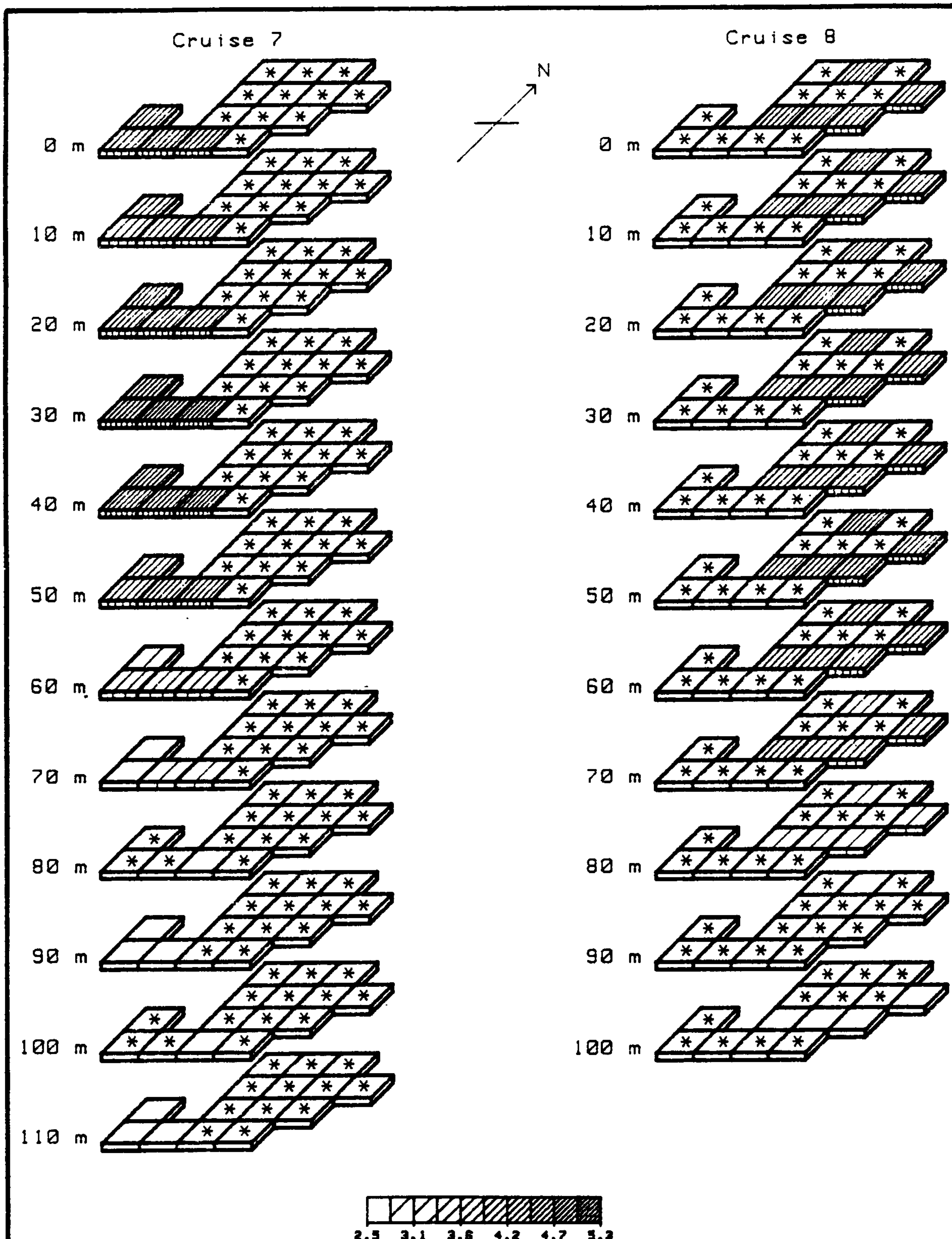


Fig. 4-12b. Oxygen (ml/l) for Phase II stations by depth, Cruises 7 and 8. (*: no data)

comparisons. For the stations sampled, DO values were rather uniform within depths between stations, but showed a striking decline to levels of 2.5 ppm below 50 m.

On Cruise 8, four stations on the East Flower Garden Bank and the eight PLB stations were surveyed for DO. Dissolved oxygen levels were not dissimilar between stations of equivalent depths, and DO was much lower immediately above the bottom for stations deeper than 70 m. The hypoxic layer was at least 20 m thick, as Figure 4-13 clearly illustrates.

Transmissivity (Turbidity)

The transmissometry data were so uniform that a cruise-by-cruise description is not furnished here, but, rather, highlights of notable observations are provided. In general, water clarity was uniform from station to station and from depth to depth, with relatively little difference between cruises. The area is characterized by very clear water, with visibility exceeding 30 m (100 ft) typically reported by divers. Average values for transmissivity on a cruise-by-cruise basis are listed in Table 4-5. They are also provided on a site-by-site basis (proceeding from west to east, corresponding to their general spatial distribution) in Table 4-6; since a major question in this study was whether or not drilling effluents might be detectable in the water and it seemed reasonable to assume that such effleunts would diminish with increasing distance from the source. Note that there were no stations which were sampled consistently throughout the program, so mean values are not strictly comparable between cruises.

Significant reductions in clarity were recorded (with few exceptions) only in a 10-m thick band (the nepheloid layer) just above the bottom (e.g. on Cruise 3 and 4 at some stations, Fig. 4-14). On occasion, the band thickened (e.g. on Cruise 5 and 6, Fig. 4-15) to extend through several tens of meters. On Cruise 5 the transmissivity readings for PLB 1-8 were reduced below 70 m. On Cruise 6; the PLB stations showed somewhat reduced transmissivity in surface layers (to over 20 m depth) and in water deeper than 80 m (Fig. 4-16). The clarity overall was poorer for most stations on both banks at most depths during Cruise 6. Clarity returned to high values at all depths at the PLB stations by Cruise 8.

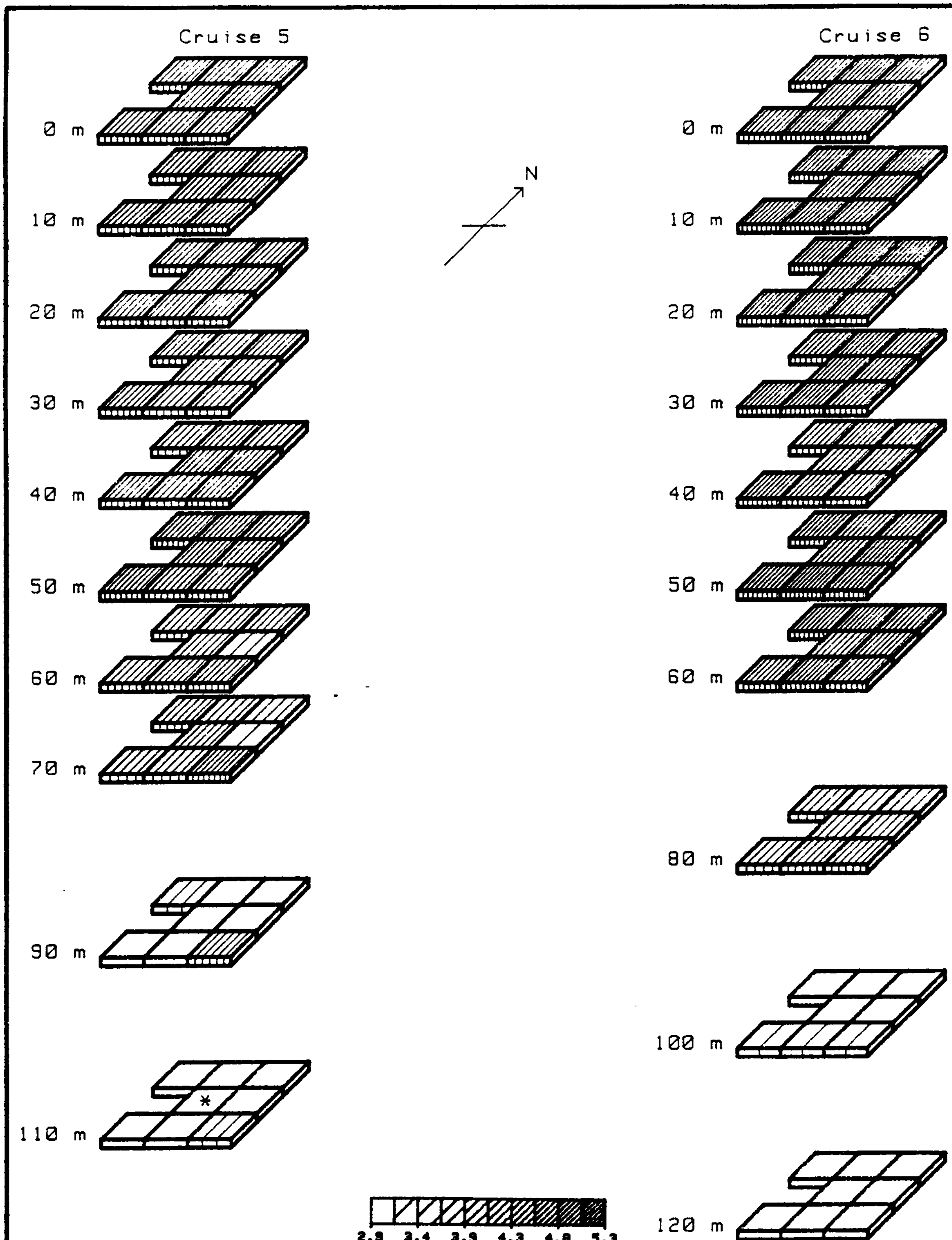


Fig. 4-13a. Oxygen (ml/l) for individual Phase II platform stations (PLB) by depth, Cruises 5 and 6. (*: no data)

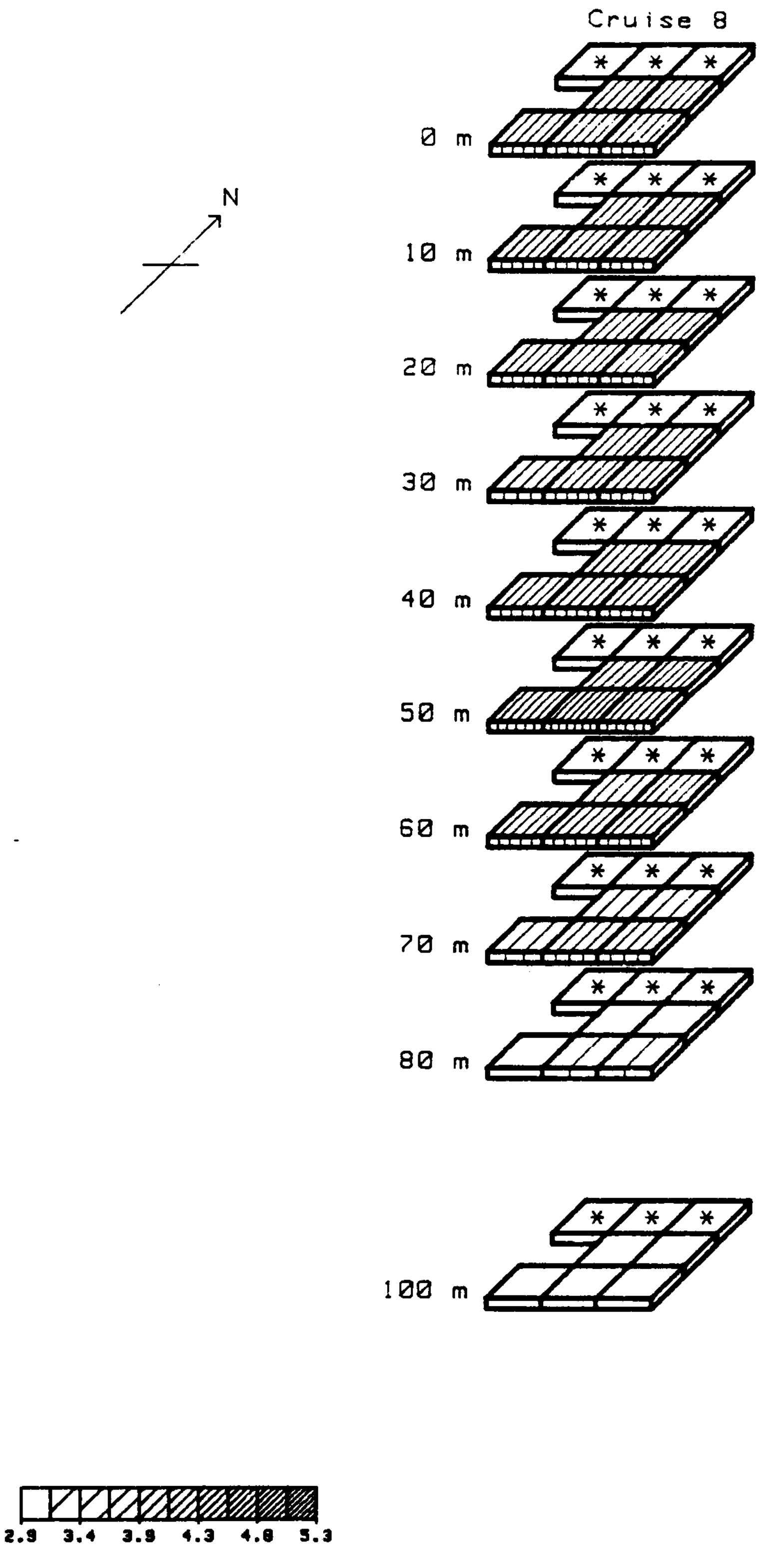


Fig. 4-13b. Oxygen (ml/l) for individual Phase II platform stations (PLB) by depth, Cruise 8. (*: no data)

Table 4-5. Transmissivity (mean %) by cruise and depth.

	Cruise								
	Phase I				Phase II				
Depth (m)	1	2	3	4	5	6	7	8	Depth Means
0	83	82	85	75	84	64	85	81	79.79
10	84	83	85	75	84	66	84	81	80.27
20	85	84	85	75	86	70	81	81	80.96
30	86	86	84	76	86	72	82	81	81.59
40	87	87	82	75	84	72	84	81	81.63
50	87	88	81	76	86	73	82	81	81.09
60	87	90	83	76	86	74	85	81	82.81
70	87	91	85	77	80	75	88	81	82.89
80	86	84	82	76	64	71	88	82	79.17
90	85	76	78	75	65	66	87	82	76.73
100	85	76	75	70	69	62	81	81	75.02
110	85	86	72	68	63	54	77	81	73.22
120	84	-	65	69	-	52	70	75	69.24

Table 4-6. Transmissivity (mean %) by station location and cruise.

Cruise	PLA	CNA	WFG	BRC	EFG	PLB
1	83.80	92.08	86.91	83.73	84.08	-
2	80.80	86.08	85.35	-	-	-
3	80.69	80.92	80.89	82.00	81.99	-
4	72.90	75.38	75.48	72.20	74.83	-
5	-	-	80.27	79.64	77.33	82.00
6	-	-	71.87	-	67.16	66.96
7	-	-	83.92	-	-	-
8	-	-	-	-	80.26	81.11
Site Means	79.55	83.62	80.67	79.39	77.61	76.69

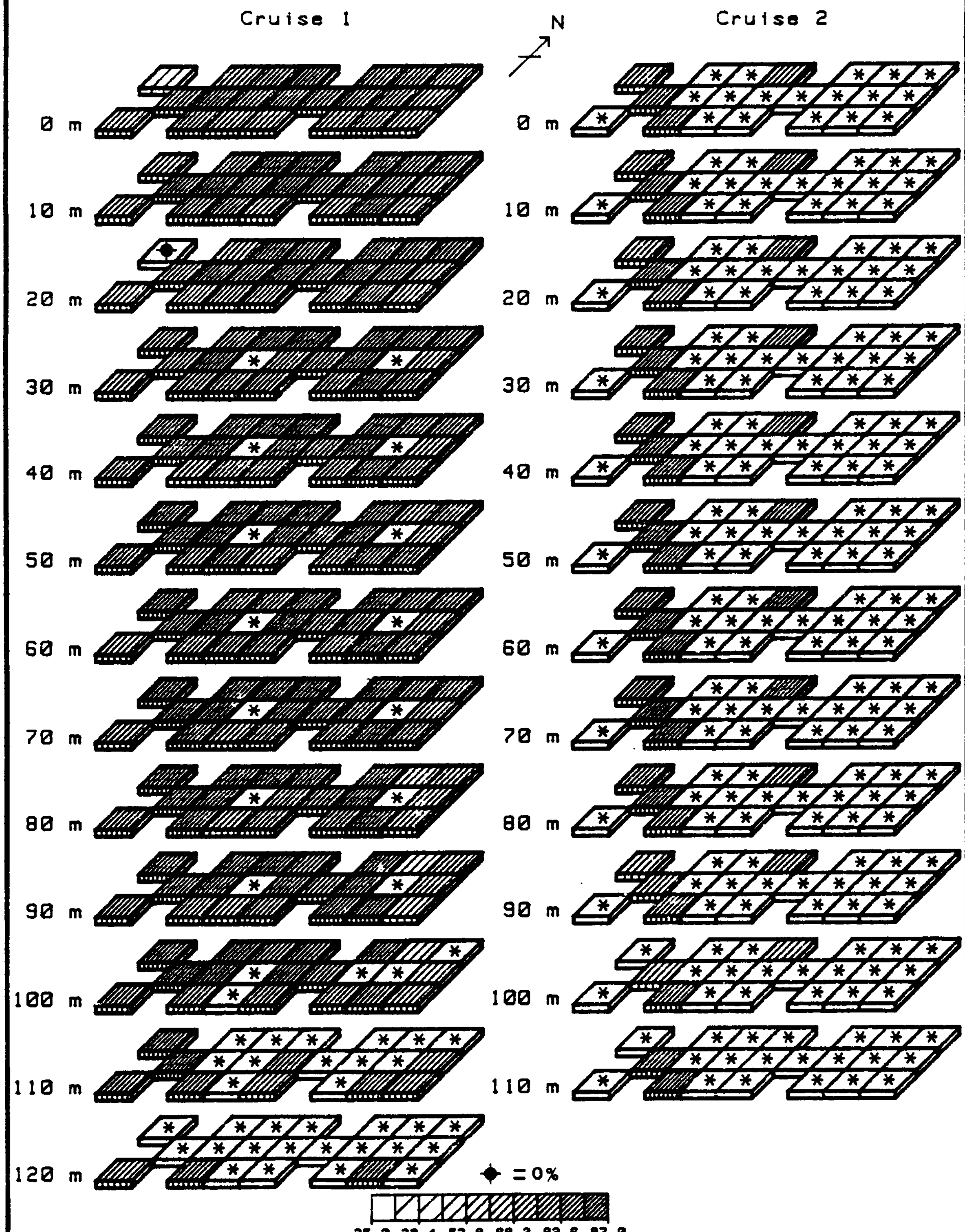


Fig. 4-14a. Transmissivity (%) for Phase I stations by depth, Cruises 1 and 2. (*: no data)

Fig. 4-14b. Transmissivity (%) for Phase I stations by depth, Cruises 3 and 4. (*: no data)

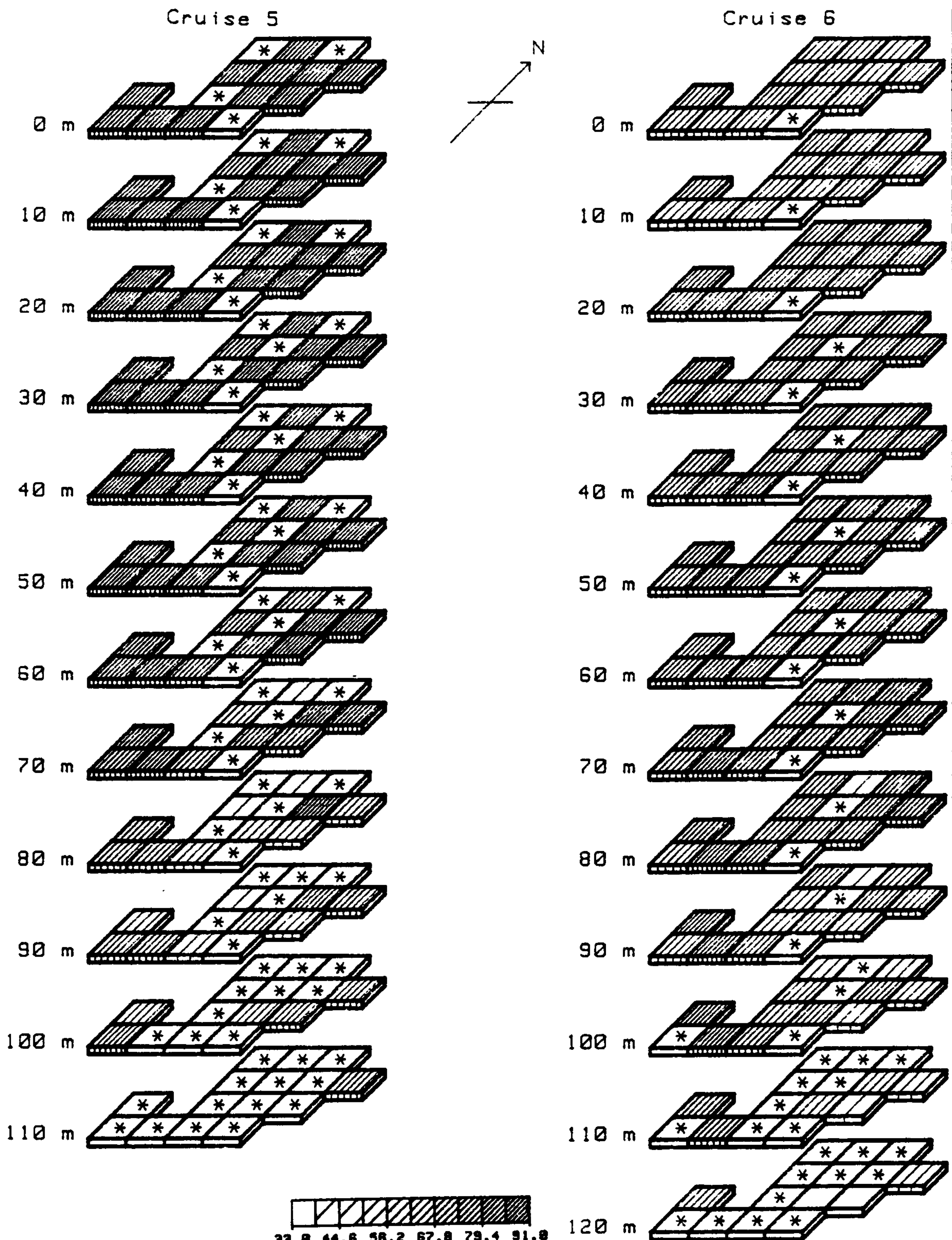


Fig. 4-15a. Transmissivity (%) for Phase II stations by depth, Cruises 5 and 6. (*: no data)

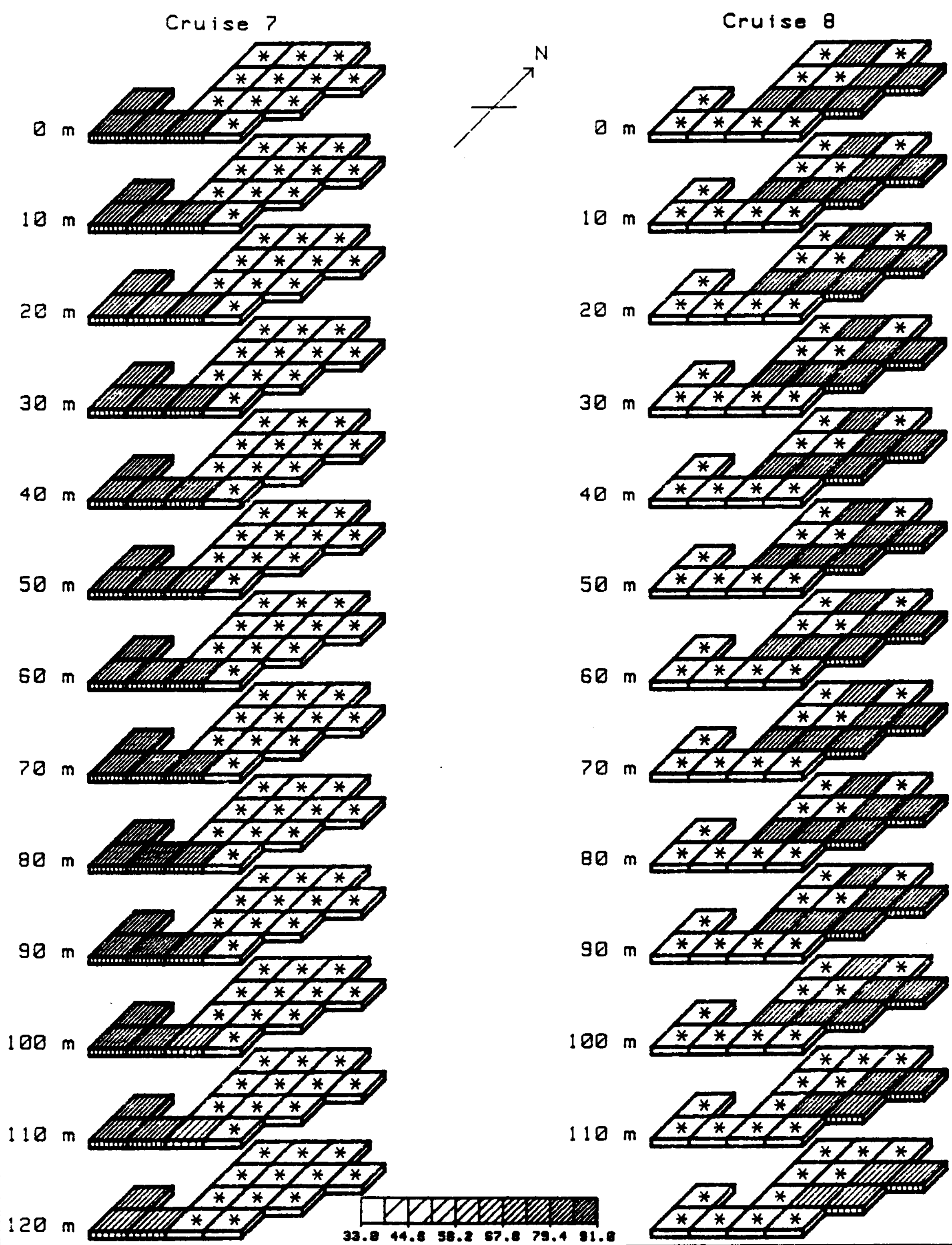


Fig. 4-15b. Transmissivity (%) for Phase II stations by depth, Cruises 7 and 8. (*: no data)

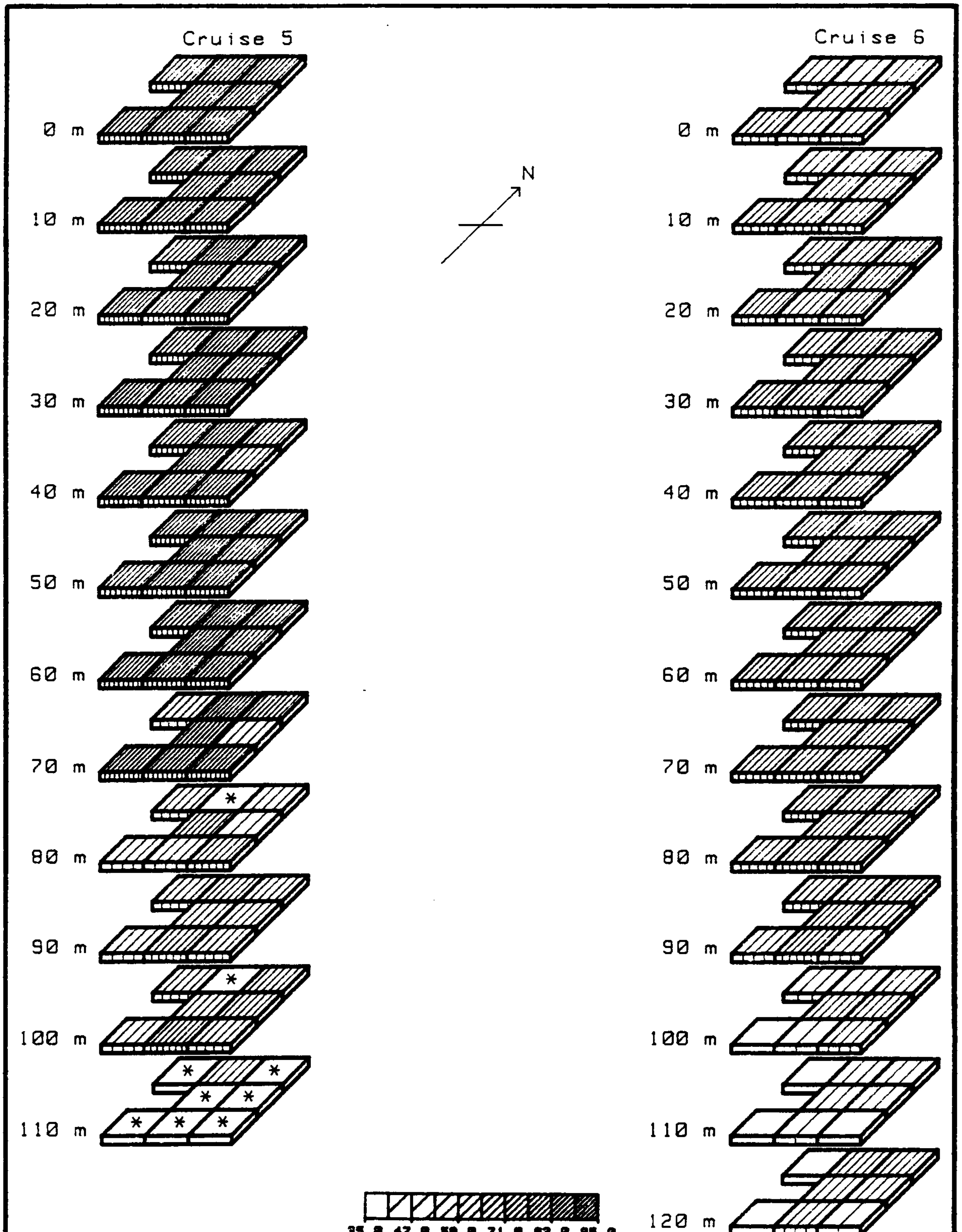


Fig. 4-16a. Transmissivity (%) for individual Phase II platform stations (PLB) by depth, Cruises 5 and 6. (*: no data)

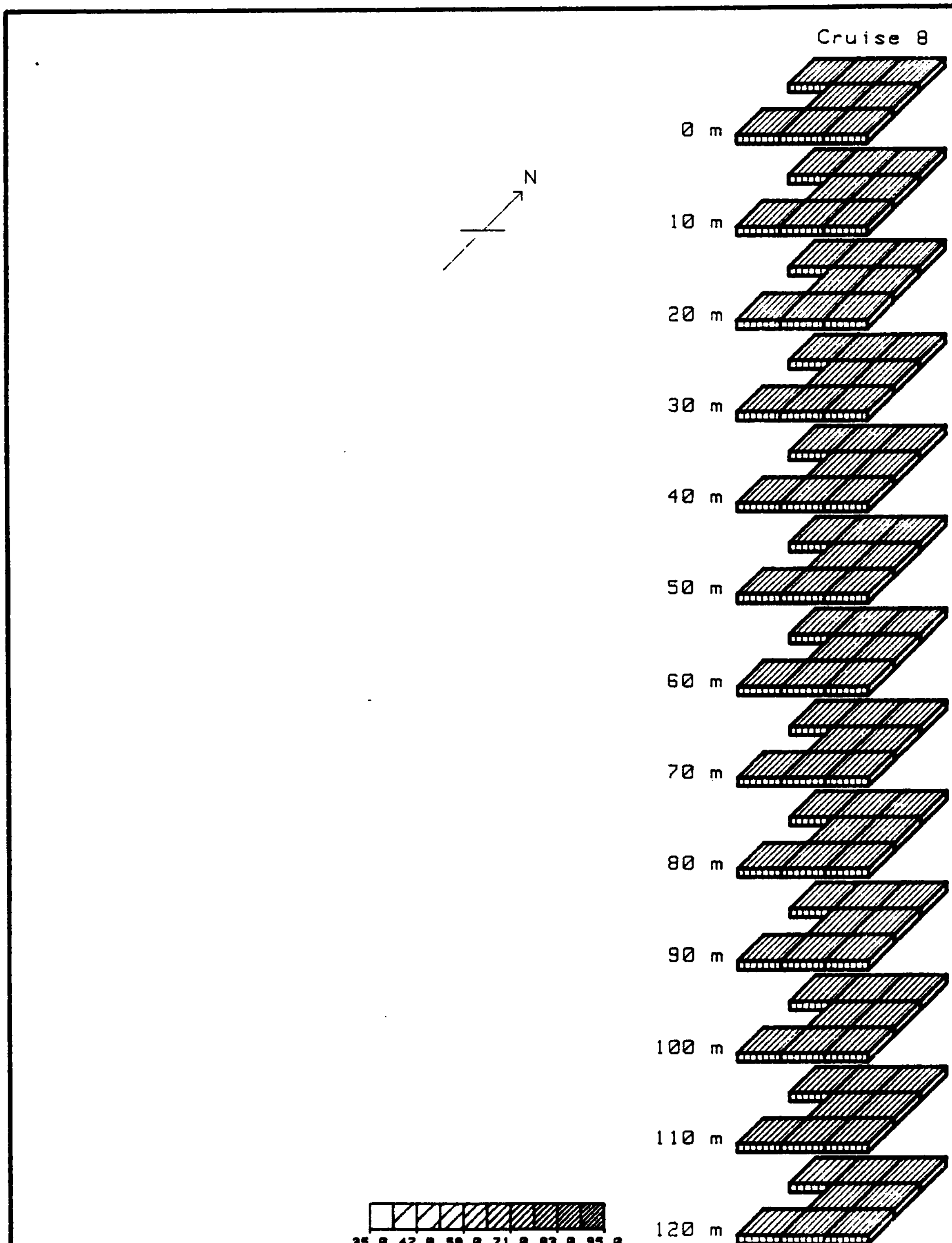


Fig. 4-16b. Transmissivity (%) for individual Phase II platform stations (PLB) by depth, Cruise 8.

On Cruise 1, most stations reported transmissivity percentages in the mid-eighties to low-nineties except immediately above the bottom, although the stations toward the western edge of the West Flower Garden Bank and the eastern edge of the East Flower Garden Bank tended toward slightly lower readings. A drastic drop (to zero) in near-surface transmissivity associated with platform discharge was observed on Cruise 1 at Station PLA 2, adjacent to Platform A. A plume (presumeably of mud and cuttings) was being discharged from the platform when the vessel was nearby. The plume was visible from the surface as a brownish stain. Transmissometer readings from PLA 2 at the time were 55%, 78%, 0%, 86%, and 90% at depths of 0, 10, 20, 30, and 50 m (respectively). Below 50 m, readings were 92-94%. Several nearby stations also had lower transmissivity, perhaps as a result of the discharge at Platform A. For example, PLA 6 (just south of the platform) had readings between 79% and 83% at all depths; CNA (just east of the platform) had readings between 78% and 87% between the surface and 30 m, below which transmissivity jumped to 93-97% except for a turbid zone at 80 m (75%).

Although there were other lower-than-average values for transmissivity at some stations on the West Flower Garden Bank during the first cruise, it would be difficult to attribute these low values to the discharge from Platform A, since intervening stations located between these stations and the platform had higher readings. This does not rule out the possibility of a platform influence, however. The discharge schedule and rate and direction of currents were not known, and it is conceivable that a pulsed discharge could produce discontinuous masses of turbid water at various locations downstream from the platform.

SECTION 5

CATCH/EFFORT, MARK/RELEASE RESULTS AND DISCUSSION

A total of 7006 fish representing 66 species were collected and recorded during 12 of the 18 cruise legs during which fishing took place (Appendix 5-1). Nineteen of these species were represented by only a single individual. A total of 5783 fish were taken by hook-and-line, 736 by trapping and 487 by divers using pole spears. Of the 66 species collected, 18 (Table 5-1) had not been previously reported from the Flower Garden Banks.

Table 5-1. Fish species collected during this study which had not been previously reported in Flower Gardens literature.

Common Name	Scientific Name
Smooth dogfish	*Mustelus canis*
Blackedge moray	*Gymnothorax nigromarginatus*
Giant snake eel	*Ophichthus rex*
Gag	*Mycteroperca microlepis*
Red barbier	*Hemanthias vivanus*[1]
Warsaw grouper	*Epinephelus nigritus*
Tiger grouper	*Mycteroperca tigris*
Blackline tilefish	*Caulolatilus cyanops*
Yellowjack	*Caranx bartholomaei*
Blackfin snapper	*Lutjanus buccanella*
Silk snapper	*Lutjanus vivanus*
Tomtate	*Haemulon aurolineatum*
Striped grunt	*Haemulon striatum*
Whitebone porgy	*Calamus leucosteus*
Red porgy	*Pagrus sedecum*
Flathead	*Bembrops* spp.
Chub mackeral	*Scomber japonicus*
Spotted scorpionfish	*Scorpaena plumieri*

[1] Obtained at Station BRC but also found in reef fish stomachs from the banks (Russell Nelson, NMFS, Beaufort, N.C., pers. comm. 1983).

CATCH SUMMARIES

Hook-and-Line Catches

As indicated above, hook-and-line collection was by far the most successful capture method used in the project, accounting for 82% of the total number of fish collected. A summary of the catches by cruise and station is provided in Appendix 5-2.

Hook-and-line catches over the banks were typically dominated by the cottonwick and/or the vermilion snapper. Hook-and-line catches of red snapper ranged from a low of 14 during summer of 1981, to a high of 135 in summer of 1982 suggesting low overall densities of this species on the banks. A single, large red snapper (810 mm, 9 kg) was taken by hook-and-line at the platform PLA.

Trap Catches

Fish traps were used as a method for collecting fish during Cruises 1-4. Trapping was discontinued after Cruise 4 due to the extensive manpower and vessel time required for trap deployment and retrieval, and because they were relatively unproductive. Only 725 fish were trapped during the entirety of Cruises 1-4 (Appendix 5-3) as compared to the 1086 fish which were collected by hook-and-line on Cruise 1 alone.

Trap catches were similar to hook-and-line catches in that cottonwick and vermilion snapper typically dominated the catches. Notable among the catches which were made using traps, in that they were uncommonly taken by other means, were representatives of scrawled cowfish (*Lactophrys quadricornis*), and the giant snake eel (*Ophichthus rex*). Additionally, two very large red snapper (about 8 kg) were taken in a single trap set over soft bottoms approximately 3 km from the edge of the West Flower Garden Bank at the Station CNA.

As noted in the methods sections, traps of the same size and design but with different mesh sizes were deployed in the collecting effort. As indicated by Table 5-2, the small-mesh traps were considerably more effective than the large-mesh traps:

Table 5-2. Comparison of catch efficiencies of similar traps having different mesh sizes.

Trap Type	Soak Time Hrs	# Individuals	# Species	# Sets Empty Out of 30 Paired Trap Sets
Large mesh (50x100 mm)	900.7	20	6	17
Small mesh (22x48 mm)	755.2	67	14	8

Diver Spearing Catches

Diver spearing proved to be an effective collecting technique for specific species within diving depths. For example, specimens of what proved to be the dominant species at the Flower Gardens, the creole-fish, were not obtained by any other method. A total of 487 fish of 17 species was collected by divers from banks and platform habitats (Appendix 5-4). The principal species collected were creole-fish (taken at all stations) and the grey triggerfish, *Balistes capriscus*, collected only from the platforms. These two species were among the few fish that were observed to have been common to both the platforms and reefs.

Trawl Catches

Trawling was performed on all cruises to provide samples for Work Unit B3 (Histopathology). An average of approximately 50 fish from the trawl collections were utilized by Work Unit B3 each cruise. Although total numbers of fish in the trawl catches were not recorded, all species obtained were identified (Table 5-3).

Trawling was the only effective method for collecting fish residing over soft bottom habitat. Many species that were collected only by trawling (such as the rock sea bass and blackear bass) were of use in making identifications of videotaped fish and several rare or unusual species (e.g. the giant snake eel) were collected in the trawls. A

Table 5-3. List of fish species obtained by trawling near EFG and WFG; Cruises 1-8; bottom depths 100-130 m.

Common Name	Scientific Name
Atlantic angel shark	Squatina dumerili
Spreadfin skate	Raja olseni
Silver conger	Hoplunnis macrurus
Yellow conger eel	Congrina sp.
Giant snake eel	Ophichthus rex
Smallscale lizardfish	Saurida caribbaea
Inshore lizardfish	Synodus foetens
Lanternfish	Diaphus sp.
Atlantic midshipman	Porichthys porosissimus
Pancake batfish	Halieutichthys aculeatus
Batfish	Ogcocephalis declivirostris
Luminous hake	Steindachneria argentea
Gulf hake	Urophycis cirratus
Southern hake	Urophycis floridana
Bearded brotula	Brotula barbata
Blackedge cusk-eel	Lepophidium graellsi
Mottled cusk-eel	Lepophidium jeannae
Rock sea bass	Centropristis philadelphica
Red barbier	Hemanthias vivanus
Roughtongue bass	Holanthias martinicensis
Yellowtail bass	Pikea mexicana
Blackear bass	Serranus atrobranchus
Tattler	Serranus phoebe
Bigeye	Priacanthus arenatus
Cardinalfish species unknown	Apogon sp.
Gulf bar-eyed tilefish	Caulolatilus intermedius
Bigeye scad	Selar crumenophthalmus
Rough scad	Trachurus lathami
Red snapper	Lutjanus campechanus
Wenchman	Pristipomoides aquilonaris
Whitebone porgy	Calamus leucosteus
Longspine porgy	Stenotomus caprinus
Silver sea trout	Cynoscion nothus
Cubbyu	Equetus umbrosus
Red goatfish	Mullus auratus
Dwarf goatfish	Upeneus parvus
Red hogfish	Decodon puellaris
Jawfish	Opistognathus sp.
Flathead	Bembrops sp.
Atlantic cutlassfish	Trichiurus lepturus
Longspine scorpionfish	Pontinus longispinis
Mexican sea robin	Prionotus paralatus
Bluespotted sea robin	Prionotus roseus
Blackfin sea robin	Prionotus rubio
Shortwing sea robin	Prionotus stearnsi
Three-eye flounder	Ancylopsetta dilecta
Sash flounder	Trichopsetta ventralis
Lined sole	Achiris lineatus

single, large red snapper (785 mm, 8 kg) was taken at the Station CNA by trawling during Cruise 3.

One trawl during Cruise 8 at the station BRC in 110 m of water brought up several serranid species that are normally associated with rock outcrops, and, although videotaped on the banks, were seldom collected. The collections included specimens of roughtongue bass, Holanthias martinicensis, and red barbier, Hemanthias vivanus, the latter not previously reported from the Flower Gardens.

The trawl station was located midway between the East and West Flower Gardens on soft bottoms, but there were apparently some rocky outcrops encountered during the trawling. Both of the unusual serranids were photographed soon after reaching the deck. The roughtongue bass (two specimens) exhibited some unusual yellow markings on the side of the head, possibly a breeding coloration. The red barbier was represented by six individuals. This species may be a major component of a group of taxa (including the yellowtail bass, Pikea mexicana) that were visually indistinguishable by the video technique.

ANALYSIS OF HISTORICAL CATCH-EFFORT DATA FOR RED SNAPPER

Analysis of the historical catch-effort data for red snapper was provided as a separate report [Milestone B1-8, Gazey and Gallaway 1980 (Appendix 5-6)]. Information from that report is summarized herein, the reader should consult Gazey and Gallaway (1980) in Appendix 5-6 for details. The data base analysed consisted of the historical catch-effort data for the red snapper commercial fishery of the Gulf of Mexico for the period 1957-74 as presented in the Gulf of Mexico Fisheries Management Council's (GMFMC) proposed management plan for red snapper (in GMFMC 1980, Appendix Tables 1 and 7). The model applied to analyse the data followed Deriso (1978, 1980).

The catch-effort data for Texas and Louisiana were considered to be representative of local or state stocks, whereas landings for Florida were considered representative of the entire Gulf of Mexico. Fishing throughout the Gulf is almost entirely conducted in areas having topographic relief (holes and rises), both of natural and artificial origin.

The Florida fishery includes several fleets of large vessels which remain at sea for extended periods and fish large geographic areas. Historically, many Florida vessels would initially fish from Florida to Galveston where the catch would be off-loaded and shipped by truck to Florida. The boats would then proceed to fish south Texas, then on to the Campeche Banks (before the area was closed to U.S. vessels), and ultimately the vessels would return to Florida. Presently, as much as 50% of the commercial red snapper catch landed in Florida may come from the northwestern gulf, particularly from the offshore area extending from the Mississippi River delta westward to Texas (Percy Thompson, NMFS, Gainsville, FL, pers. comm. April 1981). This geographic area, often referred to as the "oil patch", sustains not only the Louisiana commercial fishery and a large part of the eastern gulf snapper fishery, but also a substantial recreational fishery. The area is the most intensively developed offshore oil and gas area in the world (Fig. 5-1), and the petroleum platforms and pipelines on the middle and outer part of the shelf provide habitat for subadult (Age 1) and adult (Age 2+) red snapper.

Red snapper apparently prefer, or at least show an attraction to, reef or hard bank habitats at the end of their first year. During the first year, the Age 0 fish occupy the soft bottoms of the brown shrimp (Penaeus aztecus) grounds, particularly areas around the Mississippi River delta. Large numbers of small red snapper (and some large specimens) are taken in the by-catch of the shrimp fishery. Once red snapper have taken residence at a reef in the Northwestern Gulf, there has been little evidence that they exhibit any major movement or migratory behavior. It has been believed, based upon results of tagging studies (Fable 1979, Gallaway 1980), that the fish may remain associated with a specific reef for the entirety of their life, unless environmental conditions become intolerable, forcing movement.

Red snapper grow rapidly during their first year, attaining fork lengths of about 200 mm and grow at a rate of about 75 mm per year after the first year (Bradley and Bryan 1976). The fish become sexually mature after age two, and spawning occurs from June to October. Maximum age has been estimated at 20 years with a maximum length of 900 mm and a maximum weight of 18 kg. Most specimens which comprise the fishery are apparently two-year-olds (GMFMC 1980).

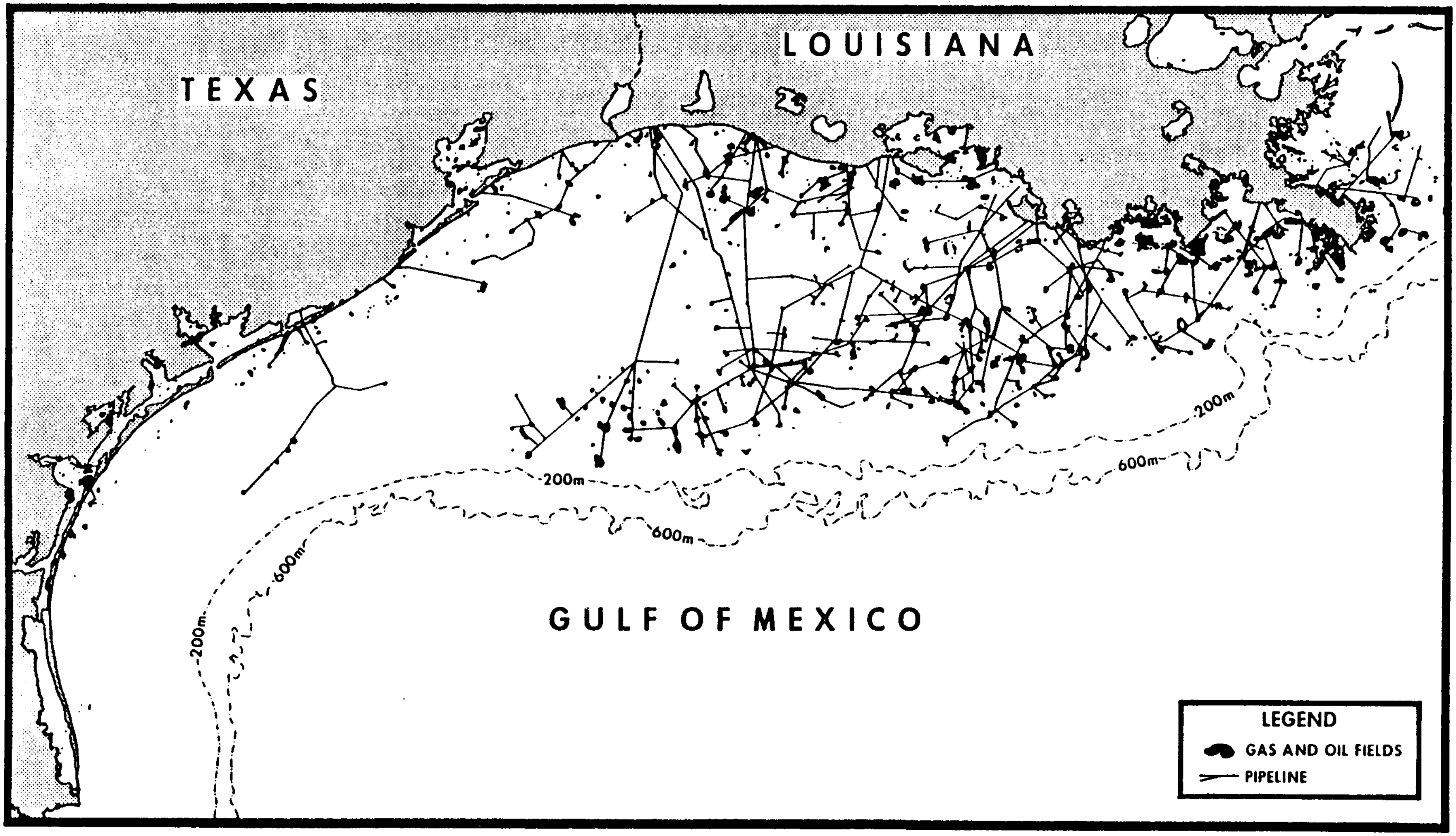


Fig. 5-1. Distribution of gas and oil fields and pipelines on the Texas-Louisiana continental shelf. Map provided by TRANSCO Companies, Inc. 1979.

The red snapper is carnivorous and food habits change with size or age. Juvenile red snapper while over soft bottoms feed on shrimp and other epifaunal benthic invertebrates, and are quite susceptible to mortality from shrimp fishing. Red snapper at reefs remain basically bottom feeders, but they do feed on some pelagic forms from the water column. With increase in size of the red snapper, fish become more prevalent in their diet. Most of the prey species consumed by red snapper are not reef or rock dwellers, and "therefore the inference can be made that the species feeds away from these areas" (GMFMC 1980).

The catch and effort data for Texas and Louisiana are shown by Fig. 5-2 and both exhibit sharp declines (from 1965 in Texas and from 1961 in Louisiana) which is not reflected by the CPUE data which exhibit an oscillatory pattern (Fig. 5-3). Since CPUE is an index of available biomass of catchable fish, one cannot immediately attribute the decline to dwindling stocks. The reduction in effort may be attributable to economic factors or an actual decline may have occurred but has been masked by a trait of the fishery. If fish are not caught almost immediately after hooks are deployed, fishing ceases and the vessel moves to another prospective site, expending very little effort at non-productive sites. In this fashion, it is possible that CPUE (catch/handline fisherman) could remain high even though fewer habitats might be utilized by commercial numbers of fish. Effort, in this scenario, would be reduced to those fishermen knowing the location of or being able to efficiently locate productive areas.

The Florida CPUE data (Fig. 5-4) support the contention that a gulf-wide decline in red snapper stocks may have occurred, but, at present, the stock is rather stable, albeit at a relatively low level.

The Deriso model was able to mimick the dynamics of the Louisiana and Texas red snapper CPUE trends reasonably well, assuming most fish matured at age 2, and that the stock recruitment relationship was represented by a density-dependent Ricker curve. Results of the model analysis indicated that red snapper were fast growing, having relatively low natural mortality and a large fraction of the spawners were vulnerable to being caught by the fishery (i.e. new recruits were as susceptible to being caught by handlining as older, larger spawners).

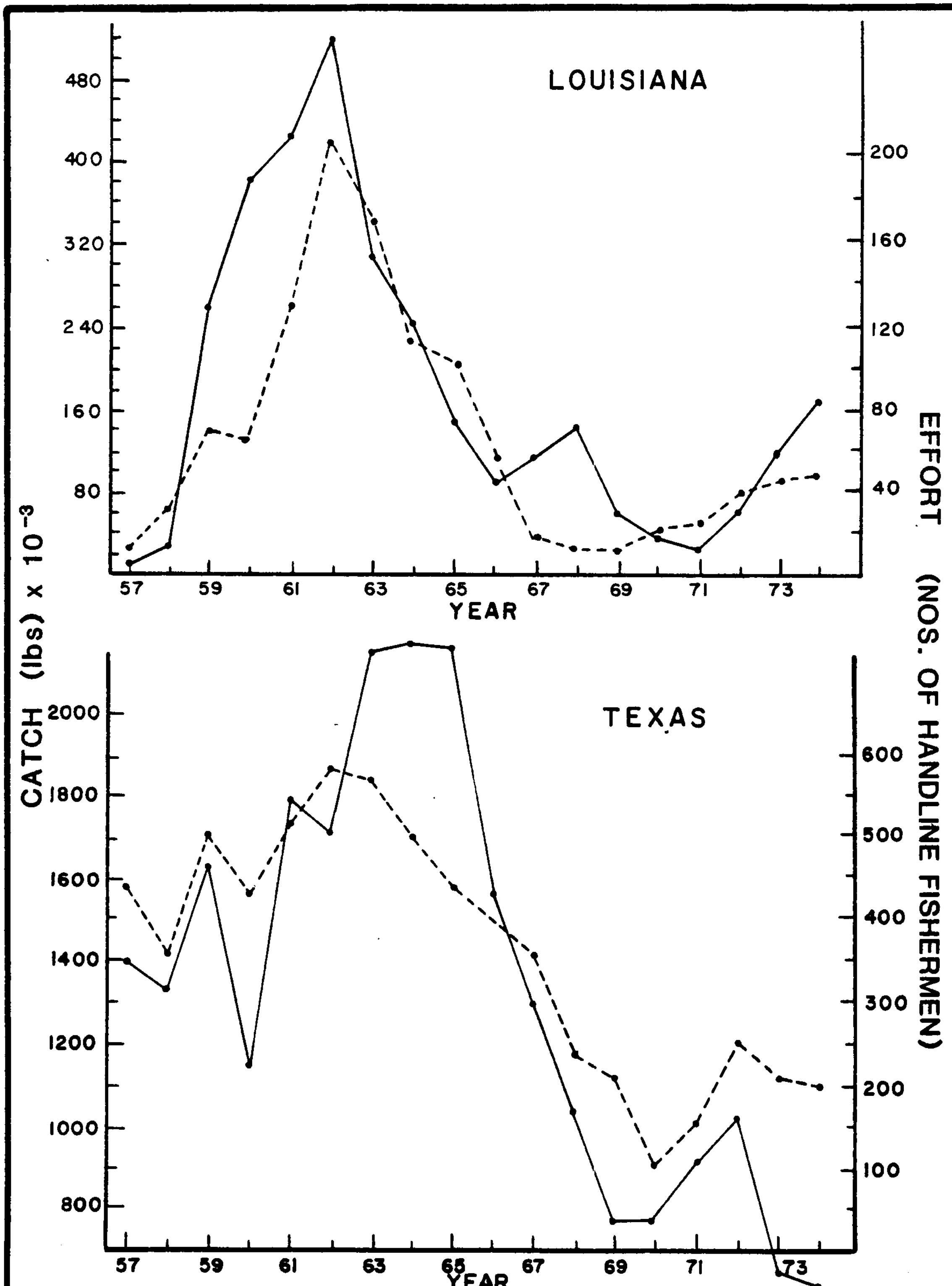


Fig. 5-2. Catch (solid line) and effort (dashed line) time series used in the regressions for (a) Louisiana, (b) Texas. (Data from GMFMC 1980)

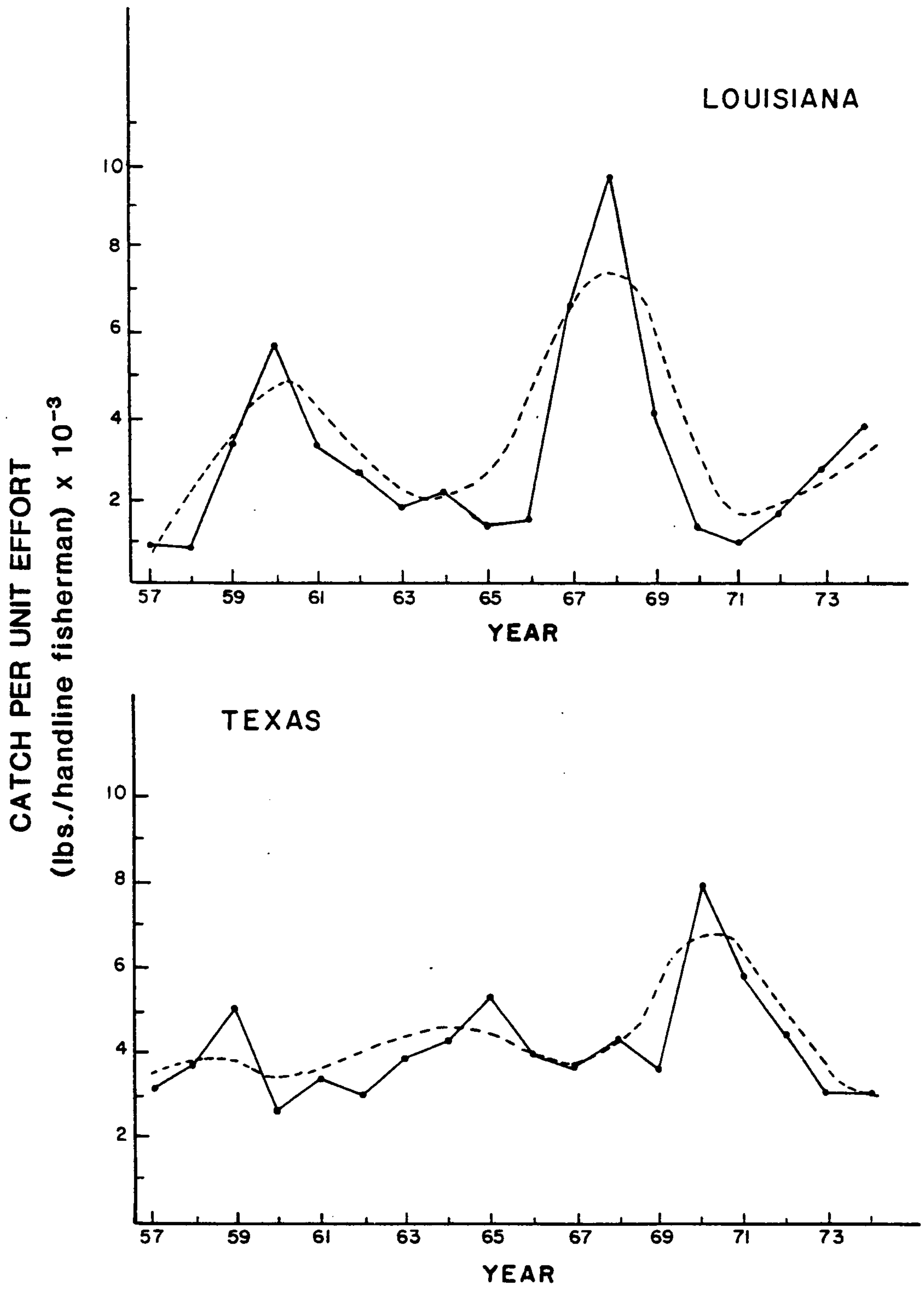


Fig. 5-3. Observed catch per unit effort (solid line) and model prediction (dashed line) for (a) Louisiana, (b) Texas. (Data from GMFMC 1980)

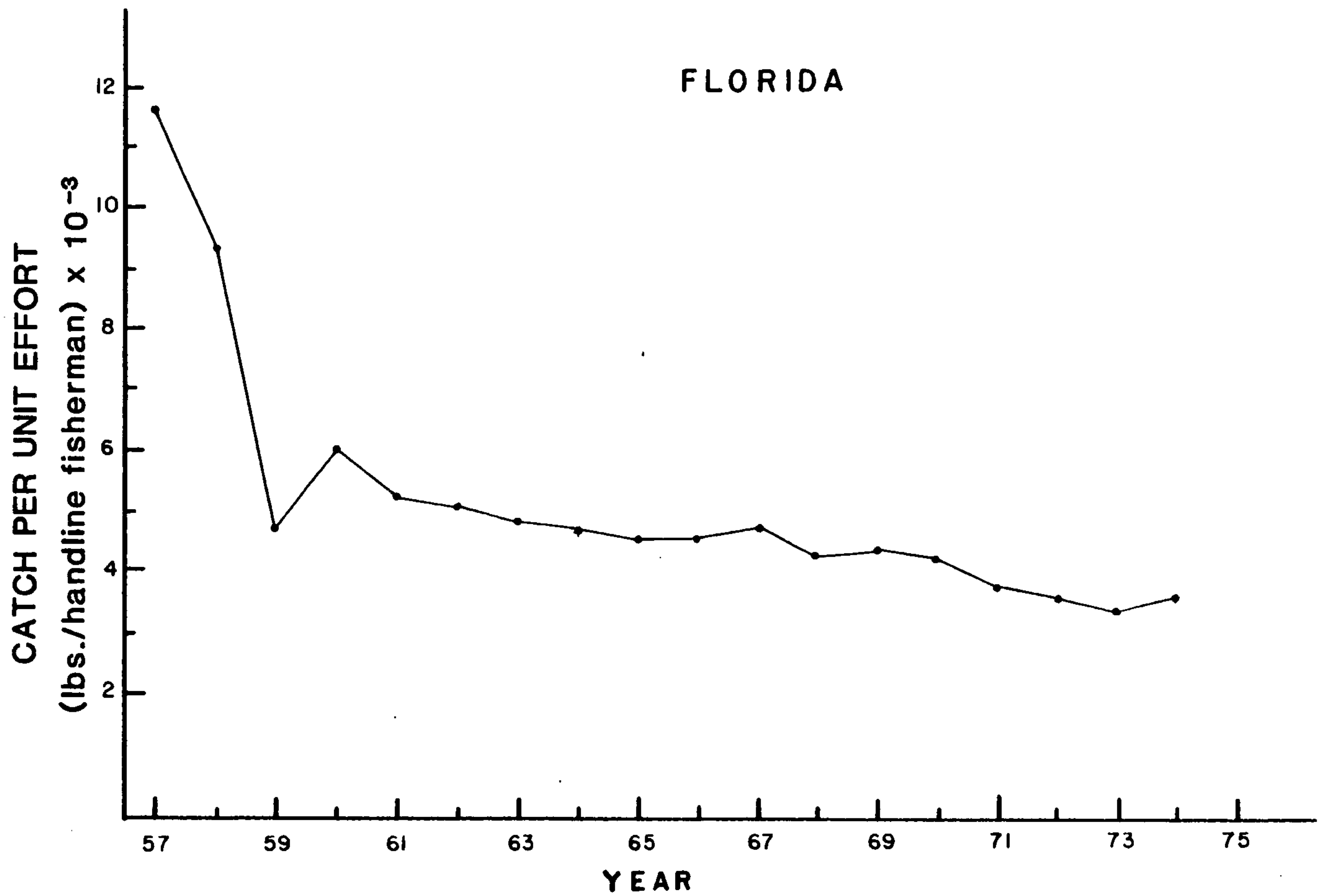


Fig. 5-4. Observed catch per unit effort for Florida. (Data from GMFMC 1980)

A density-dependent stock-recruitment relationship was unexpected. Theoretically, the recruitment curves should have followed a Beverton-Holt type curve or a Ricker curve with only slight density dependence since adult snappers are believed to have a ceiling in abundance imposed by the amount of available reef habitat. The observed dynamics could also occur if there were represented in the Gulf a population of spawners which were not being fished.

Initially, we believed the former explanation (density-dependent stock recruitment) to be the case (Gazey and Gallaway 1980), suggesting the inshore fishery (recreational and commercial) might harvest the fish in a density-dependent manner, both functionally and numerically. However, projections of the model, past the year 1974, do not agree with recently obtained data for the years 1975 and 1976. Therefore the hypothesis that red snapper dynamics can be represented as a single stock, age structured population with repeatable natural mortality, growth and recruitment functions is invalidated.

This result leads to the hypothesis that the observed dynamics might be attributable to a non-fished stock of spawners in the northwestern Gulf. There is evidence to support this contention, namely the presence of large red snapper occurring over soft bottoms well removed from reefs. In this study we took large specimens in control areas away from the reefs by trapping and by angling, and observed them in this habitat with the video system. Further, results of bottom long-lining studies conducted by the Texas Parks and Wildlife Department (Cody et al. 1981) showed large red snapper to have been one of the most abundant species taken, other than sharks. They further reported that in March 1981, approximately 100 trips were made offshore Texas by commercial vessels to long-line, and that a major target of these trips was red snapper. These results suggest that there may be far more adult red snapper living over soft bottoms than presently appreciated, and that this population might represent a major, unexploited spawning stock in the northwestern Gulf. An unexploited stock over soft bottoms would account for the observed stable population even though small fish are heavily fished in inshore areas around platforms and reefs by both the commercial and recreational fishery, and offshore reefs are heavily exploited by the commercial fishery. Given that the fish landed by the commercial fishery are predominantly two-year-olds, suggests that either (1) escapement from reef habitat is low, or (2) the fish may occupy reef habitat for only a certain period of their life, moving to soft bottom habitat with age, or (3) both.

Results of our studies indicated that the present population levels of red snapper at the Flower Garden Banks is low. During the late 1950's, huge numbers of large red snapper were harvested from the banks (Orman Farley, NMFS, Galveston, Texas, pers. comm. 1982). Apparently, the population has not recovered, indicating either recruitment to the offshore banks is slow or that the present harvest is about equal to the recruitment rate.

MARK/RELEASE

A total of 3504 fish representing 34 species were tagged and released (Table 5-4, Appendix 5-5). Of these 1868 were cottonwick, 881 were vermilion snapper, 185 were blue runner (*Caranx crysos*), 134 were longjaw squirrelfish (*Holocentrus ascensionis*) and 104 were red snapper. All but 21 of the marked fish were tagged and released from the vessel as opposed to underwater. Whereas the underwater technique which was developed appeared to work well in terms of apparent condition of the fish at time of release, the trap catches were deplorable. The technique would probably work well around small pinnacle reefs (such as Sonnier Bank) having high densities of trappable fish in a restricted area of habitat.

Of the fish marked and released representing six species, only 29 fish were subsequently recaptured. All but five specimens were obtained during the course of project-related sampling (Table 5-5). The mark-release data obtained on the project were not adequate for use in estimating population sizes, growth or mortality but did provide valuable information concerning movements and migration. The results for each species recaptured are summarized below.

A total of 20 of 1868 tagged cottonwick were recaptured (1.07%), all during project cruises. Three were obtained by trapping, one was seen on a video transect, and the remaining 16 were caught on hook-and-line. Time at large for the 19 cottonwick captured by trap or hook-and-line ranged from two hours to 92 days, with time at large averaging 26 1/3 days. All

Table 5-4. Totals for all fish tagged and released, Cruises 1-8.

Species	Common Name	Scientific Name	Total
1204	Silky shark	*Carcharhinus falciformis*	2
1218	Smooth dogfish	*Mustelus canis*	1
3306	Spotted Moray	*Gymnothorax moringa*	15
3307	Blackedge moray	*Gymnothorax nigromarginatus*	5
3698	Giant snake eel	*Ophichthus rex*	1
7823	Southern hake	*Urophycis floridanus*	1
9002	Longjaw squirrelfish	*Holocentrus ascensionis*	134
9006	Squirrelfish	*Holocentrus rufus*	9
10511	Rock hind	*Epinephelus adscensionis*	7
10515	Red Hind	*Epinephelus guttatus*	2
10538	Yellowmouth grouper	*Mycteroperca interstitialis*	12
10540	Gag	*Mycteroperca microlepis*	4
10541	Scamp	*Mycteroperca phenax*	12
10549	Creole-fish	*Paranthias furcifer*	3
10902	Bigeye	*Priacanthus arenatus*	7
11504	Blue runner	*Caranx crysos*	185
11506	Horse-eye jack	*Caranx latus*	22
11515	Rainbow runner	*Elagatis bipinnulata*	1
11524	Greater amberjack	*Seriola dumerili*	51
11526	Almaco jack	*Seriola rivoliana*	7
11905	Blackfin snapper	*Lutjanus buccanella*	9
11906	Red snapper	*Lutjanus campechanus*	104
11912	Silk snapper	*Lutjanus vivanus*	1
11915	Vermilion snapper	*Rhomboplites aurorubens*	881
12212	Cottonwick	*Haemulon melanurum*	1868
12308	Knobbed porgy	*Calamus nodosus*	74
12314	Red porgy	*Pagrus sedecim*	62
12703	Yellow chub	*Kyphosus incisor*	8
12906	Reef butterflyfish	*Chaetodon sedentarius*	2
13514	Puddingwife	*Halichoeres radiatus*	1
18205	Gray triggerfish	*Balistes capriscus*	3
18207	Queen triggerfish	*Balistes vetula*	2
18211	Ocean triggerfish	*Canthidermis sufflamen*	1
18303	Scrawled cowfish	*Lactophrys quadricornis*	7
GRAND TOTAL			3504

Table 5-5. Tag return data. (I, recaptured during Flower Garden project cruises; II, return from general public; III, recapture from LGL video system.)

	Obs #	Species	Tag Date	Site	Return Date	Days at Large	Tagging Location		Return Location		Dist. Trav. (km)	Fork Length (mm)			Weight (g)			Recapture Method
							N Latitude	W Longitude	N Latitude	W Longitude		Release	Return	Change	Release	Return	Change	
I	1	CW	11-20-80	WFG	11-22-80	2	27°52.50'	93°49.52'	27°52.54'	93°49.74'	1.1	290	287	-3	510	454	-58	Hook & Line
	2	CW	11-20-80	WFG	11-22-80	2	27°52.50'	93°49.52'	27°52.54'	93°49.74'	1.1	273	273	0	425	454	+29	H & L
	3	CW	11-20-80	WFG	12-02-80	12	27°52.50'	93°49.52'	27°52.43'	93°49.57'	0.4	253	258	+5	369	425	+56	H & L
	4	CW	11-20-80	WFG	12-02-80	12	27°52.50'	93°49.52'	27°52.43'	93°49.57'	0.4	262	266	+4	425	425	0	H & L
	5	CW	11-21-80	WFG	11-22-80	1/10	27°52.54'	93°49.74'	27°52.54'	93°49.74'	0.0	281	283	+2	454	454	0	H & L
	6	CW	11-21-80	WFG	12-06-80	15	27°52.50'	93°49.52'	27°52.51'	93°49.68'	0.4	295	292	-3	510	454	-56	H & L
	7	CW	11-21-80	WFG	12-06-80	15	27°52.54'	93°49.74'	27°52.51'	93°49.68'	0.3	270	270	0	454	397	-57	H & L
	8	CW	11-21-80	WFG	12-07-80	16	27°52.54'	93°49.74'	27°52.51'	93°49.68'	0.3	268	272	+4	397	397	0	H & L
	9	CW	11-21-80	WFG	01-23-81	63	27°52.50'	93°49.52'	27°52.55'	93°49.07'	2.0	266	266	0	397	400	+-3	Trap
	10	CW	11-22-80	WFG	12-07-80	15	27°52.54'	93°49.74'	27°52.51'	93°49.68'	0.3	276	270	-6	425	454	+30	H & L
	11	CW	11-22-80	WFG	12-06-80	14	27°52.54'	93°49.74'	27°52.51'	93°49.68'	0.3	286	287	+1	454	454	0	H & L
	12	CW	11-22-80	WFG	12-06-80	14	27°52.54'	93°49.74'	27°52.51'	93°49.68'	0.3	266	268	+2	425	397	-28	H & L
	13	CW	11-22-80	WFG	01-23-81	62	27°52.54'	93°49.74'	27°52.55'	93°49.07'	3.1	274	277	+3	482	500	+18	Trap
	14	CW	12-02-80	WFG	01-23-81	29	27°52.43'	93°49.57'	27°52.55'	93°49.07'	2.4	300	297	-3	539	550	+11	Trap
	15	CW	12-06-80	WFG	-1-22-81	47	27°52.51'	93°49.68'	27°52.50'	93°49.50'	0.9	321	320	-1	539	525	-14	H & L
	16	CW	05-01-02	EFG	08-01-82	92	27°54.73'	93°35.32'	27°54.22'	93°35.38'	0.9	292	299	+7	460	490	+30	H & L
	17	CW	08-01-82	EFG	08-03-82	3	27°54.22'	93°35.38'	27°54.23'	93°35.30'	0.1	276	280	+4	410	350	-60	H & L
	18	CW	08-03-82	EFG	08-13-82	10	27°54.23'	93°35.30'	27°54.32'	93°35.31'	0.2	278	273	-5	300	400	+100	H & L
	19	CW	08-08-82	EFG	10-24-82	77	27°54.63'	93°35.06'	27°54.44'	93°35.47'	0.8	269	265	-4	390	390	0	H & L
	20	VS	12-03-80	WFG	04-20-81	138	27°52.26'	93°49.92'	27°52.10'	93°49.87'	0.4	304	322	+18	539	550	+11	H & L
	21	VS	12-03-80	WFG	04-20-81	138	27°52.26'	93°49.92'	27°52.10'	93°49.87'	0.4	260	261	+1	397	325	-72	H & L
	22	VS	08-01-82	EFG	10-21-82	81	27°54.22'	93°35.38'	27°54.37'	93°35.55'	0.5	359	350	-9	730	690	-40	H & L
II	23	BM	01-25-81	PLA	04-10-81	65	27°52.40'	93°59.70'	27°52.40'	93°59.70'	0.0	730	762[1]	+32	1000	-	-	H & L
	24	RS	04-17-81	EFG	04-01-82	350	27°53.50'	93°36.31'	27°58.00'	91°44.00'	180.4[2]	594	-	-	4000	-	-	H & L
	25	VS	07-14-81	EFG	08-28-82	410	27°54.11'	93°48.50'	28°30.00'	90°20.50'[3]	320.5	310	-	-	575	-	-	H & L
	26	VS	07-16-81	WFG	05-22-82	311	27°53.75'	93°48.53'	WFG	WFG[4]	0.0	321	-	-	475	-	-	H & L
	27	SD	08-06-82	EFG	02-21-83	199	27°54.56'	93°35.08'	27°48.00'	93°36.50'	11.9	1060	1206	+146	-	-	-	H & L
III	28	CW[5]	04-28-82	EFG	05-02-83	1-4	27°54.31'	93°35.36'	27°54.35'	93°35.80'	0.8	-	-	-	-	-	-	Video
	29	BR	10-21-82	EFG	10-24-83	3	27°54.10'	93°35.33'	27°53.77'	93°35.41'	0.6	-	-	-	-	-	-	Video

[1] Estimated length by fisherman on platform.
[2] Approximately 9 km from Jakkula Bank.
[3] General location of offshore platform cluster.
[4] Recapture position not known but on same bank as release.
[5] Only probable release site and date - tag appeared new.

Species Codes:
CW - Cottonwick (*Haemulon melanurum*);
VS - Vermilion snapper (*Rhomboplites aurorubens*)
BM - Blackedge moray (*Gymnothorax nigromarginatus*)
RS - Red snapper (*Lutjanus campechanus*)
SD - Smooth dogfish (*Mustelus canis*)
BR - Blue runner (*Caranx crysos*)

recaptures were made on the same bank as release. Distance traveled ranged from 0 km to 3.1 km with a mean of 0.8 km.

A diurnal movement pattern of cottonwick from the edge of the upper coral reef or over a drowned reef outcrop during the day to algal nodule terraces at night was suggested by the combination of results from the daytime video surveys versus the nighttime hook-and-line sampling. In the video surveys, cottonwick were always seen adjacent to the edges of the reef and never over the algal nodule flats where they were angled and trapped in abundance at night. The single video observation of a tagged cottonwick was made at the edge of the upper coral reef. Judged by the bright and fresh appearance of the tag, the fish must have been tagged at night a day or so earlier at one of three locations over the algal nodule terrace (Fig. 5-5). The suggested movement pattern is consistent with published accounts of the movement behavior of grunts (Bohlke and Chaplin 1968, Randall 1968).

Determinations of fish growth while at large had perplexing results. Fish at large up to 77 days showed decreasing size. Fork length changes ranged from +0.4 mm/day to -1.5 mm/day for fish at large longer than one day. The mean length change rate was -0.01 mm/day.

"Negative growth" of tagged fish is difficult to explain. Cases where the change is only a few millimeters are probably due to measuring error, but even in cases of length decreases larger than 10 or 20 mm this explanation may also be valid. This problem seems to be common to many tagging studies; e.g. Fable (1980) reported length decreases for red snapper of 20 and 25 mm after being at large for as long as 253 days.

Weight changes in the 19 returned cottonwick were highly variable. The variability is likely due to measurement error. The rolling deck of a ship is not conducive to weighing live, flopping fish. Weight changes ranged from +14.5 g/day to -29 g/day with a mean change of -1.3 g/day. These results may indicate that tagging and/or capture has detrimental effects but the evidence is not conclusive. Measurement error is an equally probable explanation.

Five of 881 (0.57%) tagged vermilion snapper were recaptured; three during the course of project activities and two by the general public. The low return rate of tagged vermilion snapper in this study is comparable to that described for several other tagging studies. Grimes et

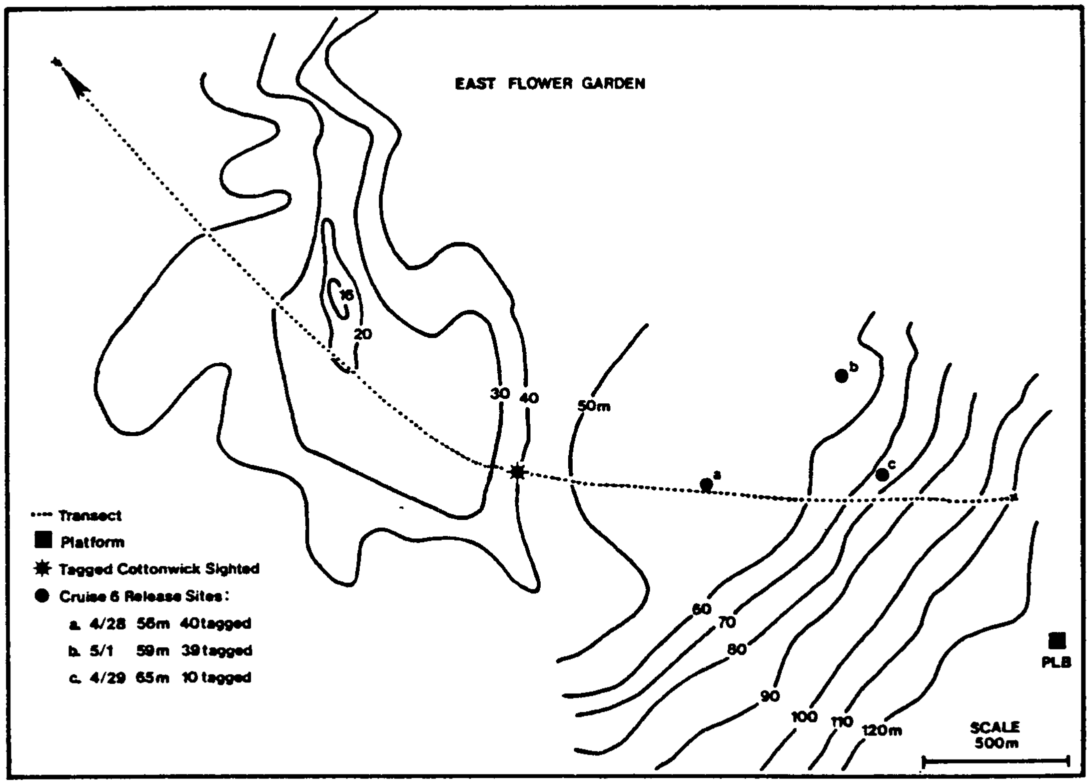


Fig. 5-5. Location of tagged cottonwick observed by video and locations of release sites previous to observation.

al. (1982) tagged 458 fish off of North and South Carolina and had a return rate of only 0.4%. Several studies report tagging and releasing vermilion snapper with no returns being made (Topp 1963, Beaumariage and Wittich 1966, Moe 1963). Fable (1980) however, tagged 793 vermilion snapper of which some 4.9% were recaptured.

Two of the project recaptures were taken on the same date (20 April 1981) within 0.4 km of where they had been tagged and released together on the West Flower Garden Bank on the same date (3 December 1981) some 138 days earlier. The other project recapture of a vermilion snapper was a fish which was both tagged and recaptured on the East Flower Garden Bank. At large for 81 days, this fish was recaptured at a location only 0.5 km from where it had been originally tagged and released.

Of the two recaptures obtained from the public, one was taken at an unspecified location on the West Flower Garden Bank some 311 days after having been tagged and released at the same bank. In contrast, the other fish received from the public had been tagged and released on the East Bank and was recaptured at a group of platforms located over 320 km from the bank south of Belle Pass, Louisiana following over a year at large (410 days). This event represents a departure from the general observation that the species appears non-migratory (Beaumariage 1964, Fable 1980, Grimes et al. 1982, this study).

A single red snapper out of the 104 specimens marked and released was recaptured. This fish was a large specimen (594 mm long, 4 kg in weight) which was recaptured at a snapper bank (Jakkula Bank) some 180 km due east of the East Flower Garden Bank where it had been tagged and released about a year (350 days) earlier. The fish had been marked in April (1981) and was likewise recaptured in April (1982).

Of the 185 blue runner which were tagged and released, only one was resighted. The observation was made using the video system. The fish was believed to have been one tagged three days earlier at a site within about 0.6 km of the resighting location.

A total of five blackedge moray eels were tagged and released, two of which were at the platform PLA. One of these was recaptured 65 days later by a worker fishing from the platform.

Although only one smooth dogfish shark was tagged and released, it was subsequently recaptured. The shark had been tagged and released at the East Flower Garden Bank on 6 August 1982. It was recaptured some 199 days later by a fisherman fishing at a site estimated to have been about 12 km away from the release site.

The most obvious reason accounting for the low recapture rates of marked fish was that not enough fish were tagged and released. Other contributing factors likely included tag-induced mortality and tag retention problems. Several experiments were conducted during the project to determine the effects of the tagging procedure on the fish. The experiments were restricted, by necessity, to cottonwick which was the only species captured in enough numbers at the designated time and place of the experiments.

The first experiment was conducted during Cruise 1 at a depth of 45 m. Five fish were caught at the bottom, raised to surface, tagged, and then lowered to the bottom in a cage attached to the video frame for observation. One cottonwick escaped from the trap during the first 5 minutes demonstrating (on video) that trapping a fish is not a one-way event.

No mortality was observed over the 1-h observation period and the only observable effect of the tagging process on the remaining four fish was that they had difficulty in maintaining a normal orientation. We believe that the swim bladders of these fish had been ruptured as they were raised to the surface for tagging leaving the fish negatively buoyant after returning to depth. The rupture of the swim bladder is suggested rather than a gradual diffusion of gas out of the bladder while at the surface based upon video observations of cottonwick being raised in a trap from the bottom during the underwater marking sessions. At a depth of approximately 20 m, numerous gas bubbles were seen coming from inside the fish trap and no other source of gas would explain these observations.

The second experiment was performed during Cruise 7, and included four tagged fish and five untagged fish which had been caught at a depth of 57 m. After reaching the bottom all fish seemed to be in similar condition. When the fish were swimming, the posterior part of the body pointed down due to apparent bouyancy problems as seen in the first experiment. After a short period of time most fish were sitting on the bottom of the trap, tilted a bit to one side, and some lay completely on their sides on the bottom of the cage. There were no apparent differences in behavior between tagged and untagged fish throughout the experiment.

No significant improvement in bouyancy control was evidenced over the 24 h observation period. The only major change in behavior was caused by changes in the position of the cage, which either rested on the bottom or was suspended a few meters above the bottom. When the cage was resting on the bottom without movement, all fish settled onto the bottom of the cage and either lay on their sides or on their ventral surface, tilting to the side. They seemed to be so negatively buoyant that the pectoral fins had to be used to prevent the fish from falling over. When the cage was suspended above the bottom the fish would often swim around inside the cage to avoid abrasion due to movement of the cage from wave surge. All fish swam in a very abnormal orientation with the tail down, sometimes at an angle of as much as 70-80° but more commonly at an angle of about 20° from horizontal. All of the fish were alive at the end of the 24-h observation period.

The third tagging effects experiment was also conducted on Cruise 7 and was ended after 10 hours with no apparent differences observed between seven tagged and seven untagged fish. The behavior of all fish was similar to that seen in previous experiments and no mortalities occurred.

It is probable that the swim bladders were ruptured on all cottonwicks as they were raised to the surface for tagging and the fish did not re-establish any buoyancy control over a period of 24 hours. Although the rupture of the swim bladder was not immediately fatal, the fish were certainly not in good condition upon return to the bottom. It is unknown what percentage of cottonwick raised from depth eventually died as a result of the tagging procedure. While the tag returns from this study demonstrated that mortality was not 100%, the very low tag return rates indicate the possibility that significant mortality resulted from the tagging procedure. This is particularly true when it is considered that the cottonwick was among the most hardy of the fishes marked and released.

Tag loss may also have been a significant problem contributing to low return rates. Several studies have been performed using anchor tags similar to those used in this study with mixed results. Crossland (1976) obtained very poor results using anchor tags on snapper in New Zealand. Only one return was made out of 531 fish tagged. Crossland stated that the most serious cause of "tag loss" was likely to be prolonged and moderately heavy mortality caused by infection of the tag wound. Anchor tags were also used in the Buccaneer Gas and Oil Field study by LGL (Gallaway and Martin 1980). Return rates of red snapper were as high as 29%, with 79 days the longest period at large. Ian Rossman, a graduate student at Texas A&M University, performed an extensive red snapper tagging study based from Galveston, Texas, using anchor tags and techniques similar to those used in the Flower Gardens study (pers. comm., March 1983). The tag return rate was 7.3% from 1352 released snapper. As a result of holding tank experiments, Rossman concluded one of the major reasons for low numbers of tag returns was tag loss. The tagging technique used most often in the Flower Gardens study and also by Rossman involved the insertion of the anchor tag through both sides of the fish just behind the dorsal fin. This technique (compared to partial insertion) was believed to decrease the chances of a tag being pulled out of the fish. Rossman showed that this method may have caused greater tag loss than might have occurred by anchoring the tag internally. In one of Rossman's experiments, 17 red snapper were tagged and placed into a holding tank. After 28 days only four fish had retained their tags. Apparently the swimming movement of the red snapper caused movement of the tag. This body movement kept the tag wound open and eventually cut a groove through the fish's back, resulting in tag loss. A similar experiment was performed by Rossman on nine internally-tagged red snapper retained in a holding tank. Only one tag was lost after 60 days. Rossman also believed that water loss through the open tag wound may have been a major factor contributing to mortality and low tag returns. The longest period at large for fish tagged by Rossman was 91 days, with a mean time of about 30 days.

Grimes et al. (1982) experienced similar problems with red porgy and vermilion snapper using both disc tags and barbed dart tags. The internally-anchored dart tag (similar to the T-anchor tag), had a very high loss rate on red porgy retained in holding tanks. After two months, 60% of the dart-tagged porgy lost their tags (Grimes et al. 1982). Grimes et al. (1982) also reported that the longest period at large for dart-tagged fish in their study was 57 days.

The maximum time at large of the Flower Gardens study for fish with anchor tags was 410 days, indicating at least some long-term tag retention. Twelve returns were from fish released over 60 days previously. On two occasions the tag portion bearing the legend was known to have been lost. One cottonwick and a red hind were caught on hook-and-line on the East Flower Garden Bank with only the nylon tips of the tags remaining in the fish. Apparently the Cyanoacrylate ester glue used to join the two parts of the tags had weakened and caused the separation. This problem has been commonly reported in the literature (Bruger 1981). Bruger found defective dart tags (the same construction as Floy anchor tags) to comprise up to 22% of a tag batch produced by Floy Tag and Manufactoring Inc.

SECTION 6

REMOTE SENSING RESULTS AND DISCUSSION

A total of 357 hours of videotapes containing records for 189,094 fish were obtained over the 12 cruises (Appendices 6-1 and 6-2). Cruise 1 was largely experimental and was devoted to developing and perfecting methodologies and transecting techniques. Cruise 2 took place exclusively at the West Flower Garden Bank and efforts of Cruises 3 and 4 were divided between the two banks. During Phase II (Cruises 5, 6, 7 and 8), all effort was expended at the East Flower Garden Bank and the new production platform PLB.

Figures 6-1 and 6-2 illustrate the location of the video transects which were conducted at the West Flower Garden Bank. Total area surveyed on the West Bank was 427,108 m^2 over all habitat types. Survey area broken down by habitat type appears in Appendix 6-3. Figure 6-3 shows positions of the transects which were videotaped on the East Bank during Cruises 3 and 4 of Phase I. During Phase II, sample effort was significantly increased as illustrated by Figure 6-4. Total area transected was 1,137,055 m^2 during Cruises 5-8 over all habitat types. Appendix 6-4 lists areas surveyed within individual habitat types on the East Flower Garden Banks.

A total of 141 separate taxa were videotaped using the remote sensing apparatus (Appendix 6-5). In Appendix 6-5, 165 taxa are listed, but some of these represent higher taxonomic groupings of individual taxa. A total of 16 species not previously reported in Flower Gardens literature were observed by the video cameras (Table 6-1).

In the following parts of this section, we first provide qualitative descriptions of (1) the biological communities associated with study area habitats, (2) sightings of unusual or rare species, (3) behavioral observations and (4) observations of brine and gas seeps. This section is followed by comparisons of fish size distributions based upon video determinations to size distributions obtained from measured specimens collected by hook-and-line.

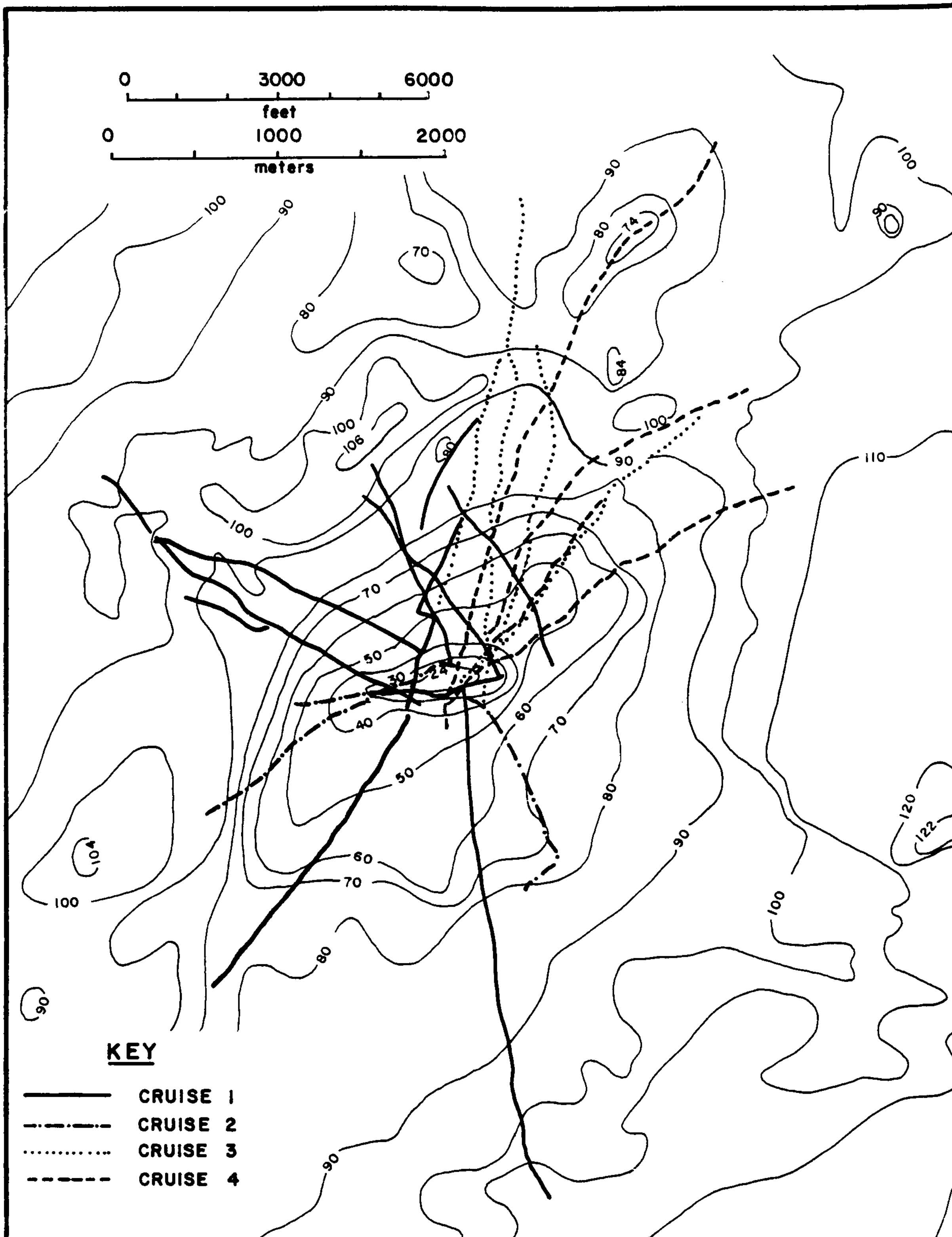


Fig. 6-1. Location of video transects on primary crest of the West Flower Garden Bank, Cruises 1-4.

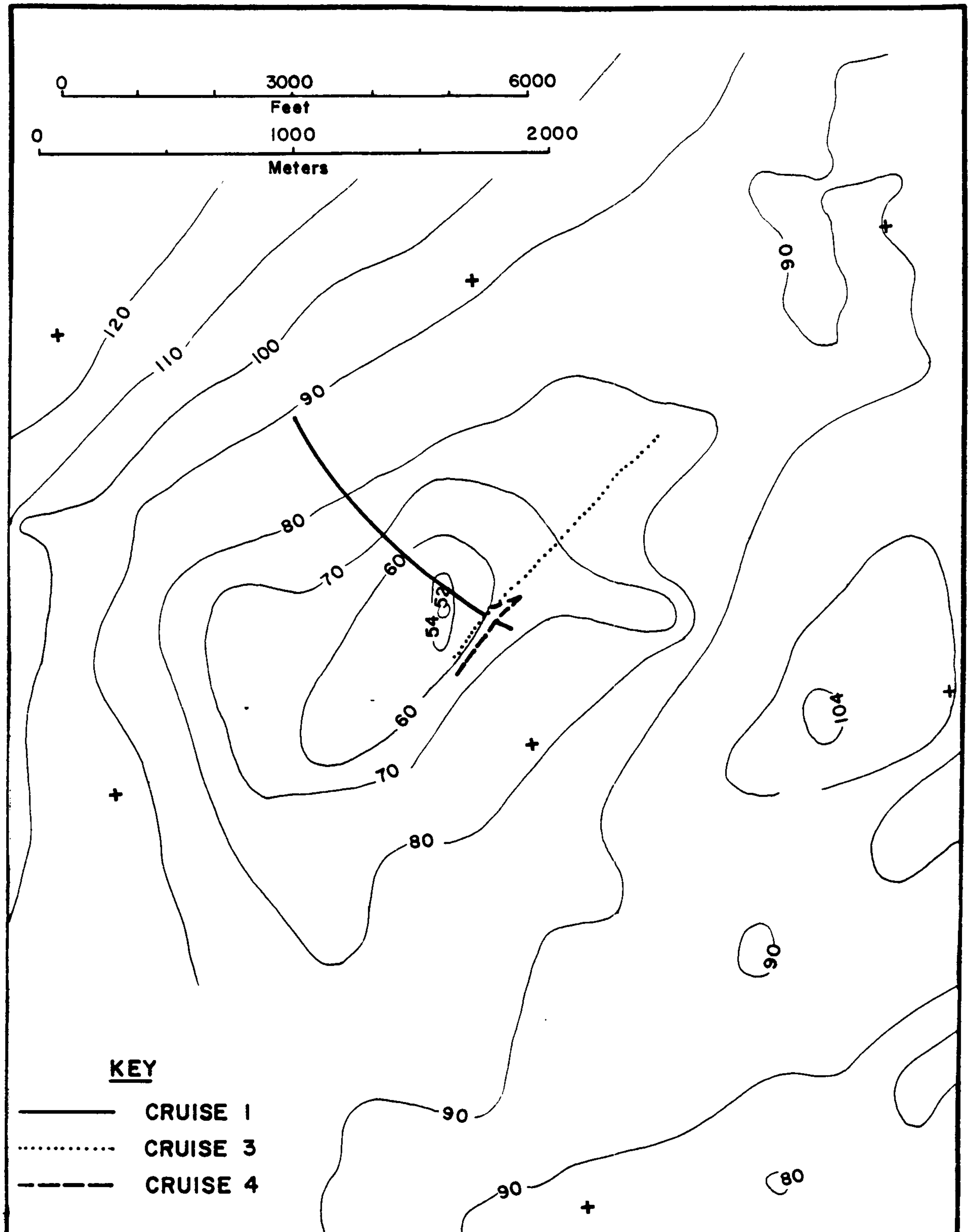


Fig. 6-2. Location of video transects on western peak of West Flower Garden Bank (see Fig. 1-5), Cruises 1-4.

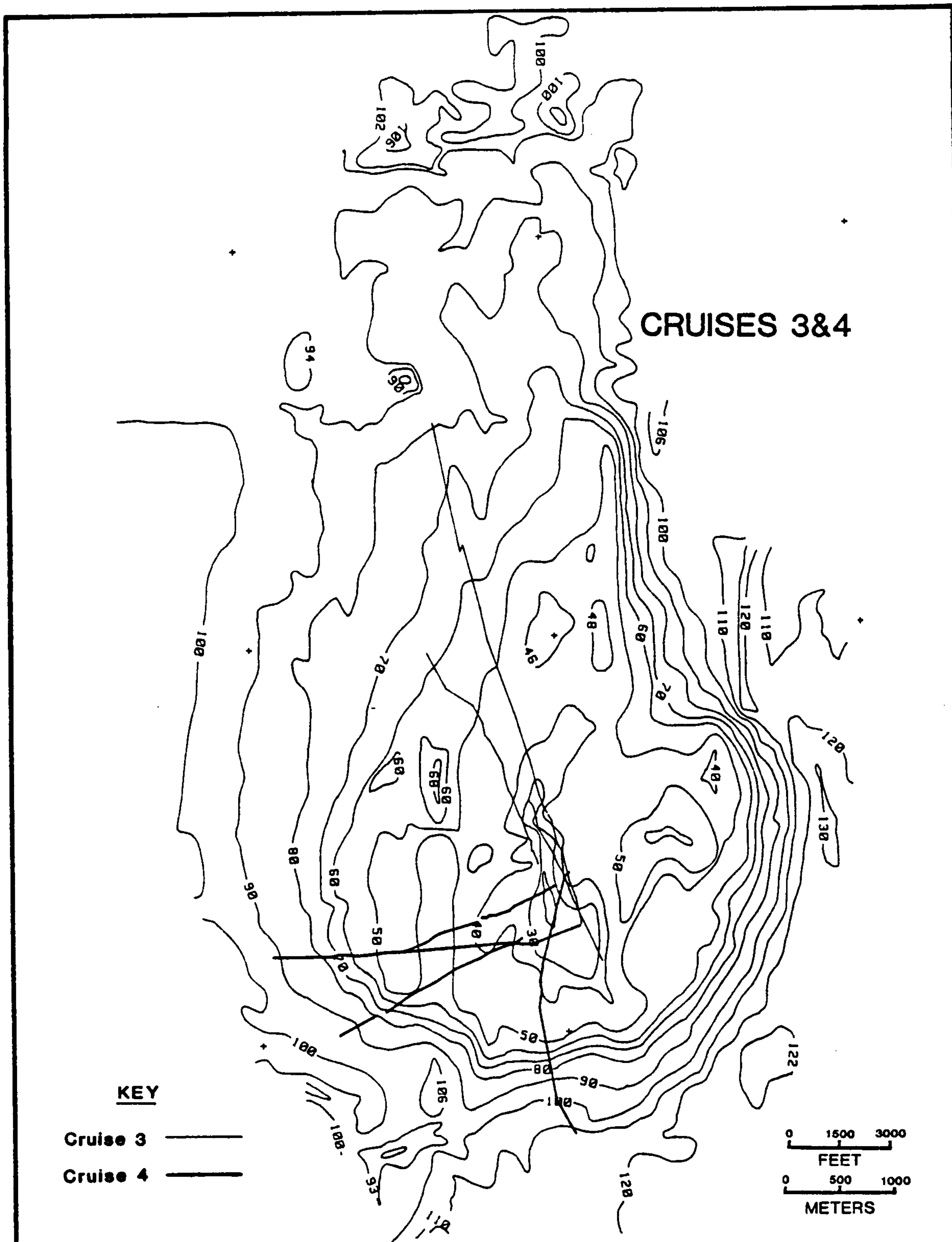


Fig. 6-3. Location of video transects on East Flower Garden Bank, Phase I, Cruises 3 and 4.

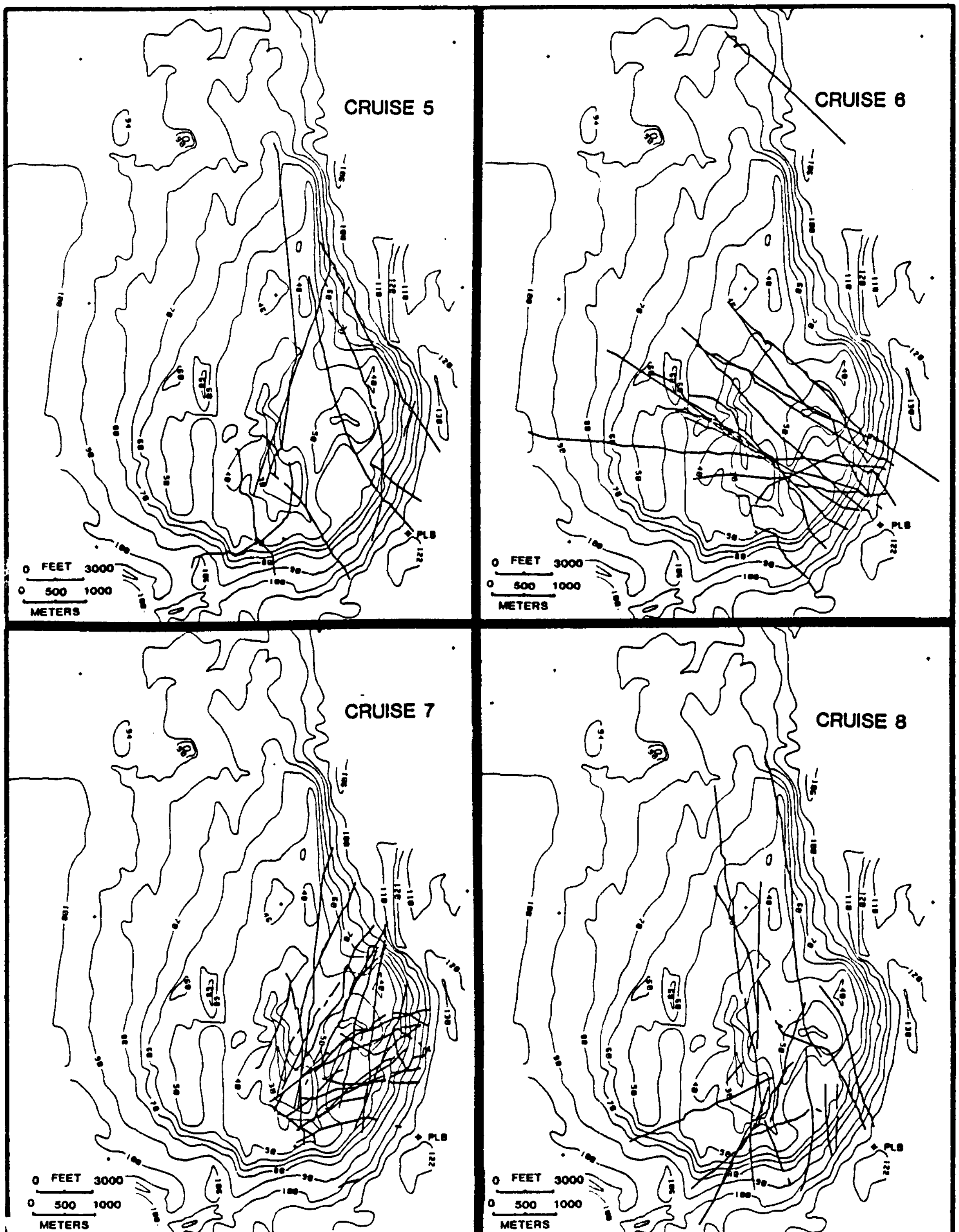


Fig. 6-4. Location of video transects on East Flower Garden Bank, Phase II, Cruises 5-8.

Table 6-1. Species observed by video technique and not previously reported in Flower Gardens literature.

Common Name	Scientific Name
Shortfin mako	Isurus oxyrinchus
Giant snake eel	Ophichthus rex
Warsaw grouper	Epinephelus nigritus
Black grouper	Mycteroperca bonaci
Tiger grouper	Mycteroperca tigris
Gulf bar-eye tilefish	Caulolatilus intermedius
Yellowjack	Caranx bartholomaei
Black jack	Caranx lugubris
Dog snapper	Lutjanus jocu
Red porgy	Pagrus sedecim
Banded butterflyfish	Chaetodon striatus
Hogfish	Lachnolaimus maximus
Flathead	Bembrops spp.
Unicorn filefish	Aluterus monoceros
Whitespotted filefish	Cantherhines macrocerus
Porcupinefish	Diodon hystrix

QUALITATIVE COMMUNITY CHARACTERIZATIONS

Bank Habitats

During a SCUBA dive on top of the coral bank, the first group of fishes one would probably notice would be the suprabenthic plankton feeders. These species include the numerically dominant fish on the coral reef, the creole-fish, and other abundant species such as brown chromis, Chromis multilineatus, and creole wrasse, Clepticus parrai. These fish are usually seen feeding up to several meters above the coral heads, often in large aggregations. Other fish species abundant on the bottom include several damselfish species, Pomacentrus spp., and the bluehead wrasse, Thalasoma bifasciatum. Several pelagic species often occur in large numbers over the coral reef including the almaco jack, Seriola rivoliana, horse-eye jack, Caranx latus, bar jack, Caranx ruber and chubs, Kyphosus spp. Many other tropical reef fish species are not relatively as numerous as the above species, but are common and conspicuous on the coral reef. Examples of these would include the queen angelfish, Holacanthus ciliaris, reef butterflyfish, Chaetodon sedentarius, rock beauty, Holacanthus tricolor, hogfishes, Bodianus spp., parrotfishes of several species, (e.g. Scarus spp. and Sparisoma spp.) and many species of groupers, of the genera Mycteroperca and Epinephelus.

One of the dominant motile invertebrates on the coral reef is the sea urchin, Diadema antillarum. These echinoderms can be seen grazing on top of coral heads throughout the entire coral reef area at night. Easily observed mollusk species are relatively rare. Empty shells are virtually non-existent. The few common species encountered include the stocky cerith, Cerithium litteratum; rough lima, Lima tenera; imbricated star-shell, Astraea tecta; and the Atlantic thorny oyster, Spondylus americanus.

Spiny lobsters, Panulirus argus, are known to occur on the coral reefs at both the East and West Flower Garden Banks, but very few were observed in this study. By far the more numerous (observable) lobster species represented is the spotted lobster, Panulirus guttatus. The spotted lobster can be seen during any night dive on the coral reef. As many as seven spotted lobsters were observed on a single night dive on the East Flower Garden Bank.

A unique habitat subtype formed by large knolls (structurally very different than the hermatypic coral bank) occurs within the Upper Coral Reef Zone of the East Flower Garden Bank. Some of these knolls are composed entirely of the finger coral, Madracis mirabilis and others are completely covered by leafy algae dominated by species of the genera Dictyota and Lobophora. Typically underlying these algal mats is a layer of unknown depth composed primarily of dead Madracis coral pieces, apparently cemented into a single mass by coralline algae. These unusual areas were first named by Bright and Rezak (1976) as Madracis and Leafy Algae Zones.

These areas were included within the general habitat type of Upper Coral Reef in this study for several reasons: (1) the total area of Madracis and Leafy Algae Zones computer-digitized from habitat charts developed by Dr. T.J. Bright, (in McGrail et al. 1982) indicated they made up only 2% of the total coral reef area; (2) many areas of these knolls included a few hermatypic coral outcrops creating a very similar habitat to the coral reef with respect to fish; and (3) there was no way to determine total areas of knolls with and without significant hermatypic coral outcrops.

Beyond the edge of the coral reef from about 46 m to about 88 m, the next major habitat type occurs, the Lower Live Bottom or Algal-Nodule Sponge Zone. The substrate is dominated by algal nodules formed from coralline algae. Although of low-relief, this habitat provides a variety of micro-habitats. Most all the leafy algae occurring on the banks is represented within this zone (McGrail et al. 1982). A few species of coral are also found in this zone but are characterized by highly variable abundance. The saucer coral, Helioseris cucullata and species of leaf corals (Agaricia) are present along with species of Madracis.

One of the important components of this habitat type relative to fish is the sponge, Neofibularia nolitangere. This conspicuous species forms large colonies with numerous spires several centimeters tall. The relief created by the sponge attracts a variety of invertebrates and fishes, the most common being yellowtail reeffish, Chromis enchrysurus, reef butterflyfish, and the cherub fish, Centropyge argi.

Overall, two species of fish are probably the most characteristic of the Algal-Nodule Zone, namely the sand tilefish, Malacanthus plumieri, and the French angelfish, Pomacanthus paru. The French angelfish is not very abundant in the Algal-Nodule Sponge Zone but it is striking in both shape and size and is the only large benthic fish consistently seen cruising over the nodule flats in areas devoid of outcrops or other areas of relief. The sand tilefish provides its own cover in the form of burrows which it constructs in the algal nodule bottom. Substantial piles of excavated nodules often occur around the entrances to the burrows. These piles of nodules apparently provide habitat attracting other small fishes.

Another major habitat type (Shallow Drowned Reef) also occurs within this zone of algal nodule cover. Figure 6-5 shows a diagrammatic representation of the major components of the Shallow Drowned Reef Habitat. The surface of Shallow Drowned Reef outcrops (termed partially drowned reefs in McGrail et al. 1982) are typically heavily encrusted, primarily by coralline algae. Leafy algae and sessile invertebrates characteristic of the algal nodule community per se also occur on the surface of these outcrops. Large anemones such as Condylactis gigantea are conspicuously present (Fig. 6-5). Small colonies of hermatypic corals are infrequently encountered but some are represented including Helioseris cucullata, Agaricia spp., Montastrea cavernosa and Stephanocoenia michelini (McGrail et al. 1982).

The protection provided by the outcrops, and food sources provided by the diverse epifauna attracts numerous fish species to shallow drowned reefs. Figure 6-5 depicts several of the more common species. The most abundant species found on Shallow Drowned Reef outcrops is the yellowtail reeffish, which is not often seen on the Coral Reef. It can occur in aggregations of several hundred individuals within a relatively small area of Shallow Drowned Reef outcrops. Other commonly encountered species would include many forms common to the Coral Reef Habitat such as the reef butterflyfish, spotfin hogfish and squirrelfishes. Some commercially important species almost never occurring on the Upper Coral Reef are found on both Shallow and Deep Drowned Reefs. These include both the red snapper, and vermilion snapper. Several species of groupers (Mycteroperca spp. and Epinephelus spp.) also occur on Drowned Reefs as well as on the Coral Reef.

Fig. 6-5 . Illustration of Shallow Drowned Reef habitat with characteristic fish species: (A) yellowtail reeffish, (B) spotfin hogfish, (C) squirrelfish sp., and (D) reef butterflyfish.

Deep Drowned Reefs occur below about 82 m on the East Flower Garden Bank and below about 88 m at the West Flower Garden Bank. At these depths, coralline algae do not thrive and Deep Drowned Reef Habitats are distinctly different from Shallow Drowned Reefs (Fig. 6-6). The fish fauna and attached epifauna are typically represented by fewer numbers of species on Deep Drowned Reef as compared to Shallow Drowned Reef. These changes in species composition are likely related to the presence of a highly turbid water layer, termed the nepheloid layer. In general, the boundary between the Shallow and Deep Drowned Reefs represents the shallowest depth of penetration by the nepheloid layer which introduces comparatively turbid water which deposits fine sediments onto bottom substrate.

Hermatypic corals are never found on Deep Drowned Reefs and coralline algae is virtually absent. The most conspicuous attached organisms are antipatharian sea whips and comatulid crinoids (Fig. 6-6). These organisms can thrive even though the outcrop surfaces they are attached to may be covered with a thin veneer of sediment. Other deep-water octocoral sea whips and fans also occur on deep drowned reefs.

The most abundant fish species rapidly changes from the yellowtail reeffish found on Shallow Drowned Reefs to the roughtongue bass, characteristic of Deep Drowned Reefs. This shift in abundance is directly associated with the change in habitat type though a few roughtongue bass can be found on Shallow Drowned Reef and yellowtail reeffish are occasionally found in Deep Drowned Reef Habitat. Other conspicuous fish species occupying Deep Drowned Reefs include the bigeye, groupers, *Mycteroperca* spp. and occasionally, a bank butterflyfish, *Chaetodon aya*.

Soft Bottom Habitats

Beginning at approximately 75 m of depth on the Flower Garden Banks, the nature of the bottom abruptly changes from algal nodules to a soft bottom which, adjacent to the bank, is predominantly composed of coarse calcareous sand mixed with the tests of the foraminifer, *Amphistegina* spp. (McGrail et al. 1982). This bottom type gradually changes with depth with the coarser sediments being replaced with fine muds. The Deep Drowned Reef Habitat previously described occurs in these regions. The deeper mud

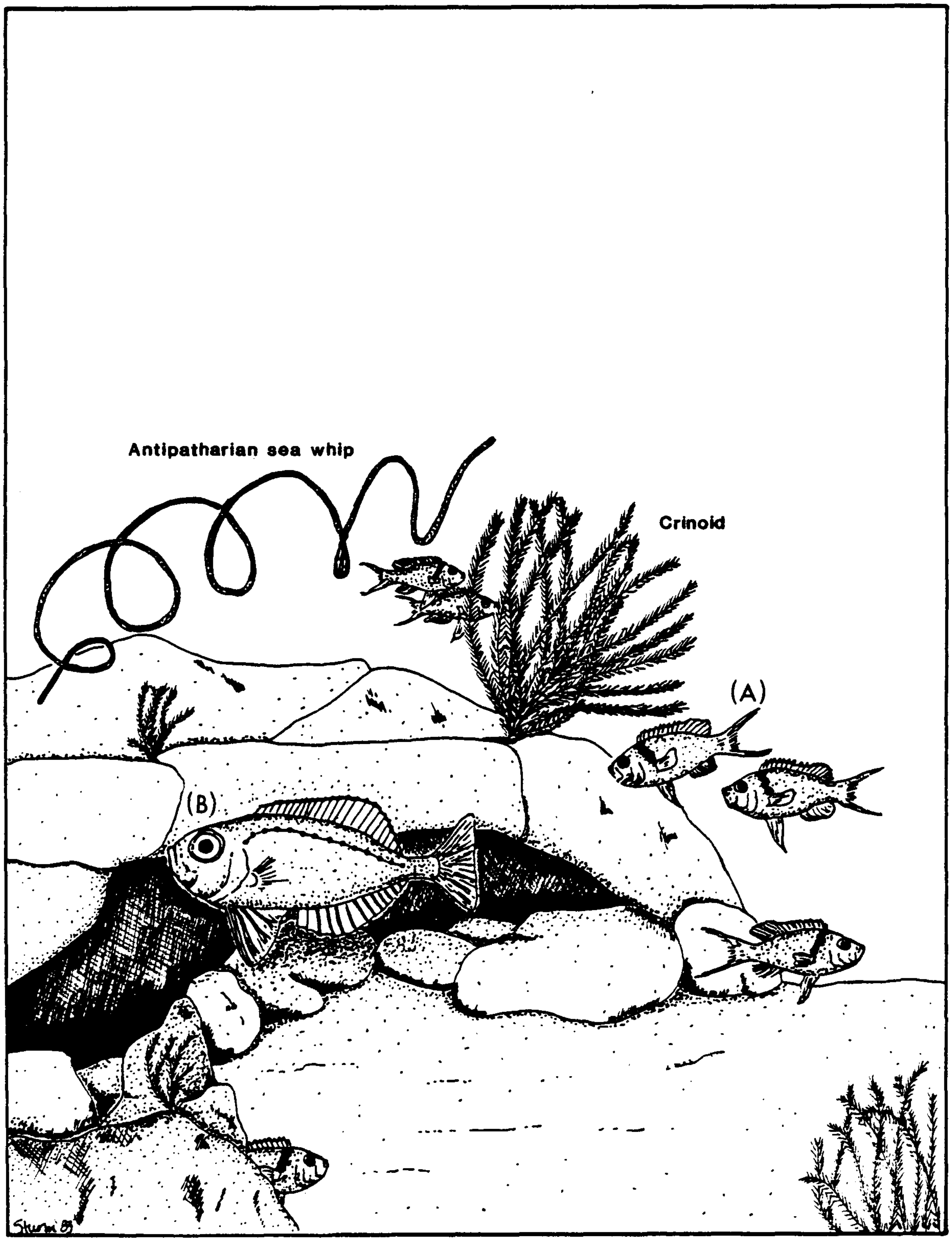


Fig. 6-6. Illustration of Deep Drowned Reef habitat with characteristic fish species: (A) roughtongue bass and (B) bigeye.

bottom of the Flower Garden Banks are esentially the same as the soft bottom beneath the two study platforms, PLA (9 nm from the crest of WFG), and PLB (adjacent to EFG). The only differences in characteristics between these two soft bottom habitats would be the presence of accumulated drilling muds and cuttings very close to the platforms and the possibility of other perturbations to the bottom surface, including debris dropped overboard from the platform and attending vessels, or trenches left behind from platform and/or pipeline installations.

There are relatively few conspicuous fish species evident to visual assessment methodologies over the soft bottom. Characteristic species would include lizzard fishes, flounders, batfishes, scorpion fishes, sea robins and a variety of small serranids such as the rock sea bass, *Centropristis philadelphica* and the blackear bass, *Serranus atrobranchus* (see Table 5-3). Some soft-bottom areas near the banks are well populated with antipatharian whips, *Cirrhipathes* spp., and comatulid crinoids while other areas appear devoid of any macrobenthos.

Platform A (PLA) MO-HI-A595-D

This platform was surveyed during Phase I of the study and was located approximately 9 nautical miles from the crest of the West Flower Garden Bank. The platform structure was installed on 18 April, 1980 and the first dive for qualitative census of the fish and fouling communities was made by LGL diving scientists during Cruise 3 on 14 April, 1981. The structure had been in the water very close to one year at that time. The primary purpose of platform dives was to collect specimens for contaminant analysis by other work units but general descriptions of the fish and fouling communities were also recorded.

The fouling community was relatively sparse in comparison to other platforms which we have observed in the general region. However, these had all been in place for several years. After a year of colonization, virtually all of the steel surfaces of PLA were covered by some type of fouling organism, but in most places it was fairly thin.

This drilling platform was permitted to discharge muds and cuttings at the surface due to its distance from the Flower Garden Banks. As a result, the top surface of some horizontal cross-members had become buried in what appeared to be clumps of drill cuttings. In some areas, the muddy clumps were several centimeters deep. There were no apparent effects of these discharge materials on the fouling community other than physical burial.

The dominant encrusting organisms included algae, hydroids and both encrusting and branching bryozoans. Colonies of these fouling species located directly adjacent to the drill cuttings seemed to be healthy with no apparent differences in appearance as compared to colonies located in other areas at some distance away from the cutting piles or on vertical legs.

Other attached epifauna included the barnacle, Balanus tintinnabulum (Megabalanus antillensis) which were scattered sparsely about on vertical support legs down to about 20 m. Many of these barnacle shells were empty, providing habitat for several species of blennies. Gooseneck barnacles, Lepas spp. were rare, occurring only near the surface. A few patches of sponges were seen, the largest being about 30 cm in diameter and purple in color. The Atlantic pearl oyster, Pinctada imbricata, was fairly common, and a few Atlantic winged oysters, Pteria colymbus and small Atlantic thorny oysters, Spondylus americanus, were also seen. A cluster of penshells, Pinna carnea, was observed near the surface at about 1 m of depth.

Motile invertebrates which were observed included two species of sea urchins, Diadema antillarum and Arbacia punctulata. Two species of crabs were noted, a single unidentified xanthid crab and numerous arrow crabs, Stenorhynchus seticornis. Three small spiny lobsters, were seen in a well collar support at a depth of about 23 m at a location where there were major horizontal support structures.

The one-year-old fish community included many tropical reef fish species. Most all of these species were seen either inside or near to well collars or around horizontal cross-members and the joints of vertical and horizontal support members. The redspotted hawkfish, Amblycirrhitus pinos, was especially abundant at these joints. Some species, including blue tang, Acanthurus coeruleus and brown chromis, were common only at the shallow horizontal cross members. Sergeant majors, Abudefduf saxatilis, were also seen at this level apparently guarding egg nests. These individuals were large in size and were apparently recruited to the platform as adults. Other tropicals seen included many spotfin hogfish, Bodianus pulchellus, a single Spanish hogfish, Bodianus rufus, a few orangespotted filefish, Cantherhines pullus, and the creole-fish. Only a few dozen creole-fish were seen, all of them being subadult in size with estimated lengths of approximately 150-200 mm. Small rock-hinds, Epinephelus adscensionis, were very abundant and this species was the dominant grouper on the platform at this time. A few other small groupers, Mycteroperca spp., were also observed. Grey triggerfish were fairly common.

Three species of blennies were seen occupying dead barnacle shells, primarily from the surface to about 10 m of depth. These three species were the barnacle blenny, Hypsoblenius invemar, molly miller, Blennius cristatus and the seaweed blenny, Blennius marmoreus.

Schooling pelagic species represented the greatest fish biomass in and around the platform. Groups of several jacks were noted including the greater amberjack; almaco jack; rainbow runner, Elagatis bipinnulata; and the most abundant species, blue runner, numbering into the several hundreds. A small school of chubs, Kyphosus spp. was also observed near the surface.

Platform B(PLB) MO-HI-A389-A

One of the most significant effects of the installation of the platform in proximity to the East Flower Garden Bank was its colonization by a diverse community of epibiota and fishes where none existed before. Table 6-2 lists the species and estimated numbers of fish which were censused during the four cruises when the platform was in place.

The first underwater reconnaissance dive on the partially completed structure was made by LGL diving scientists about three weeks after its installation on 21 October, 1981. At that time there was no permanent above-water superstructure, and only three well casings had been installed underwater. The platform consisted of eight primary support legs (four on each side), with their supplementary diagonal and horizontal support members. Two principal boat bumper/landing areas were situated in the center section of each side with 14 small, vertical supports extending approximately 2-3 m above and below the water line. The majority of fish

Table 6-2. Species list for Mobil Platform MO-HI-A389-A (PLB).

	Estimated No. Individuals			
Cruise No.:	5	6	7	8
Survey Date:	21 Oct 1981	29 Apr 1982	4 Aug 1982	24 Oct 1982
Platform Age (Days):	21	211	308	389
Species Name				
Silky shark (*Carcharhinus falciformis*)		1		
Frogfish (*Antennarius* spp.)				1
Longjaw squirrelfish* (*Holocentrus ascensionis*)			1	
Squirrelfish (*Holocentrus rufus*)			1	
Rock hind (*Epinephelus adscensionis*)			10-15	20-30
Warsaw grouper (*Epinephelus nigritus*)		6 (video)		1 (video)
Yellowmouth grouper (*Mycteroperca interstitialis*)		1 (juv)	2 (juv)	3 (juv)
Grouper (*Mycteroperca* spp.)			6-10	20-40
Creole-fish (*Paranthias furcifer*)		50 small	400-500 small	500
Blue runner (*Caranx crysos*)	20-30 (juv)			100 (juv)
Crevalle jack (*Caranx hippos*)	10	50		25 (juv)
Bar jack (*Caranx ruber*)		1	6	3-6
Rainbow runner (*Elagatis bipinnulata*)		10		10
Greater amberjack (*Seriola dumerili*)	6	50	20-30	
Almaco jack (*Seriola rivoliana*)	40-50	10-20	10-20	20
Rough scad (*Trachurus lathami*)		100-200		
Jack (*Caranx* spp.)	2000-3000 (juv)			
Yellow goatfish (*Mulloidichthys martinicus*)			3	
Chub (*Kyphosus* spp.)		14		4-10
Reef butterflyfish (*Chaetodon sedentarius*)			1	4-6
Angelfish (*Holacanthus* spp.)				3 (juv)
Sergeant major (*Abudefduf saxatilis*)	1 (juv)	6	5	20-30
Brown chromis (*Chromis multilineatus*)				10-20
Bicolor damselfish (*Pomacentrus partitus*)		3		3
Damselfish (*Pomacentrus* spp.)		3	6	3-6
Redspotted hawkfish (*Amblycirrhitus pinos*)				1
Spotfin hogfish (*Bodianus pulchellus*)		10-20 (juv)		3
Unknown wrasse (*Halichoeres* spp.)		2		1
Redband parrotfish (*Sparisoma aurofrenatum*)				1
Great barracuda (*Sphyraena barracuda*)	1	20	30	50
Unknown goby (Family Gobiidae)		1	10-20	
Seaweed blenny (*Blennius marmoreus*)		3	6	3
Crested blenny (*Hypleurochilus geminatus*)				1
Barnacle blenny** (*Hypsoblennius invemar*)			3	3
Blue tang (*Acanthurus coeruleus*)	2 (juv)		5 (juv)	20-30
Surgeonfish (*Acanthurus* spp.)			1	30-50
Scrawled filefish (*Aluterus scriptus*)		1		1
Gray triggerfish (*Balistes capriscus*)	200 (juv)	20-30	40-50	8
Orangespotted filefish (*Cantherhines pullus*)		3	2	2
Ocean triggerfish (*Canthidermis sufflamen*)		6	6	
Sharpnose puffer (*Canthigaster rostrata*)		3	3	3
Total No. Species	9	24	~~22~~ 23	32

*Common name from Randall 1968.
**New species--no official common name (Smith-Vaniz 1980).

habitat was provided around well casings and support collars, habitats which were located at 8 and 36 m of depth.

During this first cruise only nine species of fish were observed between the surface and 36 m (120 ft) of depth. Five of these species were jacks, considered to be more or less wandering, pelagic species. The larger adults of crevalle, almaco and amberjacks may have been recruited from the nearby East Flower Garden Bank. The other two jack species were juveniles and were probably recruited from the passing water mass. Three of the remaining four species censused during Cruise 5 were also small juveniles, and included a single sergeant major, two small blue tang and about 200 small gray triggerfish estimated to range between 100 and 120 mm long. A single greater barracuda was also observed.

The fouling community at this time was virtually non-existent. The platform structure had obviously never been in seawater previous to its transportation and installation at the edge of the East Flower Garden Bank. The only obvious epifauna seen were a few scattered patches of an unidentified feathery white hydroid down to 18 m of depth, and green filamentous algae which was present near the surface. The vast majority of the subsurface area was coated in orange rust with black anoxic corrosion occurring in many areas below the superficial rust layer.

The second reconnaissance dive on the platform was made on 29 April 1982 during Cruise 6. Thus, the structure had been in place for a total of about 211 days. Drilling had begun three days previous to the dive on 26 April. The most striking change to the platform community was the almost complete cover of the legs and cross-members by fouling organisms. Although the fouling mat was quite thin in most places it was dramatically different from the bright orange rust cover which had been present on the previous cruise. The number of fish species observed almost tripled with 24 species represented as compared to nine species before (Table 6-2). Eighteen of these were new species not observed during Cruise 5. Two of the juvenile jack species and the blue tang which had been observed previously were not resighted. Numbers of barracuda had increased to 20 individuals, and both crevalle and amberjack were represented by approximately 50 individuals.

Some 20-30 moderate-sized (200-250 mm) grey triggerfish were censused suggesting a carryover from the 200 smaller juveniles which had been seen during Cruise 5. Several tropical species were first observed during Cruise 6 including about 50 small creole-fish (the dominant species on the Flower Gardens coral reefs) and representatives of the bicolor damselfish, an unknown wrasse, spotfin hogfish, two species of filefish, sharpnose puffer, an unknown goby and the seaweed blenny.

The fouling community at this time was dominated in some areas by thick mats of filamentous algae and hydroids, both of which were teaming with several species of amphipods. Large unidentified nudibranches (3-5 cm long) were also seen grazing through these thick mats. In other areas large patches of colonial tunicates dominated the fouling mat. At the surface, several of the boat bumpers had become heavily encrusted with gooseneck barnacles. A single small colony of the octocoral, _Telesto riisei_, was observed at a depth of 12 m.

Other motile invertebrates were also observed during this cruise. Two species of sea urchins were present, small _Diadema antillarum_ and _Arbacia punctulata_. Fireworms, _Hermodice carunculata_, were abundant at both the 8 m and 36 m levels of horizontal supports. Two crab species were observed at 36 m, one an unknown xanthid crab and the other the arrow crab which was represented by several individuals. Three small spiny lobsters were seen inside a well collar surrounding a well casing at the 36-m depth. One was very small with an estimated carapace length of about 5 cm.

Census dives were made again on 4 August 1982 (Cruise 7). The platform had been in the water for about 308 days at that time. During this cruise, fewer fish species were observed than in April 1982, but the total number of individuals seen had generally increased. Fourteen species observed during Cruise 7 were common to Cruise 6. Eight new species appeared during Cruise 7 including barnacle blennies, a frogfish and numerous tropical reef species, namely the reef butterflyfish, surgeon fish, yellow goatfish and rock hinds. Blue tang also reappeared after being first observed during Cruise 5 and absent during Cruise 6. A single squirrelfish was seen for the first time at 8 m of depth.

However, the most notable change in the fish community was the dramatic increase in the creole-fish population. A best-guess estimate of their numbers was between 400 and 500 individuals. All of these fish were small. Specimens collected for Histopathology averaged 124 mm and ranged in size from 85-142 mm in fork length, compared to lengths twice that size for specimens collected from the Flower Garden coral reef banks.

The fouling community was becoming dominated by bivalve molluscs. The thick hydroid and algal mats were much reduced in comparison to the previous spring cruise. The dominant bivalve occurring on the platform in August 1982 was the Atlantic pearl oyster. The acorn barnacle, though sparse, was prevalent from about 10 m to the surface. Many barnacles had reached approximately 3-4 cm in basal diameter, and the few which had died provided excellent habitat for the newly occurring barnacle blennies and the increased numbers of seaweed blennies.

Gooseneck barnacles remained abundant near the surface but were not nearly as thick on boat bumper surfaces as they had been in April. Encrusting bryozoan patches had increased dramatically in size, and one red species had developed delicate branches extending several centimeters above the basal part of the colony.

Motile invertebrates which were seen included red-banded coral shrimp, (probably Stenopus hispidus) hiding inside well collars at both 8- and 36-m depths. Arrow crabs and fireworms were again observed. Spiny lobsters were seen in the same well collar where they had been seen during Cruise 7. At this time there were at least six individuals present, and all were significantly larger than the ones which had been previously observed during Cruise 7, 97 days earlier.

The final observational survey of the study platform was made during Cruise 8 on 24 October 1982, some 389 days after its installation. Both the fish and fouling communities had become surprisingly well established after little more than a year of colonization beginning from a bare steel structure. The number of fish species observed had increased to 32. Fourteen new species were noted during Cruise 8 and 15 species were common to both Cruises 7 and 8. New species included the longjaw squirrelfish, juvenile angelfish (Holacanthus spp.), brown chromis, red-spotted hawkfish, red band parrotfish and one additional blenny species, the crested blenny. Several species had increased substantially in numbers, including the sergeant major which was represented by five individuals during Cruise 7 as compared to between 20 and 30 individuals on Cruise 8. Small groupers (Mycteroperca spp.) increased from around 6-10 fish to between 20 and 40 individuals.

Creole-fish remained the numerically dominant species, maintaining a similar population from Cruise 7 to Cruise 8 of approximately 500 individuals. Creole-fish appeared to be significantly larger during Cruise 8 as compared to 7. Fork lengths of 23 fish collected at the platform during Cruise 8 ranged from 140-181 mm, having a mean length of 153 mm. This compares to a mean length of 124 mm for the 41 fish collected during Cruise 7.

The fouling community had become quite diverse and it was impossible to account for all its components within the limited time of the few dives made on the platform. In general, the fouling community had become well established. Many species on the platform were observed for the first time during this cruise. Atlantic pearl cysters had become larger and more numerous, especially on the top surfaces of the horizontal cross members. Several rock snails, Thais haemastoma, and winged oysters, Pteria colymbus, were also seen. The octocoral, Telesto riisei which had been isolated in a single location at 12 m during Cruises 6 and 7 was observed in small patches at six other locations ranging in depth between about 5 and 16 m. The fouling mat consisted primarily of algae, bryozoan and hydroids of several species. Two taxa of leafy algae abundant on the Flower Garden Banks (Lobophora and Dictyota) were prevalent on the surfaces of horizontal supports at both 8- and 36-m depths. Acorn barnacles had become larger and were now distributed to a maximum depth of about 36 m. Encrusting sponge colonies which had not been previously observed were established, and in some areas were as large as 30 cm in diameter.

The fish and fouling community observed on PLB during Cruise 8 was, in general, very similar to the community which was present on the PLA platform, 9 nm to the west of the West Flower Gardens. Both fouling communities were dominated by algae, hydroids, bryzoans and bivalve molluscs characteristic of blue water platforms. Notable species common to both platforms included spiny lobsters, sea urchins and arrow crabs.

The great majority of fish species were also represented on both platforms. One of the few obvious differences between the near- and far-field platforms was the abundance of crecle-fish found on the near-field platform. As the creole-fish is the numerically dominant species on the Flower Garden coral reefs, perhaps this appearance of large numbers of creole-fish to the platform within 1500 m of the coral reef of the East Flower Garden Bank represents a recruitment from the bank. This may also be true for the recruitment of groupers to the platform. Motile invertebrates represented on the platforms included fireworms, red-banded coral shrimp and arrow crabs. Portunid and xanthid crabs were also encountered on the platforms as were spiny lobsters. Spotted lobster common to the coral reef was not seen on the platforms.

Two species of sea urchins were present on the platforms with , the shorter spined form (Arbacia punctulata) being more numerous than the long spined form (Diadema antillarum). One of the most striking invertebrates seen was a species of anenome, probably Calliactis tricolor. This anenome was seen in several locations often attached to the sides of barnacle shells.

Very little census work was performed close to the platform below the 36 m depth due to restrictions of diving depths and difficulty in maneuvering the camera frame close to platform legs. The available observations indicate that fouling organisms were very sparse below 40-m depths. Several vertical transects were performed with the video cameras while tied to the structures. The only fish species observed adjacent to the platform, with one exception, were all pelagic species such as almaco jack, greater amberjacks, rainbow runners, greater barracuda and chub. The exception was the sighting of very large warsaw groupers during Cruises 6 and 8. A total of six individuals were seen during Cruise 6 all at a depth of around 90 m just above the interface of a highly turbid nepheloid layer. Three of these fish were measured using the stereo video cameras and had fork lengths of 810, 877 and 919 mm. During the vertical transect performed during Cruise 8, a single warsaw grouper was again sighted just above the turbid layer at about 90 m. This grouper was measured on videotape and had a fork length of 1314 mm.

After more than 13 months of recolonization, the Mobil platform adjacent to the East Flower Garden Bank remains radically different than the habitat encountered on the coral reef or other areas of the East Flower Gardens. The dominant invertebrates on the reef, the corals, have not yet been observed on the platform. Many other invertebrates are common to both areas but there are many exceptions. Notably, the lobster population on the platform (spiny lobster, Panulirus argus) is not the same species as the dominant species seen on the coral reef (spotted lobster, Panulirus guttatus). The majority of the 41 fish species recorded on the platform also occur on the Flower Gardens but some do not. However, several species were observed on platform PLB which have not been previously reported in the literature of the Flower Garden Banks (Table 6-3). Overall, the proximity of the PLB platform to the East Flower Garden Bank thus far seems to have a limited effect on its community composition. The community at this platform is basically the same as we have seen on other blue water platforms well removed from any bank.

RARE AND/OR UNUSUAL BIOLOGICAL OBSERVATIONS

Lobsters

Only one lobster was recorded during video transects throughout the project, probably because the surveys were conducted during the day and the dominant lobster species on the banks (the spotted lobster) is nocturnal (Caillouet et al. 1971). The lobster seen on video, however, appeared to be a spiny lobster. It was walking on top of a dead coral head in the middle of the day on the upper coral reef of the East Flower Gardens. Its total length was approximately 500 mm, determined from stereo-video measurements. The large size and daytime sighting indicate it was probably a Panulirus argus. Lobster surveys conducted by NMFS and LGL divers on the 1983 summer supplementary leg of Cruise 7 discovered nearly 100% spotted lobsters during the course of numerous night dives on the East Flower Gardens coral reef. Interestingly, all the lobsters which colonized the new Mobile platform PLB (six observed) were spiny lobsters, Panulirus argus.

Sharks and Rays

Only three species of sharks were videotaped; nurse sharks (Ginglymostoma cirratum), silky sharks (Carcharhinus falciformis, identified after capture) and a single shortfin mako shark (Isurus oxyrinchus). Based upon our experience, sharks are very abundant around the banks in winter. On other projects, we have observed tiger sharks,

Table 6-3. Species not previously reported in Flower Gardens literature observed by SCUBA divers on Mobil Platform MO-HI-A389-A[1] (PLB).

Common Name	Scientific Name	Depth
Frogfish	*Antennarius* spp.	36 m
Sergeant major	*Abudefduf saxatilis*	1-8 m
Seaweed blenny	*Blennius marmoreus*	1-36 m
Crested blenny	*Hypleurochilus geminatus*	18 m
Barnacle blenny[2]	*Hypsoblennius invemar*	1-8 m

[1]Mobil Platform bottom depth 123 m, approximately 1500 m from coral bank.
[2]New species - common name by authors.

Galeocerdo cuvieri; bull sharks, *Carcharhinus leucas*; nurse sharks; large schools of scalloped hammerheads, *Sphyrna lewini*, and an unidentified *Carcharhinus* species in schools of 50-60 fish while conducting scientific SCUBA dives during the winter season. Although a number of hours of video surveys were conducted during winter on this project, sharks were seldom seen. The information suggests that sharks may be attracted to divers as compared to a drifting camera frame.

Other cartilaginous fishes which were videotaped include the Atlantic manta, *Manta birostris*, and a large stingray, probably the southern stingray, *Dasyatis americana*. Manta rays seen on the Flower Gardens are generally solitary and apparently patrol the entire reef. A single individual believed to have been the same fish was often seen on several different occasions and over different parts of the reef during the same cruise. Some attraction of manta rays to the video frame appears to occur. On one occasion a very large manta ray approached the video frame from behind and dipped down, almost touching the bottom directly in front of the cameras. Similar attraction of a manta ray to divers has been observed by the first author in other areas and also on the East Flower Gardens. A large manta approached two divers in 1976 and performed loops and upside-down swimming in very close proximity to the divers.

Other large rays have also been observed on the Flower Gardens. A school of six large spotted eagle rays, *Aetobatus narinari*, were observed by LGL diving scientists on a previous Flower Gardens survey in 1979 performed by Texas A&M University for the Bureau of Land Management, but this species was not seen during this study.

Giant Snake Eel

A giant snake eel was observed on a video transect at a depth of 125 m in the vicinity of the East Flower Garden Bank. This was the only actual sighting of the eel underwater but burrows large enough for an animal of this size were frequently seen on the deep, soft bottom surrounding the banks. The eel was seen inside its burrow with only its head and a small portion of the body extending outside. It showed no fear of the camera frame and light as it passed overhead. A stereo video measurement of head length from snout to the end of the opercle was 230 mm. Using a mean head-length-to-total-length ratio of 12% (Bohlke and Caruso 1980), this giant snake eel was estimated to be approximately 2 m (1917 mm) long. This figure is reasonable based on specimens obtained by traps and trawling. The largest measurements of specimens examined by Bohlke and Curuso was 2100 mm long.

Red Snapper

Whereas red snapper was not a particularly unusual sighting, one was videotaped over soft bottom, well removed from any rock outcrop or platform at a depth of 120 m. The specimen was estimated to have ranged between 700 and 800 mm long. As previously described, large specimens were also trapped, trawled and angled over soft bottoms. Specimens observed by video or collected on the banks were typically smaller than the specimens observed or collected over soft-bottom habitat.

Turtles

Two different loggerhead turtles (Caretta caretta) were seen swimming along the bottom at different times on the West Flower Gardens. Distinct patterns of barnacles on the shells was used to distinguish between individuals. A single, very "friendly" loggerhead turtle was observed by the senior author on the West Flower Gardens over a period of two years during biological monitoring cruises conducted by LGL for Texas A&M University between 1979 and 1981. This same turtle was one of the two sighted on a video transect over a year following its previous sighting by LGL diving scientists. This suggests turtles may be resident on specific reefs or at least return to particular sites after leaving for any period of time.

Dolphins (Cetacea)

Dolphins were commonly observed at the surface over the banks but seldom seen underwater. A group of six dolphins were videotaped during Cruise 7 as they swam by the camera frame resting on the bottom in 60 m of water during a tagging mortality study.

BEHAVIORAL OBSERVATIONS

One of the greatest handicaps to the study of fish behavior is the restricted time available to divers for direct observation of fish in their natural environments. This program produced over 357 hours of underwater videotapes, offering a unique opportunity for behavioral observations. A variety of behavioral observations are described below.

Perhaps the first subject to be addressed in behavioral studies should be the reaction of animals to the observer. In this project the "observer" consisted of a video camera frame 1-1/4 m tall, suspended from a cable, drifting with the water current. With few exceptions, the camera frame had little apparent effect on fish behavior.

One line of support for this view lies in the number of species observed by the remote video cameras. A total of 141 distinct taxa were documented during this project, compared to 103 by Bright and Pequegnat (1974). However, Bright and Pequegnat's study was generally limited to the Coral Reef Zone. Only two very rare species reported in the literature were not seen by cameras during this study, excluding cryptic or small forms not expected to be seen by video techniques (Table 6-4).

Table 6-4. Species not observed by video technique[1] previously reported in Flower Gardens literature.

Common Name	Scientific Name	Comments
Yellowtail snapper	*Ocyurus chrysurus*	Last seen 1970[2]
Gray angelfish	*Pomacanthus arcuatus*	Only one pair ever sighted 1975[3]

[1]Excluding small and/or cryptic species, individuals included within species "groups" used in video analyses or species collected only at the surface not characteristic of a reef fish population.

[2]Cashman, C.W. *in* Bright and Pequegnat 1974.

[3]Bright and Rezak 1976.

A number of behavior patterns such as interspecific aggression and feeding were commonly observed. Parrotfish were frequently seen feeding on algae as close to the video frame as 1 m. Schools of chub apparently fed normally within a few meters of the camera on algae found on the coral reefs. Typically wary fish (such as the sargassum triggerfish (Xanthichthys ringens), or squirrel fish) usually entered crevices in the reef only when the video frame came closer than about 1 m. The majority of fish species could be approached much more closely with the video apparatus than by SCUBA diver. On one occasion a grouper was actually hit on the head by one leg of the drifting video frame.

Descriptions of fish reproductive behavior in situ are rare. One of the most interesting observations on the Flower Gardens was of nesting ocean triggerfish (Canthidermis sufflamen) in sand flats of the upper coral reef. Balistidae (triggerfishes) is one of the very few bony fish families which does not produce planktonic eggs, but rather, lays demersal eggs. Densities of ocean triggerfish as high as 6.7 fish/1000 m^2 were recorded on coral reef sand flats on Cruises 4 and 7. Both of these cruises were during the summer months of July and August. Densities recorded on all other cruises were significantly lower. The ocean triggerfish were nearly always sighted in pairs hovering above a small sand flat between coral heads. Fish coloration was different from that seen during other seasons and at other depths. These triggerfish had a light head and a dark mottled body with dark bars appearing in some. They were frequently observed chasing off intruding fish which swam close to the small sand flat areas. Atypical coloration and defensive behavior of ocean triggerfish was also reported by Nellis (1980). Nellis found hundreds of small fry in a cloud 10-50 cm above a depression in the sand the triggerfish were guarding.

Mycteroperca groupers were observed involved in curious behavior on two occasions. During Cruise 5 in October 1981, one grouper was seen touching its snout to the side of another grouper while hovering motionless in the water just above the bottom. Two groupers were again observed touching each other during Cruise 7 in July of 1983.

A number of acts of agonistic behavior were observed, especially during Cruise 5 in October 1981. Damselfish (well known for their bold defense of individual territories) were commonly observed attacking much larger fish. More unusual sightings included intraspecific aggression by creole wrasse and queen triggerfish.

A group of six queen triggerfish was observed chasing one another for short distances above a low relief drowned reef outcrop at a depth of 52 m. One fish would start rapidly swimming towards others but the other fish would always maintain their distances by swimming away at the same rate. Only one fish was observed as the aggressor. It is not known if the aggressor was protecting a nest, exhibiting mating behavior or chasing the other queen triggers for some other reason.

Creole wrasse were frequently seen chasing one another within large schools. This behavior may have been the aggressive courtship described by Thresher (1980). Males fight with each other for access to females during spawning periods. Actual courtship involves the male chasing the female at high speeds over the reef. One prominent example was seen during Cruise 5 in October 1981.

During Cruise 8, aggressive behavior by the yellowtail reeffish was observed. A single individual was seen chasing a sand tilefish as it approached its sponge habitat.

Predatory hunting and feeding behavior was witnessed occasionally. For example, large amberjacks were seen in front of the camera frame rapidly swimming across the bottom attempting to capture small fish. On one instance an amberjack actually gulped something into its mouth, presumably a small fish as it was not visible on tape. One could speculate that the jacks were following the camera frame because it sometimes caused small reef fish to abandon cover within the rock outcrops.

During the first cruise some underwater video observations were made of hook-and-line fishing. On this occasion, a school of red snapper was seen with the camera on the bottom and their presence was announced to the crew that was prepared to fish with hook-and-line on the back deck of the vessel. Suddenly the snapper turned and started swimming towards the surface. A few moments later, several sets of baited hooks and lines reached the bottom with a school of red snapper surrounding them. Some of the fish had quite a talent for eating the squid bait without biting the hook. A couple of fish were immediately caught and the rest of the hooks became bare after a few jerks. Witnessing the event hit home for all the crew after reminiscing of long gaps in fishing success and finding empty hooks after reeling up lines.

Rubbing or scraping behavior commonly seen and reported for jacks (Rezak and Bright 1981) was also observed for other species, including creole-fish and Mycteroperca groupers. Greater amberjack were most often seen exhibiting these curious actions. Typically the fish swam rapidly towards a sandy or other soft bottom, turned on their sides as they approached, then flopped rapidly along the bottom for a few swimming strokes while on their sides. One possible explanation for this behavior is for the removal of external parasites or parasites attached to the gills, a condition common to these species on the Flower Garden Banks (John Grizzle, Auburn Univ., AL, pers. comm. 1983).

BRINE AND GAS SEEPS

The existence of a hypersaline (200 ppt) brine lake and outflow on the southeast side of the East Flower Garden Bank has been known since 1976. It was first discovered by Dr. T.J. Bright in the Texas A&M research submersible D/RV DIAPHUS at a depth of 71 m (Bright and Rezak 1978). During this study, a second brine seep was documented to occur at a depth of 48 m on the southwest side of the bank during a video transect on Cruise 1 of this study.

The new brine seep was observed at a distance of about 250 m from the coral bank at a position of 27°54.37'N latitude and 93°36.49'W longitude (Fig. 6-7). The high density brine water was seen in the bottom of a series of ripple troughs characteristic of the area. The edges of the apparent interface between brine water and normal seawater exhibited the same kind of white deposits described at the edges of the original brine lake by Bright. The ripples containing the high salinity brine water had no visible discharge. Numerous gas seeps were seen in the general vicinity of the brine pool.

From analyses of a variety of brine waters, Brooks et al. (1979) suggested that the brine flowing from the East Flower Garden Bank is a product of the dissolution of salt deposits beneath the bank. This occurs by the percolation of seawater through the overlying sediments and porous limestone cap rock of the salt dome. The continued dissolution of the salt beneath the cap rock can cause faulting due to gravity. The outflow from the southeastern brine seep has been calculated to be 864 m^3/day, and

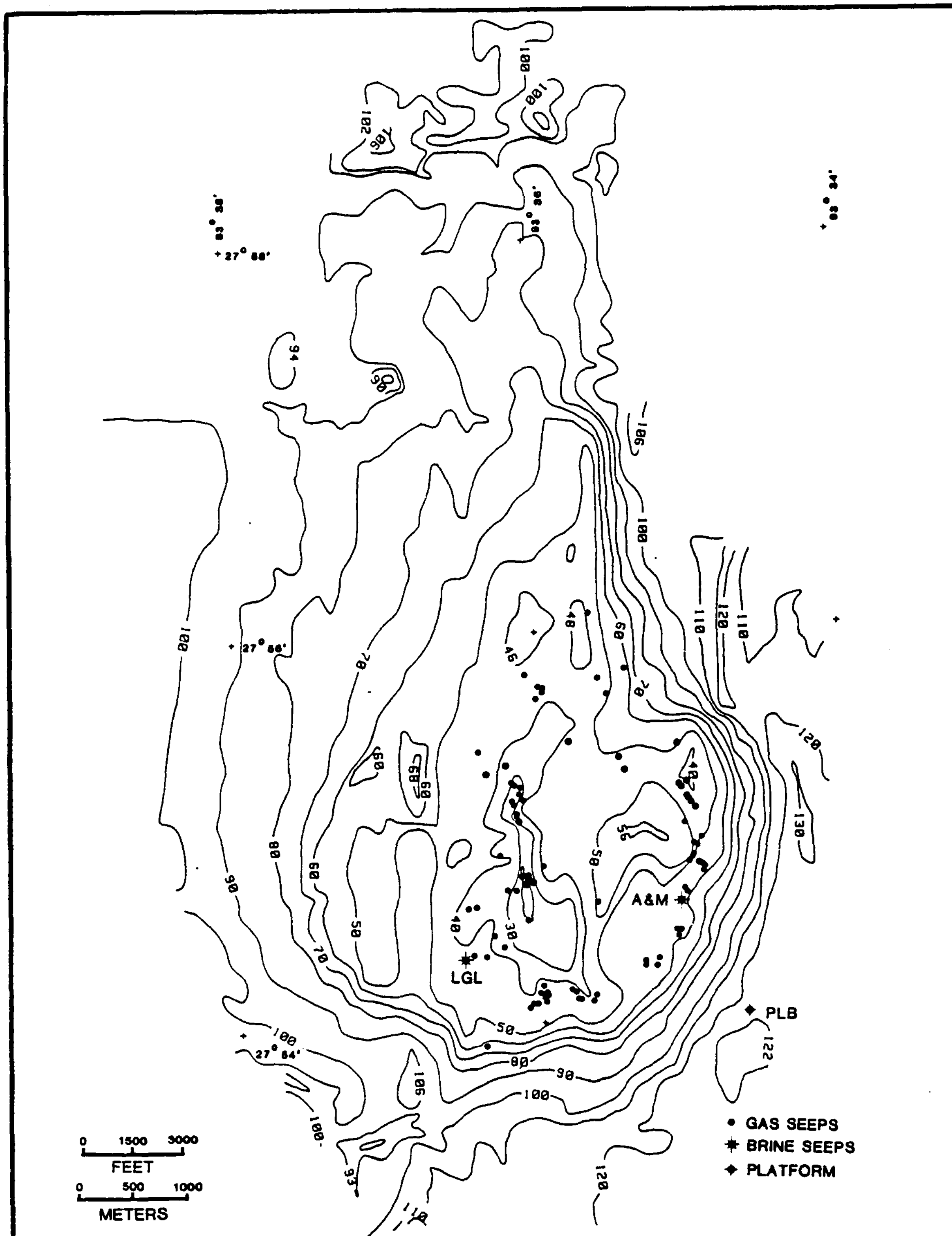


Fig. 6-7. Locations of natural gas seeps and brine seeps observed during video transects, Cruises 3-8, East Flower Garden Bank.

a collapse of the crest of the bank was predicted in the "not too distant future" (Rezak and Bright 1981).

Naturally-occurring gas seeps were frequently observed during video transects conducted during Cruises 3-8. Figure 6-7 depicts their positions on the East Flower Garden Bank. The composition of the emitted gas in other seeps on the banks has been reported to be primarily methane with very small amounts of ethane and propane (Rezak and Bright 1981). There appeared to be a definite pattern in zonation of the seeps. The zonation is probably related to the sub-surface structure and position of the underlying salt dome (Tissot and Welte 1978). There were some regions with a very high density of gas seeps. On the coral bank itself there were several zones of closely spaced gas seep locations. Seeps off the coral reef proper seemed to be limited mainly to the south and to the east sides of the bank. The majority of these sites were at a depth of between 50 and 70 m. Closely associated gas seeps were seen at both the A&M brine seep area and the newly discovered LGL brine seep. Natural gas seeps appear common on most other banks in the northwestern Gulf of Mexico (Bernard et al. 1976).

SUMMARY AND EVALUATION OF REMOTE MEASUREMENTS

A total of 830 specimens representing 52 species of fish were measured <u>in situ</u> using the video apparatus (Table 6-5). Many of these were species for which size determinations are seldom reported because they are not susceptible to capture by other means (e.g. the roughtongue bass). Comparisons of video-derived measurements to actual measurements of fish following their capture indicated that the videotape-derived lengths tended to be about 6 to 7% smaller than actual lengths. This error occurred in spite of the system calibration procedure as described in the Methods section of this report. This observed error likely results from the measured target not being exactly perpendicular to the cameras. Unfortunately, the opportunity to compare measurement accuracy on fish in the field occurred on only two occasions. Measurement error for fixed objects of known size was generally less than 2%.

Results of comparisons of fish size distributions based upon data obtained from the videotapes versus those from collections made by hook-

Table 6-5. Fork length data from all fish measured by stereo video techniques, Cruises 1-8.

Species	Common Name	Scientific Name	Fork Length/mm			N	Range	Std	Std Err
			Max	Min	Mean				
1204	Silky shark	*Carcharhinus falciformis*	1549	1549	1549	1	0	0.000	0.000
2099	Sting ray	*Dasyatis* spp.	250	250	250	1	0	0.000	0.000
2201	Atlantic manta	*Manta birostris*	1407	1407	1407	1	0	0.000	0.000
7499	Batfish	Family Ogcocephalidae	81	81	81	1	0	0.000	0.000
9099	Squirrelfish	*Holocentrus* spp.	232	196	217	3	36	18.735	10.817
10508	Marbled grouper	*Dermatolepis inermis*	764	423	576	4	341	155.406	77.703
10511	Rock hind	*Epinephelus adscensionis*	459	459	459	1	0	0.000	0.000
10517	Red grouper	*Epinephelus morio*	382	300	341	2	82	57.983	41.000
10519	Warsaw grouper	*Epinephelus nigritus*	1314	810	953	6	504	184.169	75.187
10537	Black grouper	*Mycteroperca bonaci*	453	453	453	1	0	0.000	0.000
10542	Tiger grouper	*Mycteroperca tigris*	871	550	704	3	321	160.936	92.916
10545	Roughtongue bass	*Holanthias martinicensis*	151	84	110	38	67	15.466	2.509
10549	Creole-fish	*Paranthias furcifer*	328	126	198	225	202	39.083	2.606
10560	Tattler	*Serranus phoebe*	168	114	149	10	54	16.518	5.223
10595	Grouper	*Mycteroperca/Epinephelus* spp.	428	347	388	2	81	57.276	40.500
10597	Unknown sea bass A (barred)	Family Serranidae	171	145	158	2	26	18.385	13.000
10598	Unknown sea bass B	Family Serranidae	105	75	88	4	30	15.086	7.543
10599	Grouper	*Mycteroperca* spp.	750	244	478	93	506	113.880	11.809
10902	Bigeye	*Priacanthus arenatus*	301	169	229	6	132	55,563	22.683
11104	Sand tilefish	*Malacanthus plumieri*	432	376	404	2	56	39.598	28.000
11505	Crevalle jack	*Caranx hippos*	1054	627	888	12	427	115.609	33.373
11506	Horse-eye jack	*Caranx latus*	507	430	472	4	77	32.035	16.018
11507	Black jack	*Caranx lugubris*	710	282	555	5	428	169.004	75.581
11508	Bar jack	*Caranx ruber*	502	228	382	7	274	104.379	39.451
11524	Greater amberjack	*Seriola dumerili*	1328	493	862	48	835	224.345	32.381
11526	Almaco jack	*Seriola rivoliana*	809	400	611	20	409	108.125	24.178
11906	Red snapper	*Lutjanus campechanus*	638	280	451	70	358	75.142	8.981
11909	Dog snapper	*Lutjanus jocu*	515	515	515	1	0	0.000	0.000
11915	Vermilion snapper	*Rhomboplites aurorubens*	384	220	302	5	164	64.978	29.059
11999	Snapper	*Lutjanus* spp.	608	530	569	2	78	55.154	39.000
12212	Cottonwick	*Haemulon melanurum*	305	202	256	13	103	33,562	9.308
12308	Knobbed porgy	*Calamus nodosus*	650	232	353	15	418	96.147	24.825
12499	Drum	*Equetus* spp.	138	138	138	1	0	0.000	0.000
12501	Yellow goatfish	*Mulloidichthys martinicus*	247	247	247	1	0	0.000	0.000
12799	Chub	*Kyphosus* spp.	485	192	341	42	293	71.093	10.970
12902	Bank butterflyfish	*Chaetodon aya*	101	101	101	1	0	0.000	0.000
12909	Queen angelfish	*Holacanthus ciliaris*	332	299	320	3	33	18.248	10.536
12912	French angelfish	*Pomacanthus paru*	373	277	336	3	96	51.433	29.695
13303	Blue chromis	*Chromis cyaneus*	128	105	116	8	23	10.453	3.696
13304	Yellowtail reeffish	*Chromis enchrysurus*	141	81	102	8	60	21.561	7.623
13306	Brown chromis	*Chromis multilineatus*	137	90	109	11	47	15.415	4.648
13503	Creole wrasse	*Clepticus parrai*	356	171	247	61	185	41.470	5.310
13608	Queen parrotfish	*Scarus vetula*	374	374	374	1	0	0.000	0.000
13614	Stoplight parrotfish	*Sparisoma viride*	444	336	371	4	108	49.676	24.838
13802	Great barracuda	*Sphyraena barracuda*	1297	384	795	22	913	224.754	47.918
18204	Scrawled filefish	*Aluterus scriptus*	650	538	573	4	112	51.636	25.818
18205	Gray triggerfish	*Balistes capriscus*	624	368	456	17	256	72.758	17.646
18207	Queen triggerfish	*Balistes vetula*	407	401	404	2	6	4.243	3.000
18208	Whitespotted filefish	*Cantherhines macrocerus*	367	305	337	5	62	27.898	12.476
18211	Ocean triggerfish	*Canthidermis sufflamen*	568	284	413	16	284	97.286	24.321
18212	Black durgon	*Melichthys niger*	393	162	295	11	231	62.527	18.853
18506	Balloonfish	*Diodon holocanthus*	158	158	158	1	0	0.000	0.000

and-line and by divers (all different fish) are shown in Table 6-6 and Figure 6-8. Five of 15 species compared showed significant differences at the 5% level. Of these, three (groupers of the genus Mycteroperca, creole-fish and cottonwick) were indicated to have been significantly smaller based upon the videotape determinations than was indicated from collections of specimens. However the difference between the mean lengths obtained by the two methods was between only 5% (creole-fish) and 8% (groupers and cottonwick). When the data from the videotaped samples were corrected for estimated measurement error, there were no significant differences in sizes of Mycteroperca groupers, creole-fish and cottonwick obtained by the two methods. This correction factor was obtained from minimal data but it was the only opportunity to test for the effects of a maximum observed error factor. Either method of collection of these three species may then either (1) yield size data representative of the actual size distribution of the population, or (2) suffer from the same size selection bias. For these species it is our opinion that the former idea is the more likely. For recruitment estimates, the gear type having the largest data base was used to estimate size distribution in the population.

For the two jack species (greater amberjack and almaco jack), videotaped specimens were significantly larger than angled specimens, indicating (when considering the measurement error associated with the video system) that the length differences were even more pronounced. Angling selected for smaller fish whereas the video system selected for larger fish (Table 6-6). Whereas the difference in size range was not much different between the two methods for almaco jack, it was pronounced for greater amberjack. Both methods are believed biased, and we are uncertain as to which method provides the best estimate of actual population structure. For the recruitment estimates, data from the two gear types were combined to provide an estimate of size distribution in the population.

The results of the analyses based upon comparisons of the videotape data adjusted for the only available observed measurement error to the data obtained from collections confirmed (1) the significance of differences between the two jacks and (2) that the other observed differences were not significant, with one exception--the red snapper. On

Table 6-6. Results of T-test comparing mean fork length measurements obtained by remote stereo video and on-deck measurements, Cruises 1-8. (H&L = hook-and-line.)

Species	Method	Number	Fork Length Data: Mean (mm)	Max (mm)	Min (mm)	Standard+ Deviation	Standard Error	Prob. > T
Longjaw squirrelfish	H&L	200	249	383	173	27.7	1.9	0.0464*
	Video	3	217	232	196	18.7	10.8	
Marbled grouper	H&L	2	487	573	400	122.3	86.5	0.5219
	Video	4	576	764	423	155.4	77.7	
Mycteroperca grouper	H&L	104	520	931	263	100.5	9.8	0.0027**
	Video	93	477	750	244	113.4	11.7	
Creole-fish	Diver	323	208	292	105	34.4	1.9	0.0049**
	Video	225	198	328	126	39.1	2.6	
Sand tilefish	H&L	3	498	554	400	85.1	49.2	0.2542
	Video	2	404	432	376	39.6	28.0	
Horse-eye jack	H&L	28	513	740	328	128.5	24.3	0.1754
	Video	4	472	507	430	32.0	16.0	
Greater amberjack	H&L	63	552	1180	295	191.3	24.1	0.0001**
	Video	48	862	1328	493	224.3	32.4	
Almaco jack	H&L	16	422	784	343	105.3	26.3	0.0001**
	Video	20	611	809	400	108.1	24.2	
Red snapper	H&L	492	433	810	258	86.2	3.9	0.0916
	Video	70	451	638	280	75.1	9.0	
Vermilion snapper	H&L	1771	293	650	154	43.3	1.0	0.6465
	Video	5	302	384	220	65.0	29.0	
Cottonwick	H&L	2583	279	395	180	21.0	0.4	0.0301*
	Video	13	256	305	202	33.6	9.3	
Knobbed porgy	H&L	144	355	440	215	46.7	3.9	0.9405
	Video	15	353	650	232	96.1	24.8	
Yellow chub	H&L	19	354	460	270	72.4	16.6	0.5015
	Video	42	341	485	192	71.1	11.0	
Gray triggerfish	H&L	49	448	548	334	42.8	6.1	0.6725
	Video	17	456	624	368	72.7	17.6	
Queen triggerfish	H&L	4	376	442	284	68.9	34.4	0.4731
	video	2	404	407	401	4.2	3.0	

*Significant at the 0.05 level.
**Significant at the 0.01 level.
+Tested for significant differences between sample variances and appropriate T-test used.

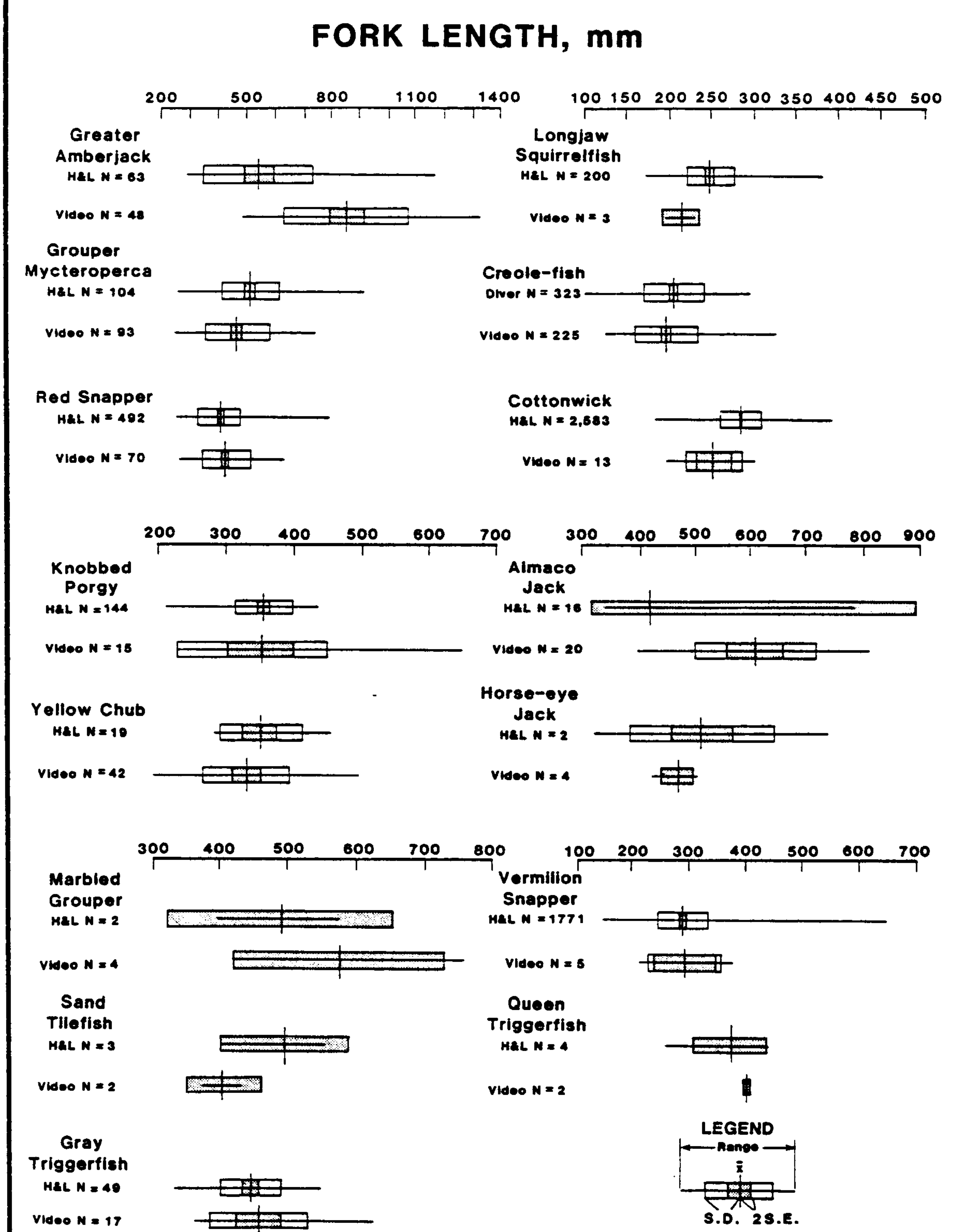


Fig. 6-8. Fork length distributions of species measured on deck and by remote stereo video. (H&L = hook-and-line).

the average, angling selected for smaller red snapper than the video system even though the largest specimen seen on the project was angled. In this instance we believe that the video data represent the best estimate of size distribution in the population at the banks. Unfortunately video data were sparse. The highly significant difference of measured lengths maintained by the two species of jacks demonstrates considerable gear selectivity must be considered for some species.

CLUSTER ANALYSES

Results of the cluster analyses are presented below for cruises (season), banks, depths and habitats, each being classified by their species attributes (fish density). The resulting classifications are evaluated based upon various inverse or nodal analyses including contingency (presence/absence), constancy (proportion of the number of occurrences in a collection group to the total possible number of occurrences that could have occurred in that group) and fidelity (ratio of constancy within a group to constancy over all groups).

Cruise (Season) Comparisons

Six of the eight cruises were subjected to cluster analysis with the data representing the spring, summer and fall seasons of 1981 and 1982. Cruises 1 and 2 represented fall and winter of 1980 and were largely experimental in nature. Therefore, these data were not included in the analyses.

The results of the analyses (Fig. 6-9) showed spring and summer of 1981 to have been decidedly different from the balance of the collections. This was undoubtably due to sampling effort being divided among the study area habitats which, because the sampling sites were widely separated, resulted in small sample sizes. The results for Group 2 (Fig. 6-9) are believed to provide the best indication of seasonal differences.

With Group 2 on Fig. 6-9, fall 1982 was most dissimilar from the other collections, due in part to the dramatic increase in creole-fish which will be discussed in a later section. Spring and summer 1982 were more similar to each other than to fall 1981. The data suggest two

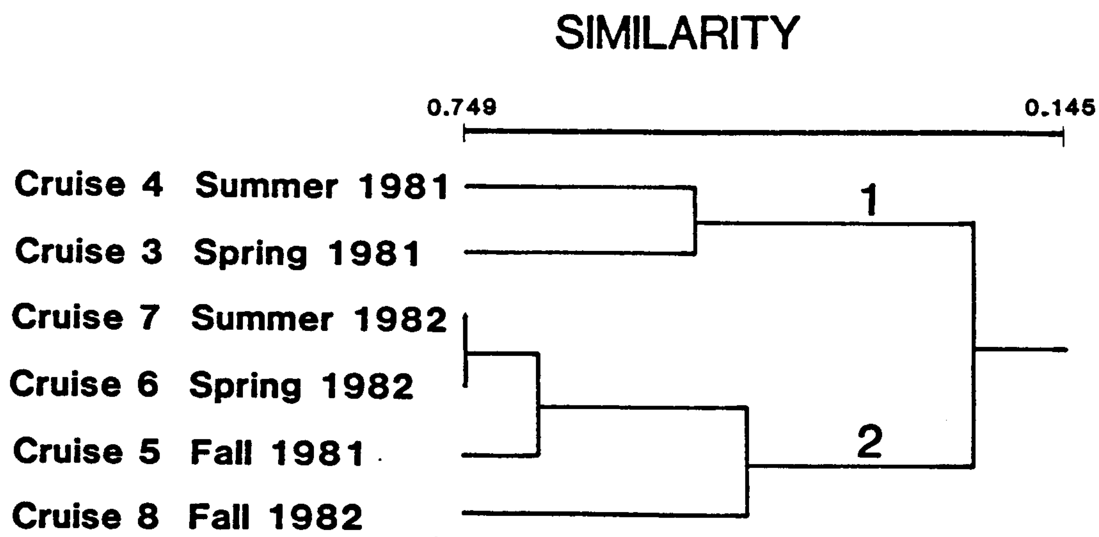


Fig. 6-9. Cluster analysis dendrogram classifying cruises or seasons based upon fish density, East Flower Garden Bank. (0.0005% species deletion level)

biological seasons; one a warm season (spring-summer) and the other fall. Whether winter represents a distinct season in terms of species attributes cannot be determined from our studies due to a lack of winter sampling.

Bank Comparisons

Based upon data obtained during Cruises 3 and 4, the 17 major habitat types represented on each bank were subjected to cluster analysis to evaluate differences among the principle study area habitats (EFG, WFG and PLA). Results of the normal and inverse analyses delineated nine groups of habitats (Fig. 6-10) and 15 species groups [(Fig. 6-11); density deletion-level was 0.0005% based on species rarefaction curve, Fig. 3-13]. Most dissimilar from all other habitats in that no species were recorded (small sample size) were the Transition Zones associated with each bank (Group 7 on Fig. 6-10). At the next level of dissimilarity were soft bottom habitats which split from all the bank associated habitats (Fig. 6-10). The soft bottom habitats around the banks were more similar to each other than to the soft bottom around PLA some 9 nm west of WFG).

Within the bank-associated grouping of habitats, the Coral Detritus Zone of WFG (Group 9) was highly dissimilar to the other habitats, having only one species represented, the sand tilefish (Fig. 6-12). The balance of the bank-associated habitats split into two major types, one characterized by high relief (Groups 5 and 6, Fig. 6-10) the other basically being of low-relief (Groups 1, 2 and 3, Fig. 6-10). The single exception was the low-relief Algal-Nodule Sponge Zone of WFG which clustered with the high relief habitats. That the same habitat from the EFG did not also cluster with the high relief habitats may have been due to small sample sizes. Over four times the area of this habitat were surveyed on the West Bank as compared to the East Bank. Examination of Figure 6-10 shows that within habitat types, the banks were generally highly similar in terms of fish community structure.

Forty-nine species were retained for this analysis (density-deletion level was 0.0004% based upon species rarefaction curve, Fig. 3-13) and formed 15 groups as described above (Fig. 6-11). Of these 15 groups, 11 were represented at least occasionally in Coral Reef Habitat with eight groups (Groups 5, 8, 10, 11, 12, 13, 14 and 15) showing very high levels

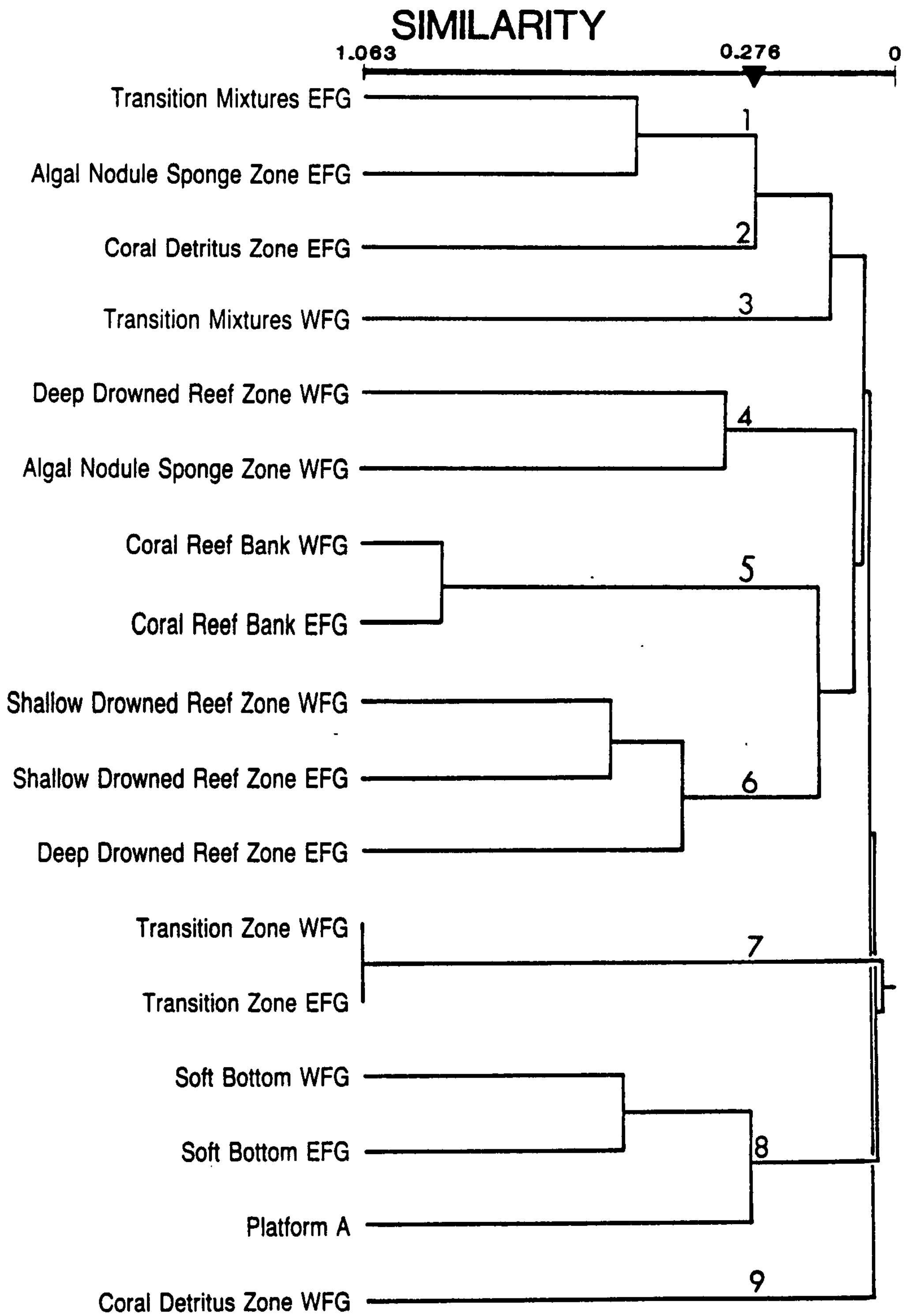


Fig. 6-10. Cluster analysis dendrogram for major habitat types of both East and West Flower Garden Banks based on fish density, Cruises 3-4. (0.0004 % species deletion level).

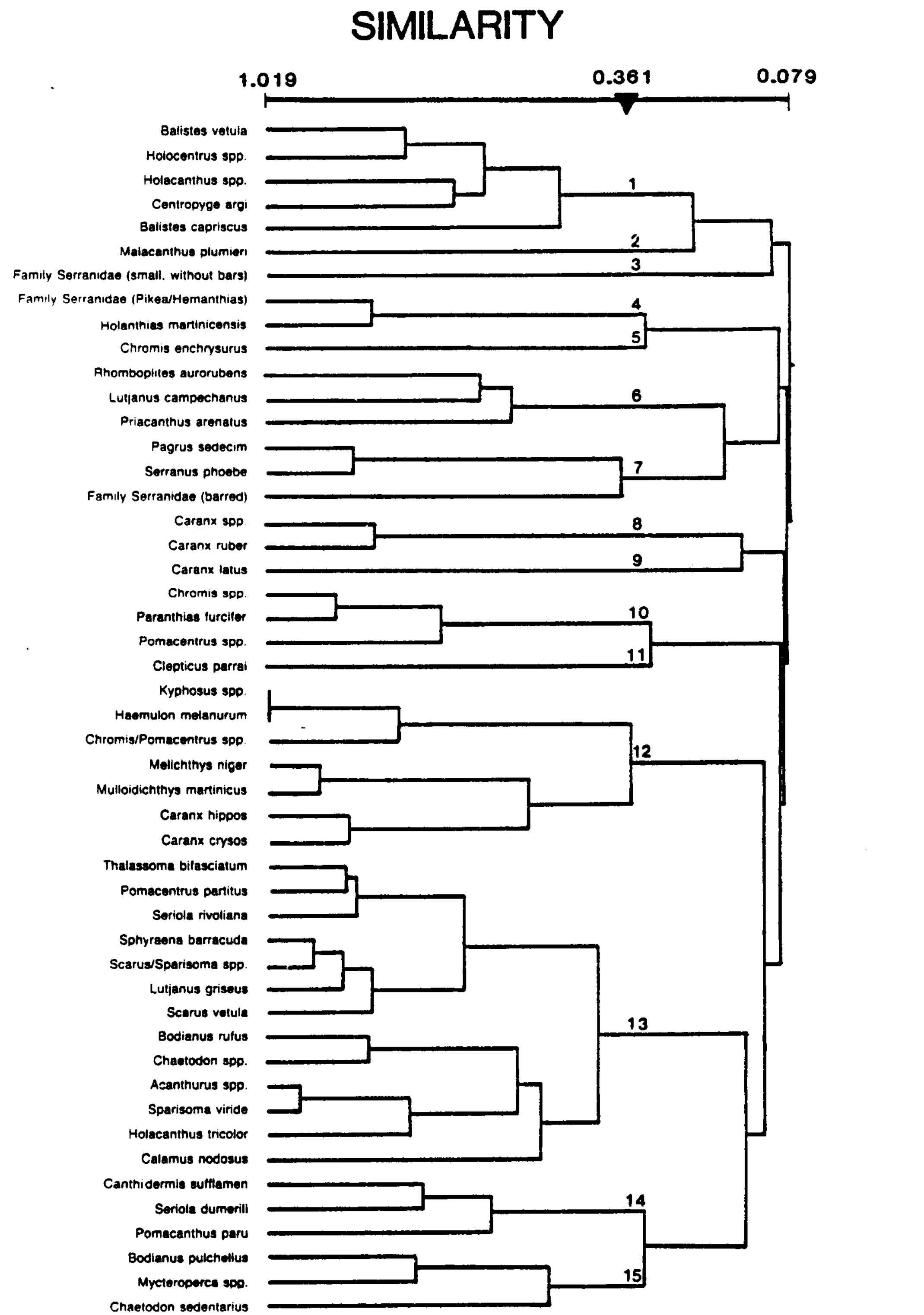


Fig. 6-11. Inverse cluster analysis dendrogram for fish species based on major habitat type, Cruises 3 and 4, East and West Flower Garden Banks (0.0004% species deletion level).

COINCIDENCE TABLE

HABITAT

SPECIES

Species group	Species	1: EFG Shallow Transition Mixtures	1: EFG Algal Nodule Sponge Zone	2: EFG Coral Detritus Zone	3: WFG Shallow Transition Mixtures	4: WFG Deep Drowned Reef Zone	4: WFG Algal Nodule Sponge Zone	5: WFG Coral Reef Bank	5: EFG Coral Reef Bank	6: WFG Shallow Drowned Reef Zone	6: EFG Shallow Drowned Reef Zone	6: EFG Deep Drowned Reef Zone	7: WFG Deep Transition Zone	7: EFG Deep Transition Zone	8: WFG Soft Bottom	8: EFG Soft Bottom	8: PLA Platform A	9: WFG Coral Detritus Zone
1	Balistes vetula	X					X	X	X	^	X							
	Holocentrus spp.					X	X	X		X	X							
	Holacanthus spp.			X			X	X	X	X	X							
	Centropyge argi					X	X			X	X							
	Balistes capriscus	X				X	X		X	X	X							
2	Malacanthus plumieri	X	X				X			X	X							X
3	Family Serranidae (small,without bars)						X								X		X	
4	Family Serranidae (Pikea/Hemanthias)					X	X			X								
	Holanthias martinicensis	X				X				X	X							
5	Chromis enchrysurus	X	X		X	X	X	X	X	X	X							
6	Rhomboplites aurorubens					X	X			X								
	Lutjanus campechanus					X				X	X							
	Priacanthus arenatus					X	X		X	X	X	X			X			
7	Pagrus sedecim					X	X		X	X								
	Serranus phoebe					X				X					X	X	X	
	Family Serranidae (barred)					X	X								X	X	X	
8	Caranx spp.				X			X										
	Caranx ruber			X	X		X	X	X									
9	Caranx latus				X													
10	Chromis spp.					X		X	X	X	X							
	Paranthias furcifer					X	X	X	X	X	X	X						
	Pomacentrus spp.						X	X	X	X	X							
11	Clepticus parrai							X	X									
12	Kyphosus spp.							X	X									
	Haemulon melanurum					X	X	X	X	X								
	Chromis/Pomacentrus spp.		X				X	X	X	X	X							
	Melichthys niger							X	X									
	Mulloidichthys martinicus							X	X									
	Caranx hippos				X			X	X									
	Caranx crysos	X					X	X										
13	Thalassoma bifasciatum						X	X	X	X								
	Pomacentrus partitus						X	X	X	X	X							
	Seriola rivoliana						X	X	X	X								
	Sphyraena barracuda	X					X	X	X									
	Scarus/Sparisoma spp.	X						X	X	X								
	Lutjanus griseus							X	X									
	Scarus vetula							X	X	X								
	Bodianus rufus							X	X	X								
	Chaetodon spp.					X	X	X	X	X	X							
	Acanthurus spp.						X	X	X	X	X							
	Sparisoma viride							X	X	X	X							
	Holacanthus tricolor					X	X	X	X	X								
	Calamus nodosus			X				X	X	X	X							
14	Canthidermis sufflamen				X	X	X	X	X	X	X	X						
	Seriola dumerili	X	X		X	X	X	X	X	X	X	X				X		
	Pomacanthus paru	X	X	X	X		X	X	X	X	X	X						
15	Bodianus pulchellus		X			X	X	X	X	X	X	X						
	Mycteroperca spp.			X		X	X	X	X	X	X	X						
	Chaetodon sedentarius	X	X	X	X	X	X	X	X	X	X							

Fig. 6-12. Two-way coincidence table relating presence of species groups in habitat type groups, Cruises 3 and 4, East and West Flower Garden Banks.

of constancy (Fig. 6-13) of which five likewise exhibited high fidelity levels (Groups 8, 10, 11, 12 and 13). The latter result suggests a selective preference of these species groups for Coral Reef Habitat (Fig. 6-14). Aside from Habitat Group 4 for which three species groups (Groups 4, 6 and 7) had high fidelity, no other habitat approached the level of apparent preference by fish as did Coral Reef.

Habitat Subtype Comparisons

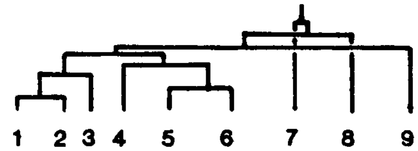
Data collected on EFG during Cruises 3-8 for 26 of the total 30 defined habitat subtypes were subjected to cluster analysis. Of the four subtypes deleted, three were artificial reef types which were found to have been too restricted in bottom area to obtain comparable samples and the other was Deep Transition Zone with prevalent leafy algae. This habitat was not encountered during the video transects. Using a density deletion level of 0.0005%, data for 47 species were used as the basis for the analysis.

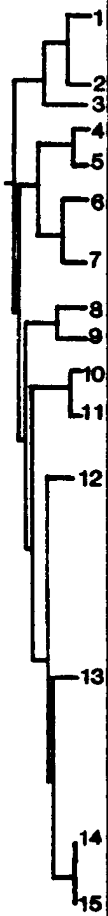
Fish densities within habitat subtypes formed nine distinct clusters (Figs. 6-15 and 6-16). Of the habitats, Groups 1 and 6-9 were believed to have resulted because of small sample sizes encountered during the videotaping transects, resulting in few if any sightings of fish. However, we believe Groups 2-5 reflect biologically meaningful groupings of habitats.

Group 2 essentially represents the Upper Coral Reef and nearby Shallow Drowned Reefs of medium to high relief. Group 3 is represented by both medium and low relief drowned reefs, as well as shallower drowned reefs having moderate structured relief. Groups 4 and 5 represent habitats of low structural relief, including soft bottoms. The latter were decidely different from shallower low-relief habitats having many fewer species represented (Fig. 6-17). Overall, the shallow habitats characterized by marked structural relief (Groups 2 and 3) were typified by the presence of a greater number of species than were present in other habitats (Fig. 6-17).

Within Habitat Group 2, 28 species exhibited very high constancy levels as compared to only nine species exhibiting very high levels of constancy in Habitat Group 3 (Fig. 6-18). No other habitat had any

CONSTANCY

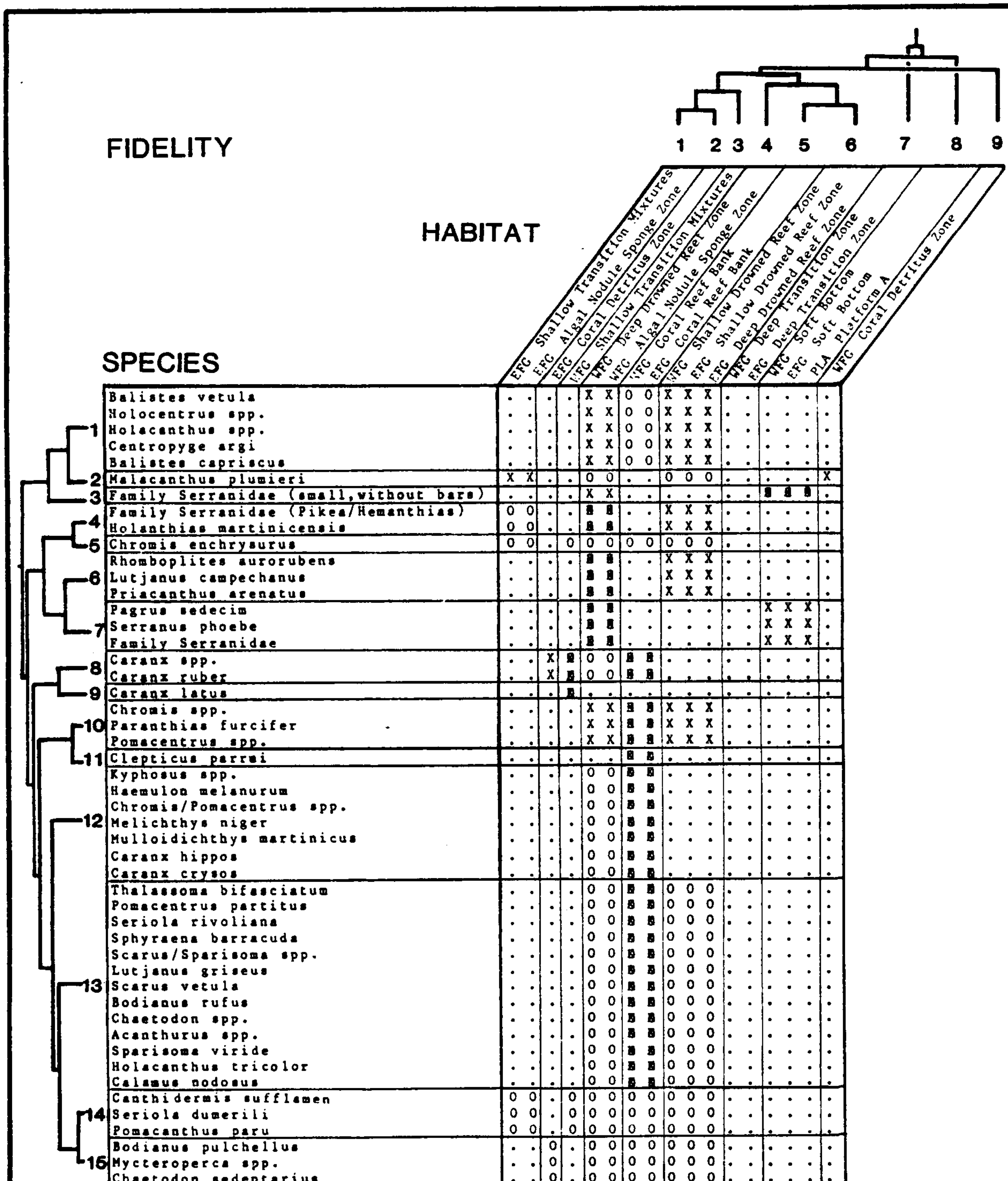




Species group	SPECIES \ HABITAT	EFG Shallow Transition Mixtures	EFG Algal Nodule Sponge Zone	EFG Coral Detritus Zone	WFG Shallow Transition Mixtures	WFG Deep Drowned Reef Zone	WFG Algal Nodule Sponge Zone	WFG Coral Reef Bank	EFG Coral Reef Bank	WFG Shallow Drowned Reef Zone	EFG Shallow Drowned Reef Zone	EFG Deep Drowned Reef Zone	WFG Deep Drowned Reef Zone	EFG Deep Transition Zone	WFG Deep Transition Zone	WFG Soft Bottom	EFG Soft Bottom	PLA Platform A	WFG Coral Detritus Zone
Habitat group		1	1	2	3	4	4	5	5	6	6	6	7	7	8	8	8	8	9
1	Balistes vetula	+	+	+	.	■	■	X	X	X	X	X	.	.	.	.	.	.
	Holocentrus spp.	+	+	+	.	■	■	X	X	X	X	X	.	.	.	.	.	.
	Holacanthus spp.	+	+	+	.	■	■	X	X	X	X	X	.	.	.	.	.	.
	Centropyge argi	+	+	+	.	■	■	X	X	X	X	X	.	.	.	.	.	.
	Balistes capriscus	+	+	+	.	■	■	X	X	X	X	X	.	.	.	.	.	.
2	Malacanthus plumieri	■	■	.	.	X	X	.	.	X	X	X	.	.	.	.	.	■
3	Family Serranidae (small, without bars)	.	.	.	.	X	X	.	.	.	.	.	.	.	X	X	X	.
4	Family Serranidae (Pikea/Hemanthias)	+	+	.	.	■	■	.	.	X	X	X	.	.	.	.	.	.
	Holanthias martinicensis	+	+	.	.	■	■	.	.	X	X	X	.	.	.	.	.	.
5	Chromis enchrysurus	■	■	.	■	■	■	■	■	X	X	X	.	.	.	.	.	.
6	Rhomboplites aurorubens	.	.	.	.	■	■	+	+	X	X	X	.	.	+	+	+	.
	Lutjanus campechanus	.	.	.	.	■	■	+	+	X	X	X	.	.	+	+	+	.
	Priacanthus arenatus	.	.	.	.	■	■	+	+	X	X	X	.	.	+	+	+	.
7	Pagrus sedecim	.	.	.	.	■	■	+	+	+	+	+	.	.	X	X	X	.
	Serranus phoebe	.	.	.	.	■	■	+	+	+	+	+	.	.	X	X	X	.
	Family Serranidae (barred)	.	.	.	.	■	■	+	+	+	+	+	.	.	X	X	X	.
8	Caranx spp.	.	.	X	■	+	+	■	■	.	.	.	.	.	.	.	.	.
	Caranx ruber	.	.	X	■	+	+	■	■	.	.	.	.	.	.	.	.	.
9	Caranx latus	.	.	.	■	.	.	.	.	.	.	.	.	.	.	.	.	.
10	Chromis spp.	.	.	.	.	X	X	■	■	■	■	■	.	.	.	.	.	.
	Paranthias furcifer	.	.	.	.	X	X	■	■	■	■	■	.	.	.	.	.	.
	Pomacentrus spp.	.	.	.	.	X	X	■	■	■	■	■	.	.	.	.	.	.
11	Clepticus parrai	.	.	.	.	.	.	■	■	.	.	.	.	.	.	.	.	.
12	Kyphosus spp.	+	+	.	+	+	+	■	■	+	+	+	.	.	.	.	.	.
	Haemulon melanurum	+	+	.	+	+	+	■	■	+	+	+	.	.	.	.	.	.
	Chromis/Pomacentrus spp.	+	+	.	+	+	+	■	■	+	+	+	.	.	.	.	.	.
	Melichthys niger	+	+	.	+	+	+	■	■	+	+	+	.	.	.	.	.	.
	Mulloidichthys martinicus	+	+	.	+	+	+	■	■	+	+	+	.	.	.	.	.	.
	Caranx hippos	+	+	.	+	+	+	■	■	+	+	+	.	.	.	.	.	.
	Caranx crysos	+	+	.	+	+	+	■	■	+	+	+	.	.	.	.	.	.
13	Thalassoma bifasciatum	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Pomacentrus partitus	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Seriola rivoliana	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Sphyraena barracuda	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Scarus/Sparisoma spp.	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Lutjanus griseus	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Scarus vetula	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Bodianus rufus	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Chaetodon spp.	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Acanthurus spp.	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Sparisoma viride	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Holacanthus tricolor	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Calamus nodosus	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
14	Canthidermis sufflamen	X	X	0	■	■	■	■	■	■	■	■	.	.	+	+	+	.
	Seriola dumerili	X	X	0	■	■	■	■	■	■	■	■	.	.	+	+	+	.
	Pomacanthus paru	X	X	0	■	■	■	■	■	■	■	■	.	.	+	+	+	.
15	Bodianus pulchellus	X	X	X	0	■	■	■	■	■	■	■	.	.	.	.	.	.
	Mycteroperca spp.	X	X	X	0	■	■	■	■	■	■	■	.	.	.	.	.	.
	Chaetodon sedentarius	X	X	X	0	■	■	■	■	■	■	■	.	.	.	.	.	.

■ ≥ 0.7	X ≥ 0.5	0 ≥ 0.3	+ ≥ 0.1	. < 0.1
VERY HIGH	HIGH	MODERATE	LOW	VERY LOW

Fig. 6-13. Nodal constancy in a two-way table of species groups in habitat type groups, Cruises 3 and 4, East and West Flower Garden Banks.



Species group	Species	EFG Shallow Transition Mixtures	EFG Algal Nodule Sponge Zone	EFG Coral Detritus Zone	WFG Shallow Transition Mixtures	WFG Deep Drowned Reef Zone	WFG Algal Nodule Sponge Zone	WFG Coral Reef Bank	EFG Coral Reef Bank	WFG Shallow Drowned Reef Zone	EFG Shallow Drowned Reef Zone	EFG Deep Drowned Reef Zone	WFG Deep Transition Zone	EFG Deep Transition Zone	WFG Soft Bottom	EFG Soft Bottom	PLA Platform A	WFG Coral Detritus Zone
1	Balistes vetula	.	.	.	.	X	X	0	0	X	X	X	.	.	.	.	.	.
	Holocentrus spp.	.	.	.	.	X	X	0	0	X	X	X	.	.	.	.	.	.
	Holacanthus spp.	.	.	.	.	X	X	0	0	X	X	X	.	.	.	.	.	.
	Centropyge argi	.	.	.	.	X	X	0	0	X	X	X	.	.	.	.	.	.
	Balistes capriscus	.	.	.	.	X	X	0	0	X	X	X	.	.	.	.	.	.
2	Malacanthus plumieri	X	X	.	.	0	0	.	.	0	0	0	.	.	.	.	.	X
3	Family Serranidae (small, without bars)	.	.	.	.	X	X	.	.	.	.	.	.	.	■	■	■	.
4	Family Serranidae (Pikea/Hemanthias)	0	0	.	.	■	■	.	.	X	X	X	.	.	.	.	.	.
	Holanthias martinicensis	0	0	.	.	■	■	.	.	X	X	X	.	.	.	.	.	.
5	Chromis enchrysurus	0	0	.	0	0	0	0	0	0	0	0	.	.	.	.	.	.
6	Rhomboplites aurorubens	.	.	.	.	■	■	.	.	X	X	X	.	.	.	.	.	.
	Lutjanus campechanus	.	.	.	.	■	■	.	.	X	X	X	.	.	.	.	.	.
	Priacanthus arenatus	.	.	.	.	■	■	.	.	X	X	X	.	.	.	.	.	.
7	Pagrus sedecim	.	.	.	.	■	■	.	.	.	.	.	.	.	X	X	X	.
	Serranus phoebe	.	.	.	.	■	■	.	.	.	.	.	.	.	X	X	X	.
	Family Serranidae	.	.	.	.	■	■	.	.	.	.	.	.	.	X	X	X	.
8	Caranx spp.	.	.	X	■	0	0	■	■	.	.	.	.	.	.	.	.	.
	Caranx ruber	.	.	X	■	0	0	■	■	.	.	.	.	.	.	.	.	.
9	Caranx latus	.	.	.	■	.	.	.	.	.	.	.	.	.	.	.	.	.
10	Chromis spp.	.	.	.	.	X	X	■	■	X	X	X	.	.	.	.	.	.
	Paranthias furcifer	.	.	.	.	X	X	■	■	X	X	X	.	.	.	.	.	.
	Pomacentrus spp.	.	.	.	.	X	X	■	■	X	X	X	.	.	.	.	.	.
11	Clepticus parrai	.	.	.	.	.	.	■	■	.	.	.	.	.	.	.	.	.
12	Kyphosus spp.	.	.	.	.	0	0	■	■	.	.	.	.	.	.	.	.	.
	Haemulon melanurum	.	.	.	.	0	0	■	■	.	.	.	.	.	.	.	.	.
	Chromis/Pomacentrus spp.	.	.	.	.	0	0	■	■	.	.	.	.	.	.	.	.	.
	Melichthys niger	.	.	.	.	0	0	■	■	.	.	.	.	.	.	.	.	.
	Mulloidichthys martinicus	.	.	.	.	0	0	■	■	.	.	.	.	.	.	.	.	.
	Caranx hippos	.	.	.	.	0	0	■	■	.	.	.	.	.	.	.	.	.
	Caranx crysos	.	.	.	.	0	0	■	■	.	.	.	.	.	.	.	.	.
13	Thalassoma bifasciatum	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Pomacentrus partitus	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Seriola rivoliana	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Sphyraena barracuda	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Scarus/Sparisoma spp.	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Lutjanus griseus	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Scarus vetula	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Bodianus rufus	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Chaetodon spp.	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Acanthurus spp.	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Sparisoma viride	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Holacanthus tricolor	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
	Calamus nodosus	.	.	.	.	0	0	■	■	0	0	0	.	.	.	.	.	.
14	Canthidermis sufflamen	0	0	.	0	0	0	0	0	0	0	0	.	.	.	.	.	.
	Seriola dumerili	0	0	.	0	0	0	0	0	0	0	0	.	.	.	.	.	.
	Pomacanthus paru	0	0	.	0	0	0	0	0	0	0	0	.	.	.	.	.	.
15	Bodianus pulchellus	.	.	0	.	0	0	0	0	0	0	0	.	.	.	.	.	.
	Mycteroperca spp.	.	.	0	.	0	0	0	0	0	0	0	.	.	.	.	.	.
	Chaetodon sedentarius	.	.	0	.	0	0	0	0	0	0	0	.	.	.	.	.	.

■ ≥ 3 HIGH X ≥ 2 MODERATE 0 ≥ 1 LOW . < 1 NEGATIVE

Fig. 6-14. Nodal fidelity in a two-way table of species groups in habitat type groups, Cruises 3 and 4, East and West Flower Garden Banks.

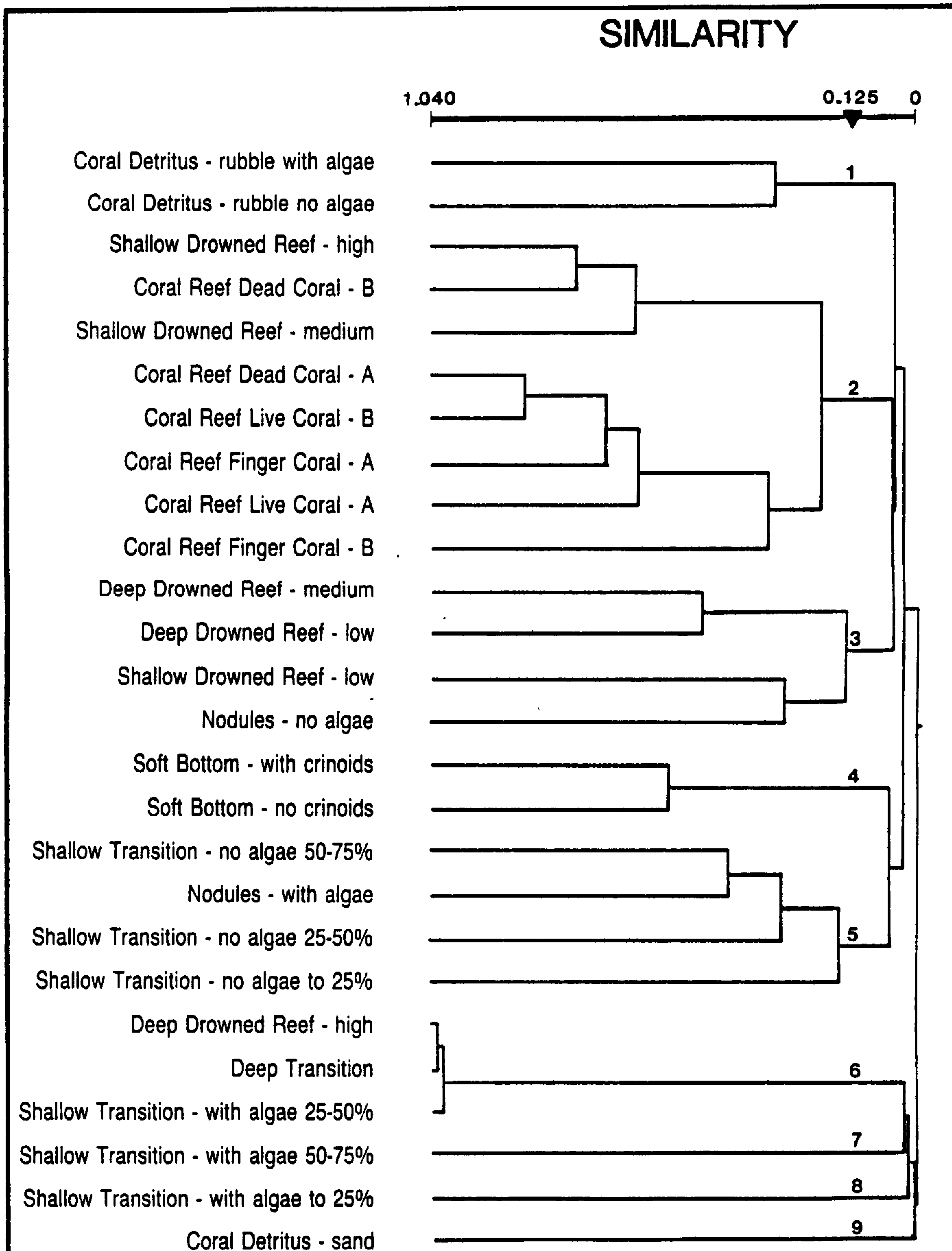


Fig. 6-15. Cluster analysis dendrogram for habitat sub-types based on fish density, Cruises 3-8, East Flower Garden Bank. (0.0005% species deletion level).

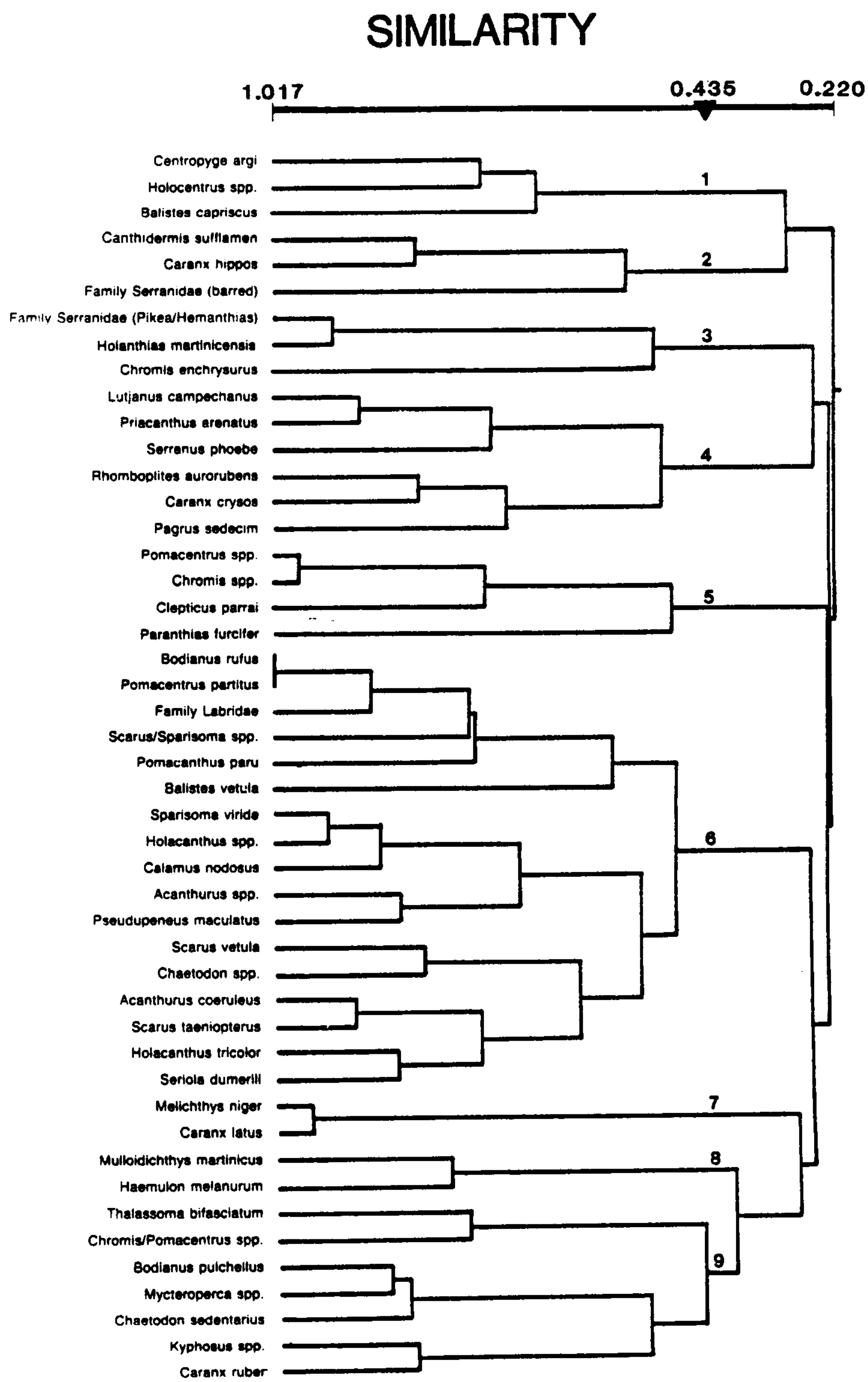


Fig. 6-16. Inverse cluster analysis dendrogram for fish species based on density by habitat type, Cruises 3-8, East Flower Garden Bank. (0.0005% species deletion level)

COINCIDENCE TABLE

HABITAT

SPECIES

Group	Species	Coral Detritus-rubble with algae	Coral Detritus-rubble no algae	Shallow Drowned Reef-high	Coral Reef Dead Coral-B	Shallow Drowned Reef-medium	Coral Reef Dead Coral-A	Coral Reef Live Coral-B	Coral Reef Finger Coral-A	Coral Reef Live Coral-A	Coral Reef Finger Coral-B	Deep Drowned Reef-medium	Deep Drowned Reef-low	Shallow Drowned Reef-low	Nodules-no algae	Soft Bottom-with crinoids	Soft Bottom-no crinoids	Shallow Transition-no algae 50-75%	Nodules-with algae	Shallow Transition-no algae 25-50%	Shallow Transition-no algae to 25%	Deep Drowned Reef-high	Deep Transition	Shallow Transition-with algae 25-50%	Shallow Transition-with algae 50-75%	Shallow Transition-with algae to 25%	Coral Detritus-sand
	Habitat group	1		2								3				4		5				6			7	8	9
	Centropyge argi					X	X	X	X	X	X			X	X			X	X								
1	Holocentrus spp.			X	X	X	X	X		X			X	X													
	Balistes capriscus				X	X				X				X	X			X	X	X					X		
	Canthidermis sufflamen				X	X	X	X	X	X			X	X	X					X							
2	Caranx hippos					X		X	X	X							X										
	Family Serranidae (barred)					X							X	X	X	X	X			X							
	Family Serranidae (Pikea/Hemanthias)			X		X						X	X	X	X												
3	Holanthias martinicensis			X		X						X	X	X	X												
	Chromis enchrysurus			X	X	X	X	X	X	X	X	X	X	X	X			X	X	X							
	Lutjanus campechanus			X		X	X			X		X	X	X			X										
	Priacanthus arenatus			X	X	X	X	X		X		X	X	X	X		X										
4	Serranus phoebe					X						X	X	X		X	X		X	X							
	Rhomboplites aurorubens					X						X	X														
	Caranx crysos											X	X	X	X			X									
	Pagrus sedecim			X		X		X	X			X	X	X													
	Pomacentrus spp.				X	X	X	X	X	X	X			X													
5	Chromis spp.			X	X	X	X	X	X	X				X													
	Clepticus parrai			X	X	X	X	X	X	X	X			X													
	Paranthias furcifer			X	X	X	X	X	X	X	X	X	X	X	X				X								
	Bodianus rufus				X	X	X	X	X	X	X			X	X			X	X								
	Pomacentrus partitus			X	X	X	X	X	X	X	X			X	X			X	X								
	Family Labridae			X	X	X	X	X	X	X	X		X	X	X												
	Scarus/Sparisoma spp.			X	X	X	X	X	X	X	X			X						X							
	Pomacanthus paru		X		X	X	X	X	X	X	X		X	X	X			X	X	X							
	Balistes vetula				X	X	X	X	X	X	X			X	X			X	X	X						X	
	Sparisoma viride			X	X	X	X	X	X	X	X			X													
	Holacanthus spp.		X	X	X	X	X	X	X	X	X	X		X	X												
6	Calamus nodosus		X	X	X	X	X	X	X	X		X	X	X	X					X							
	Acanthurus spp.			X	X	X	X	X	X	X	X			X													
	Pseudupeneus maculatus				X	X	X	X	X	X				X													
	Scarus vetula				X	X	X	X	X	X				X													
	Chaetodon spp.				X	X	X	X	X	X				X													
	Acanthurus coeruleus				X		X	X	X	X																	
	Scarus taeniopterus				X	X	X	X	X	X				X													
	Holacanthus tricolor			X	X	X	X	X	X	X		X		X	X												
	Seriola dumerili			X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X						
7	Melichthys niger						X	X	X	X																	
	Caranx latus									X																	
8	Mulloidichthys martinicus				X		X	X		X																	
	Haemulon melanurum			X	X	X	X	X	X	X			X	X	X				X								
	Thalassoma bifasciatum				X	X	X	X	X	X	X			X	X												
	Chromis/Pomacentrus spp.				X	X	X	X	X	X	X			X	X				X								
	Bodianus pulchellus			X	X	X	X	X	X	X	X	X	X	X	X				X								
9	Mycteroperca spp.		X	X	X	X	X	X	X	X	X	X	X	X	X		X		X								X
	Chaetodon sedentarius	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X		X						
	Kyphosus spp.			X	X	X	X	X	X	X					X												
	Caranx ruber		X		X		X	X	X	X				X						X							

Fig. 6-17. Two-way coincidence table relating presence of species groups in habitat sub-type groups, Cruises 3-8, East Flower Garden Bank.

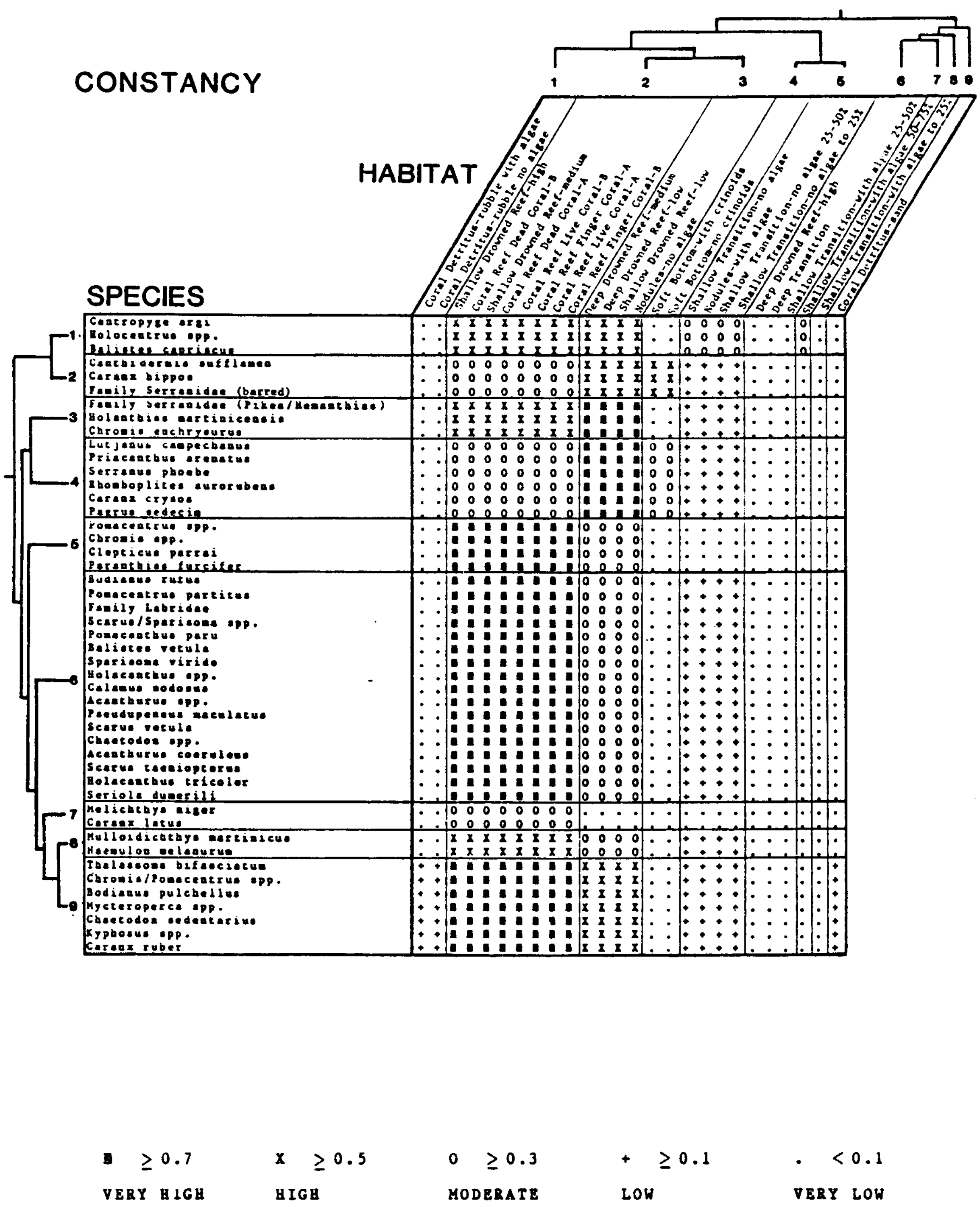


Fig. 6-18. Nodal constancy in a two-way table of species groups in habitat sub-type groups, Cruises 3-8, East Flower Garden Bank.

species exhibiting a very high level of constancy. Thirty-two species showed moderate (28 species) to high fidelity (two species) to Habitat Group 2 (Fig. 6-19). Nine species showed moderate fidelity to Habitat Group 3 with no species exhibiting a high level of fidelity.

Depth Comparisons

Data for 5-m depth intervals were subjected to cluster analysis with 50 species (0.0005% density-deletion level) serving as the basis for the analysis. Five discrete groupings of depth zones were suggested by the ordered results (Fig. 6-20). Depths below 85 m were most dissimilar and divided into two zones, one being 84 to 104 m (Group 4, Fig. 6-20) and the other represented by a depth range of 105 to 129 m (Group 5, Fig. 6-20). These groups correspond well to the distribution of Deep Drowned Reef habitat and soft bottoms, respectively.

Depth Groups 1-3 correspond to the extent of live bottom habitat on the EFG, with Groups 1 and 2 corresponding almost exactly to Bright's (in McGrail et al. 1982) High and Low Diversity Upper Coral Reef Zones, respectively. Group 3 (50- to 84-m depths) represents the area covered by the Algal-Nodule Sponge and Shallow Drowned Reef Zones.

Twelve species groups (Fig. 6-21) resulted from the analysis with the number of taxa represented at depths below 85 m being markedly fewer than was characteristic of shallower depths (Fig. 6-22).

One species group (Group 11) exhibited a very high constancy level for only Depth Group 1, (15 to 34 m), four groups (3, 5, 9 and 10) showed very high constancy for Depth Groups 1 and 2 (15 to 49 m) and two (Groups 4 and 8) had very high constancy levels in each of Depth Groups 1-3 (Fig. 6-23). Two species groups (6 and 7) comprised a mid-depth assemblage based upon the distribution of very high constancy levels in Depth Groups 3 and 4 (5 to 104 m). Unidentified serranids (Species Group 2) had very high constancy levels in waters 50 to 129 m in depth. Species Group 1 (Fig. 6-22) was a soft bottom assemblage, with high constancy levels restricted to the deepest depth zone, Depth Group 5 (Fig. 6-23).

High fidelity levels for a habitat were exhibited only by Species Group 11 for Habitat Group 1, suggesting a strong selection by these species for high diversity portions of the Upper Coral Reef. Moderate

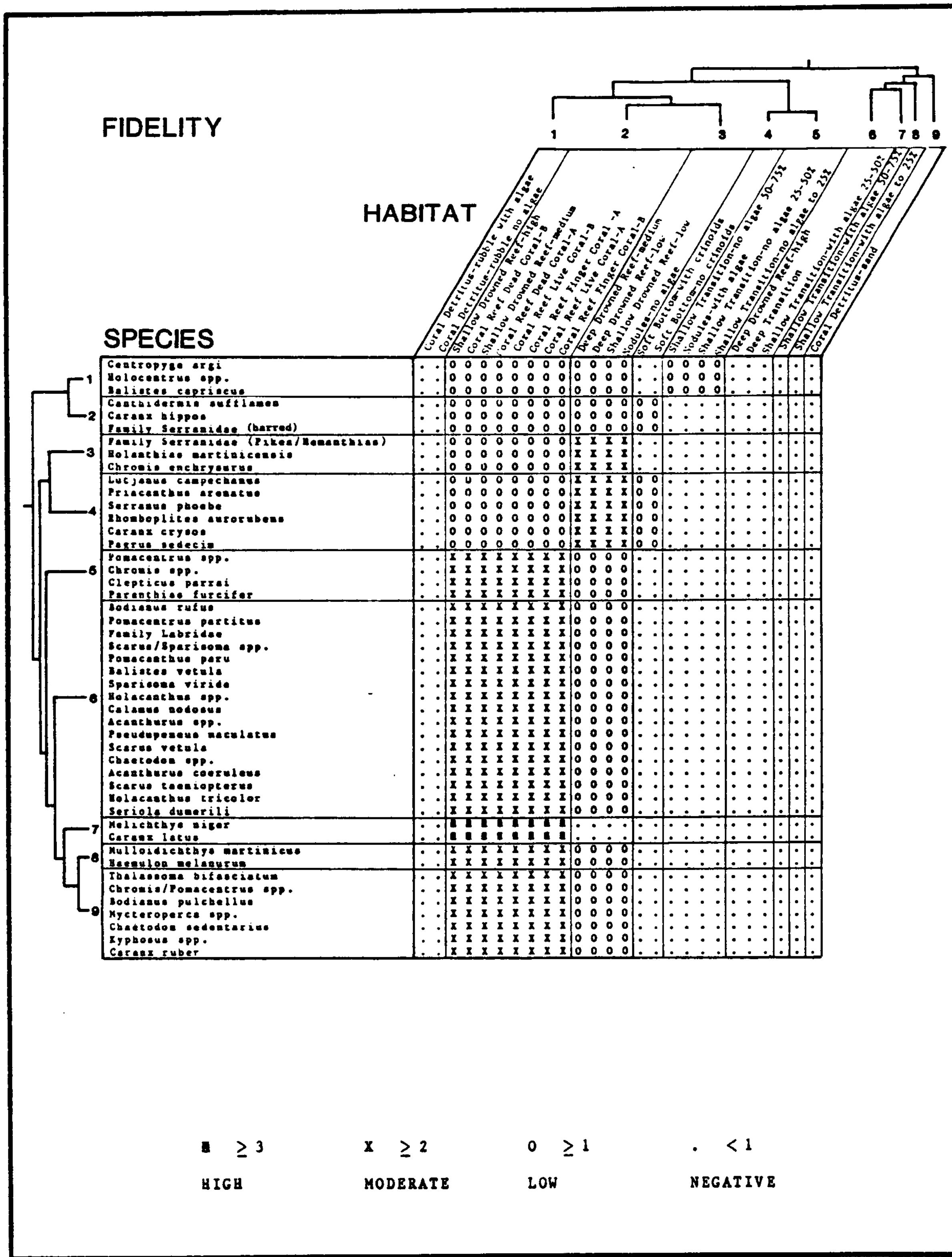


Fig. 6-19. Nodal fidelity in a two-way table of species groups in habitat sub-type groups, Cruises 3-8, East Flower Garden Bank.

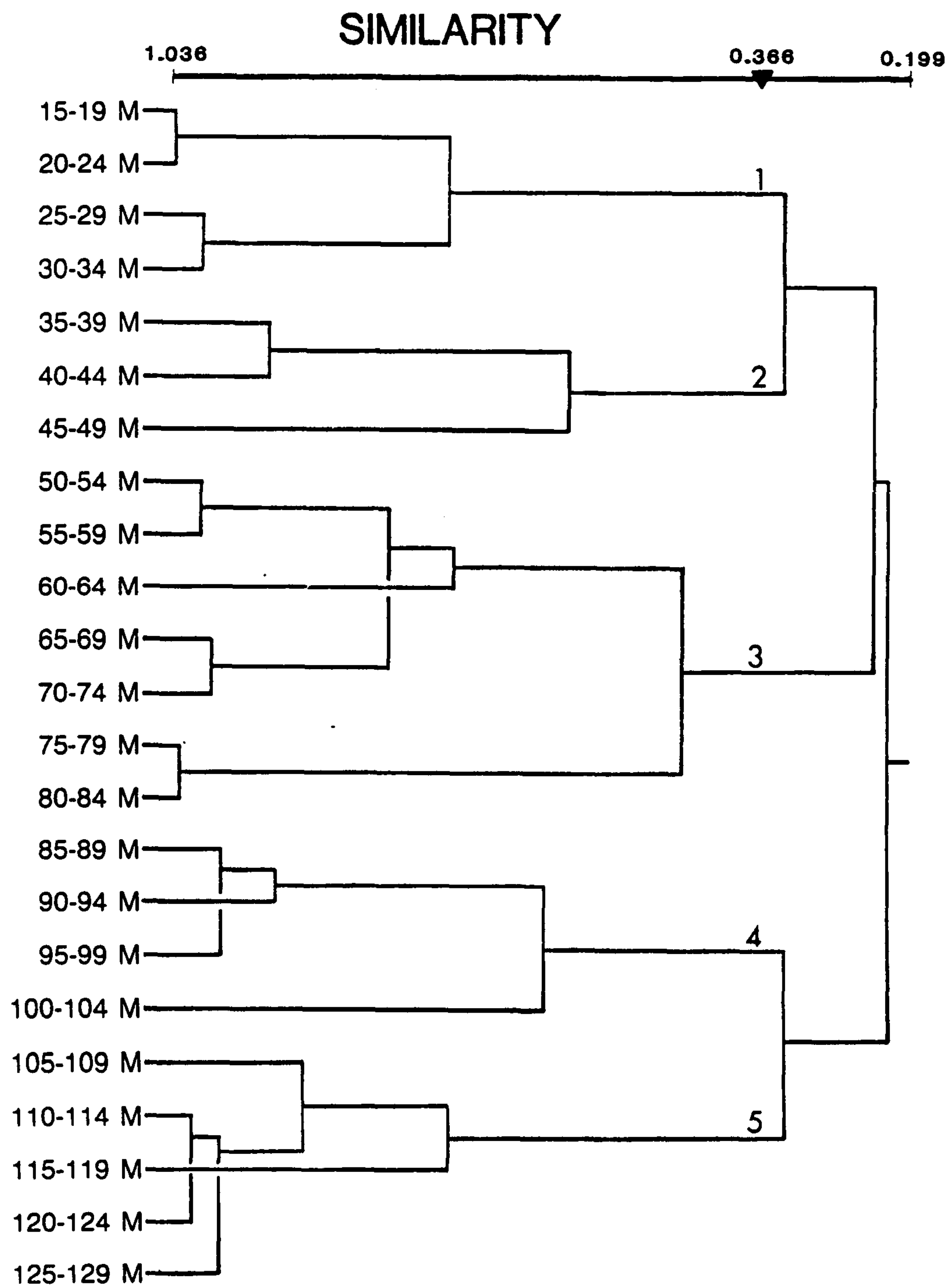


Fig. 6-20. Cluster analysis dendrogram for ordered 5 m depth increments based on fish density, Cruises 3-8, East Flower Garden Bank. (0.0005% species deletion level).

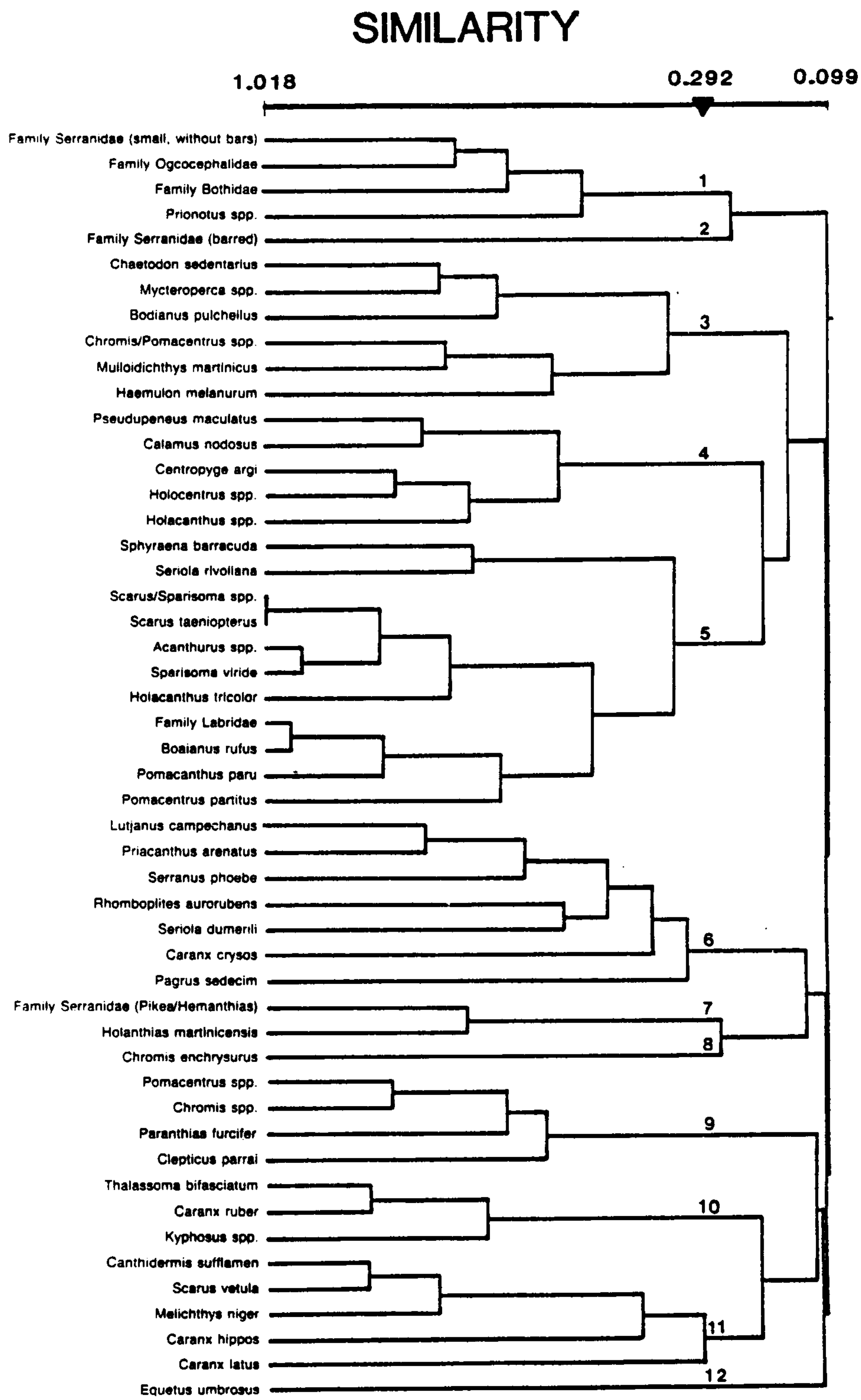


Fig. 6-21. Inverse cluster analysis dendrogram for fish species based on density by 5 m depth increments, Cruises 3-8, East Flower Garden Bank. (0.0005% species deletion level).

COINCIDENCE TABLE

DEPTH (meters)

	SPECIES	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129
	Depth group	1				2			3							4				5				
1	Family Serranidae (small, without bars)									X					X		X	X		X	X		X	X
1	Family Ogcocephalidae																X	X		X	X	X	X	
1	Family Bothidae															X			X	X	X		X	X
1	Prionotus spp.																		X		X	X	X	X
2	Family Serranidae (barred)							X		X	X	X		X	X	X	X	X	X	X	X	X	X	X
3	Chaetodon sedentarius	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							
3	Mycteroperca spp.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X				
3	Bodianus pulchellus	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X								
3	Chromis/Pomacentrus spp.	X	X	X	X	X	X	X	X	X	X													
3	Mulloidichthys martinicus	X	X	X	X	X	X	X																
3	Haemulon melanurum	X		X	X	X	X	X	X	X	X		X	X										
4	Pseudupeneus maculatus			X	X	X	X	X	X	X	X	X												
4	Calamus nodosus		X	X	X	X	X	X	X	X	X	X	X	X	X									
4	Centropyge argi		X	X	X		X	X	X	X	X	X	X											
4	Holocentrus spp.		X	X	X	X	X	X	X	X	X	X	X		X	X								
4	Holacanthus spp.	X	X	X	X	X	X	X	X	X	X				X									
5	Sphyraena barracuda	X	X	X	X	X	X	X		X														
5	Seriola rivoliana	X		X	X	X	X	X	X	X					X	X								
5	Scarus/Sparisoma spp.	X	X	X	X	X	X	X	X			X												
5	Scarus taeniopterus	X	X	X	X	X	X	X	X															
5	Acanthurus spp.	X	X	X	X	X	X	X	X															
5	Sparisoma viride	X	X	X	X	X	X	X	X	X	X													
5	Holacanthus tricolor	X	X	X	X	X	X	X	X	X	X	X		X										
5	Family Labridae	X	X	X	X	X	X	X	X	X	X	X				X	X							
5	Bodianus rufus	X	X	X	X	X	X	X	X	X	X	X												
5	Pomacanthus paru	X	X	X	X	X	X	X	X	X	X	X												
5	Pomacentrus partitus	X	X	X	X	X	X	X	X															
6	Lutjanus campechanus						X	X	X	X	X	X	X	X	X	X	X	X				X		
6	Priacanthus arenatus					X	X	X	X	X	X	X	X	X	X	X	X	X	X					
6	Serranus phoebe							X	X	X	X	X	X	X	X	X	X	X			X	X	X	X
6	Rhomboplites aurorubens										X	X	X			X	X	X						
6	Seriola dumerili	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X				
6	Caranx crysos							X	X							X	X							
6	Pagrus sedecim					X	X		X	X		X	X	X	X	X	X							
7	Family Serranidae (Pikea/Hemanthias)							X	X	X	X	X	X	X	X	X	X	X	X					
7	Holanthias martinicensis									X	X	X	X	X	X	X	X	X	X					
8	Chromis enchrysurus	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							
9	Pomacentrus spp.	X	X	X	X	X	X	X	X															
9	Chromis spp.	X	X	X	X	X	X	X	X	X	X	X												
9	Paranthias furcifer	X	X	X	X	X	X	X	X	X	X	X	X	X	X									
9	Clepticus parrai	X	X	X	X	X	X	X	X	X		X												
10	Thalassoma bifasciatum	X	X	X	X	X	X	X	X	X														
10	Caranx ruber	X	X	X	X	X	X	X																
10	Kyphosus spp.	X	X	X	X	X	X	X	X															
11	Canthidermis sufflamen	X	X	X	X	X	X	X	X			X												
11	Scarus vetula	X	X	X	X	X	X	X																
11	Melichthys niger	X	X	X	X	X	X																	
11	Caranx hippos	X	X	X	X	X			X							X								
11	Caranx latus		X																					
12	Equetus umbrosus								X						X				X					

Fig. 6-22. Two-way coincidence table relating presence of species groups in depth interval groups, Cruises 3-8, East Flower Garden Bank.

CONSTANCY

Species group	SPECIES \ DEPTH (meters)	15-19 (1)	20-24 (1)	25-29 (1)	30-34 (1)	35-39 (2)	40-44 (2)	45-49 (2)	50-54 (3)	55-59 (3)	60-64 (3)	65-69 (3)	70-74 (3)	75-79 (3)	80-84 (3)	85-89 (4)	90-94 (4)	95-99 (4)	100-104 (4)	105-109 (5)	110-114 (5)	115-119 (5)	120-124 (5)	125-129 (5)
1	Family Serranidae (small, without bars)	·	·	·	·	·	·	·	·	·	·	·	·	·	·	O	O	O	O	■	■	■	■	■
1	Family Ogcocephalidae	·	·	·	·	·	·	·	·	·	·	·	·	·	·	O	O	O	O	■	■	■	■	■
1	Family Bothidae	·	·	·	·	·	·	·	·	·	·	·	·	·	·	O	O	O	O	■	■	■	■	■
1	Prionotus spp.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	O	O	O	O	■	■	■	■	■
2	Family Serranidae	·	·	·	·	O	O	O	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
3	Chaetodon sedentarius	■	■	■	■	■	■	■	X	X	X	X	X	X	X	+	+	+	+	·	·	·	·	·
3	Mycteroperca spp.	■	■	■	■	■	■	■	X	X	X	X	X	X	X	+	+	+	+	·	·	·	·	·
3	Bodianus pulchellus	■	■	■	■	■	■	■	X	X	X	X	X	X	X	+	+	+	+	·	·	·	·	·
3	Chromis/Pomacentrus spp.	■	■	■	■	■	■	■	X	X	X	X	X	X	X	+	+	+	+	·	·	·	·	·
3	Mulloidichthys martinicus	■	■	■	■	■	■	■	X	X	X	X	X	X	X	+	+	+	+	·	·	·	·	·
3	Haemulon melanurum	■	■	■	■	■	■	■	X	X	X	X	X	X	X	+	+	+	+	·	·	·	·	·
4	Pseudupeneus maculatus	■	■	■	■	■	■	■	■	■	■	■	■	■	■	·	·	·	·	·	·	·	·	·
4	Calamus nodosus	■	■	■	■	■	■	■	■	■	■	■	■	■	■	·	·	·	·	·	·	·	·	·
4	Centropyge argi	■	■	■	■	■	■	■	■	■	■	■	■	■	■	·	·	·	·	·	·	·	·	·
4	Holocentrus spp.	■	■	■	■	■	■	■	■	■	■	■	■	■	■	·	·	·	·	·	·	·	·	·
4	Holacanthus spp.	■	■	■	■	■	■	■	■	■	■	■	■	■	■	·	·	·	·	·	·	·	·	·
5	Sphyraena barracuda	■	■	■	■	■	■	■	O	O	O	O	O	O	O	·	·	·	·	·	·	·	·	·
5	Seriola rivoliana	■	■	■	■	■	■	■	O	O	O	O	O	O	O	·	·	·	·	·	·	·	·	·
5	Scarus/Sparisoma spp.	■	■	■	■	■	■	■	O	O	O	O	O	O	O	·	·	·	·	·	·	·	·	·
5	Scarus taeniopterus	■	■	■	■	■	■	■	O	O	O	O	O	O	O	·	·	·	·	·	·	·	·	·
5	Acanthurus spp.	■	■	■	■	■	■	■	O	O	O	O	O	O	O	·	·	·	·	·	·	·	·	·
5	Sparisoma viride	■	■	■	■	■	■	■	O	O	O	O	O	O	O	·	·	·	·	·	·	·	·	·
5	Holacanthus tricolor	■	■	■	■	■	■	■	O	O	O	O	O	O	O	·	·	·	·	·	·	·	·	·
5	Family Labridae	■	■	■	■	■	■	■	O	O	O	O	O	O	O	·	·	·	·	·	·	·	·	·
5	Bodianus rufus	■	■	■	■	■	■	■	O	O	O	O	O	O	O	·	·	·	·	·	·	·	·	·
5	Pomacanthus paru	■	■	■	■	■	■	■	O	O	O	O	O	O	O	·	·	·	·	·	·	·	·	·
5	Pomacentrus partitus	■	■	■	■	■	■	■	O	O	O	O	O	O	O	·	·	·	·	·	·	·	·	·
6	Lutjanus campechanus	+	+	+	+	X	X	X	■	■	■	■	■	■	■	■	■	■	■	+	+	+	+	+
6	Priacanthus arenatus	+	+	+	+	X	X	X	■	■	■	■	■	■	■	■	■	■	■	+	+	+	+	+
6	Serranus phoebe	+	+	+	+	X	X	X	■	■	■	■	■	■	■	■	■	■	■	+	+	+	+	+
6	Rhomboplites aurorubens	+	+	+	+	X	X	X	■	■	■	■	■	■	■	■	■	■	■	+	+	+	+	+
6	Seriola dumerili	+	+	+	+	X	X	X	■	■	■	■	■	■	■	■	■	■	■	+	+	+	+	+
6	Caranx crysos	+	+	+	+	X	X	X	■	■	■	■	■	■	■	■	■	■	■	+	+	+	+	+
6	Pagrus sedecim	+	+	+	+	X	X	X	■	■	■	■	■	■	■	■	■	■	■	+	+	+	+	+
7	Family Serranidae (Pikea/Hemanthias)	·	·	·	·	+	+	+	■	■	■	■	■	■	■	■	■	■	■	·	·	·	·	·
7	Holanthias martinicensis	·	·	·	·	+	+	+	■	■	■	■	■	■	■	■	■	■	■	·	·	·	·	·
8	Chromis enchrysurus	■	■	■	■	■	■	■	■	■	■	■	■	■	■	X	X	X	X	·	·	·	·	·
9	Pomacentrus spp.	■	■	■	■	■	■	■	X	X	X	X	X	X	X	·	·	·	·	·	·	·	·	·
9	Chromis spp.	■	■	■	■	■	■	■	X	X	X	X	X	X	X	·	·	·	·	·	·	·	·	·
9	Paranthias furcifer	■	■	■	■	■	■	■	X	X	X	X	X	X	X	·	·	·	·	·	·	·	·	·
9	Clepticus parrai	■	■	■	■	■	■	■	X	X	X	X	X	X	X	·	·	·	·	·	·	·	·	·
10	Thalassoma bifasciatum	■	■	■	■	■	■	■	+	+	+	+	+	+	+	·	·	·	·	·	·	·	·	·
10	Caranx ruber	■	■	■	■	■	■	■	+	+	+	+	+	+	+	·	·	·	·	·	·	·	·	·
10	Kyphosus spp.	■	■	■	■	■	■	■	+	+	+	+	+	+	+	·	·	·	·	·	·	·	·	·
11	Canthidermis sufflamen	■	■	■	■	X	X	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
11	Scarus vetula	■	■	■	■	X	X	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
11	Melichthys niger	■	■	■	■	X	X	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
11	Caranx hippos	■	■	■	■	X	X	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
11	Caranx latus	■	■	■	■	X	X	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
12	Equetus umbrosus	·	·	·	·	·	·	·	+	+	+	+	+	+	+	+	+	+	+	·	·	·	·	·

■ ≥ 0.7	X ≥ 0.5	O ≥ 0.3	+ ≥ 0.1	. < 0.1
VERY HIGH	HIGH	MODERATE	LOW	VERY LOW

Fig. 6-23. Nodal constancy in a two-way table of species groups in depth interval groups, Cruises 3-8, East Flower Garden Bank.

levels of fidelity to Habitat Groups 1 and 2 (coral reef, both high and low diversity) was exhibited by Species Groups 5, 8, 9 and 10. These along with Species Group 11 comprise the principle, coral-reef-dependent assemblage of fishes. The only other species groups to exhibit moderate fidelity to a habitat were Species Group 1 for soft-bottom habitat and Species Group 7 for depths between 85 and 105 m in depth (Fig. 6-24).

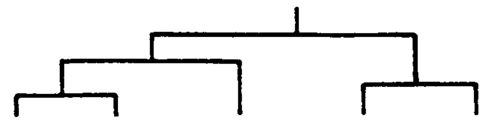
DIVERSITY ($\hat{H}'$) AND EVENNESS ($\hat{V}'$) ON THE EAST FLOWER GARDEN BANK

Diversity ($\hat{H}'$) on the East Flower Garden Bank varied from cruise to cruise but generally decreased with depth. Values ranged from a high of 2.47 to a low of 0.53. Figure 6-25, based on $\hat{H}'$ computed from density figures, illustrates diversity by depth, interpolating across depth strata where no fish were seen (and $\hat{H}'$ was, therefore, not possible to calculate). Points on either side of interpolated points are marked to emphasize that the intervening values are interpolated rather than actual $\hat{H}'$ values. Figure 6-25 gives the impression that $\hat{H}'$ fluctuated sharply between high values and low values in mid-depth; this is thought to be due to the arbitrary division of observations into 5-m increments.

Smoothed curves (Fig. 6-26) were produced for $\hat{H}'$ in order to minimize this effect (which could have reflected aliasing, i.e. falsely-perceived periodicity due to interference-phased effects caused by superposition of sampling intervals upon natural cycles that are unknown at the time of data collection), and to broaden the depth increments. The smoothed curves were generated by interpolating across undefined values for $\hat{H}'$ and $\hat{V}'$ (i.e. depth intervals at which no fish were seen) and then calculating 3-point moving averages for the values in Figure 6-25. The smoothed curves show the same gradual decrease in $\hat{H}'$ with depth.

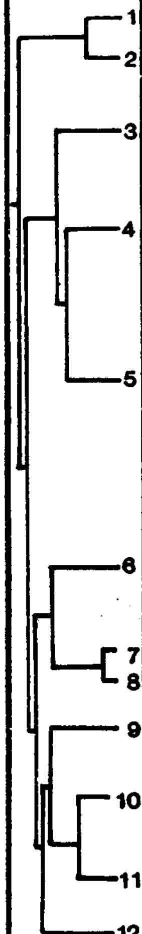
Evenness ($\hat{V}'$) on the East Flower Garden Bank also varied from cruise to cruise, but generally showed a gradual increase with depth (the converse of that observed for $\hat{H}'$) (Fig. 6-27). Figure 6-27 is based on $\hat{V}'$ computed from density figures, and contains interpolated values (between marked dots), as for $\hat{H}'$. Values ranged from a high of 1.0 to a low of 36. Understandably, the highest $\hat{V}'$ values are associated with the collections of the fewest fish belonging to the least numbers of taxa (e.g. three fish belonging to three different taxa produce a $\hat{V}' = 1.0$). Figure 6-27 gives

FIDELITY



DEPTH (meters)

Species group	SPECIES	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-64	70-74	75-79	80-84	85-89	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129
	Depth interval group	1	1	1	1	2	2	2	3	3	3	3	3	3	3	4	4	4	4	5	5	5	5	5
1	Family Serranidae (small,without bars)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	0	0	X	X	X	X	X
1	Family Ogcocephalidae	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	0	0	X	X	X	X	X
1	Family Bothidae	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	0	0	X	X	X	X	X
1	Prionotus spp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	0	0	X	X	X	X	X
2	Family Serranidae	.	.	.	.	.	.	.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Chaetodon sedentarius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.
3	Mycteroperca spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.
3	Bodianus pulchellus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.
3	Chromis/Pomacentrus spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.
3	Mulloidichthys martinicus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.
3	Haemulon melanurum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.
4	Pseudupeneus maculatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.
4	Calamus nodosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.
4	Centropyge argi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.
4	Holocentrus spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.
4	Holacanthus spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.
5	Sphyraena barracuda	X	X	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5	Seriola rivoliana	X	X	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5	Scarus/Sparisoma spp.	X	X	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5	Scarus taeniopterus	X	X	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5	Acanthurus spp.	X	X	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5	Sparisoma viride	X	X	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5	Holacanthus tricolor	X	X	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5	Family Labridae	X	X	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5	Bodianus rufus	X	X	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5	Pomacanthus paru	X	X	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5	Pomacentrus partitus	X	X	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6	Lutjanus campechanus	.	.	.	.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.
6	Priacanthus arenatus	.	.	.	.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.
6	Serranus phoebe	.	.	.	.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.
6	Rhomboplites aurorubens	.	.	.	.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.
6	Seriola dumerili	.	.	.	.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.
6	Caranx crysos	.	.	.	.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.
6	Pagrus sedecim	.	.	.	.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.
7	Family Serranidae (Pikea/Hemanthias)	.	.	.	.	.	.	.	0	0	0	0	0	0	0	X	X	X	X	.	.	.	.	.
7	Holanthias martinicensis	.	.	.	.	.	.	.	0	0	0	0	0	0	0	X	X	X	X	.	.	.	.	.
8	Chromis enchrysurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.
9	Pomacentrus spp.	X	X	X	X	X	X	X	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.
9	Chromis spp.	X	X	X	X	X	X	X	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.
9	Paranthias furcifer	X	X	X	X	X	X	X	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.
9	Clepticus parrai	X	X	X	X	X	X	X	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.
10	Thalassoma bifasciatum	X	X	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10	Caranx ruber	X	X	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10	Kyphosus spp.	X	X	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11	Canthidermis sufflamen	■	■	■	■	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11	Scarus vetula	■	■	■	■	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11	Melichthys niger	■	■	■	■	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11	Caranx hippos	■	■	■	■	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11	Caranx latus	■	■	■	■	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12	Equetus umbrosus	.	.	.	.	.	.	.	X	X	X	X	X	X	X	0	0	0	0	.	.	.	.	.



■ ≥ 3 HIGH   X ≥ 2 MODERATE   0 ≥ 1 LOW   . < 1 NEGATIVE

Fig. 6-24. Nodal fidelity in a two-way table of species groups in depth interval groups, Cruises 3-8, East Flower Garden Bank.

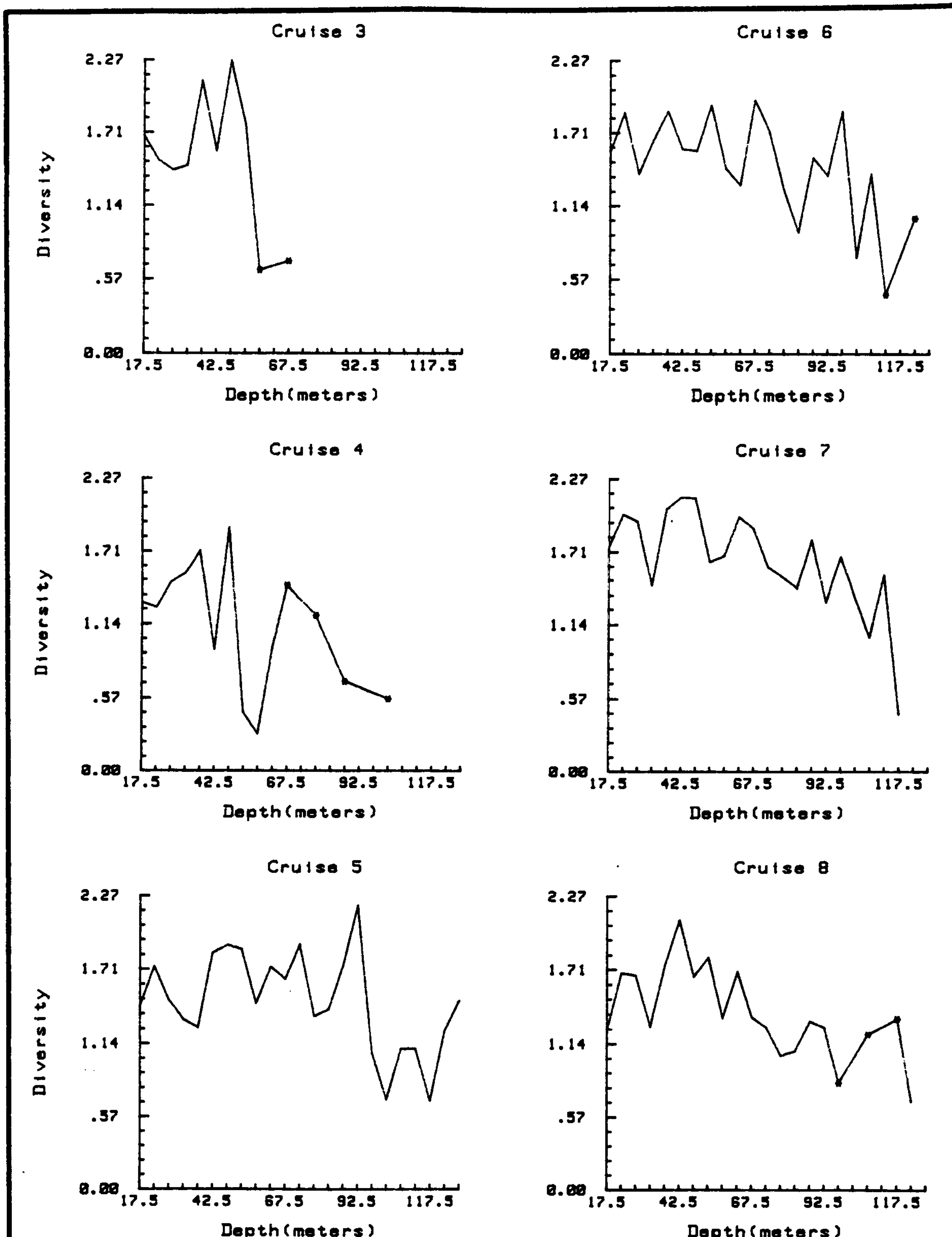


Fig. 6-25. Diversity (Ĥ') by depth, Cruises 3-8, East Flower Garden Bank. Values between dots are interpolated.

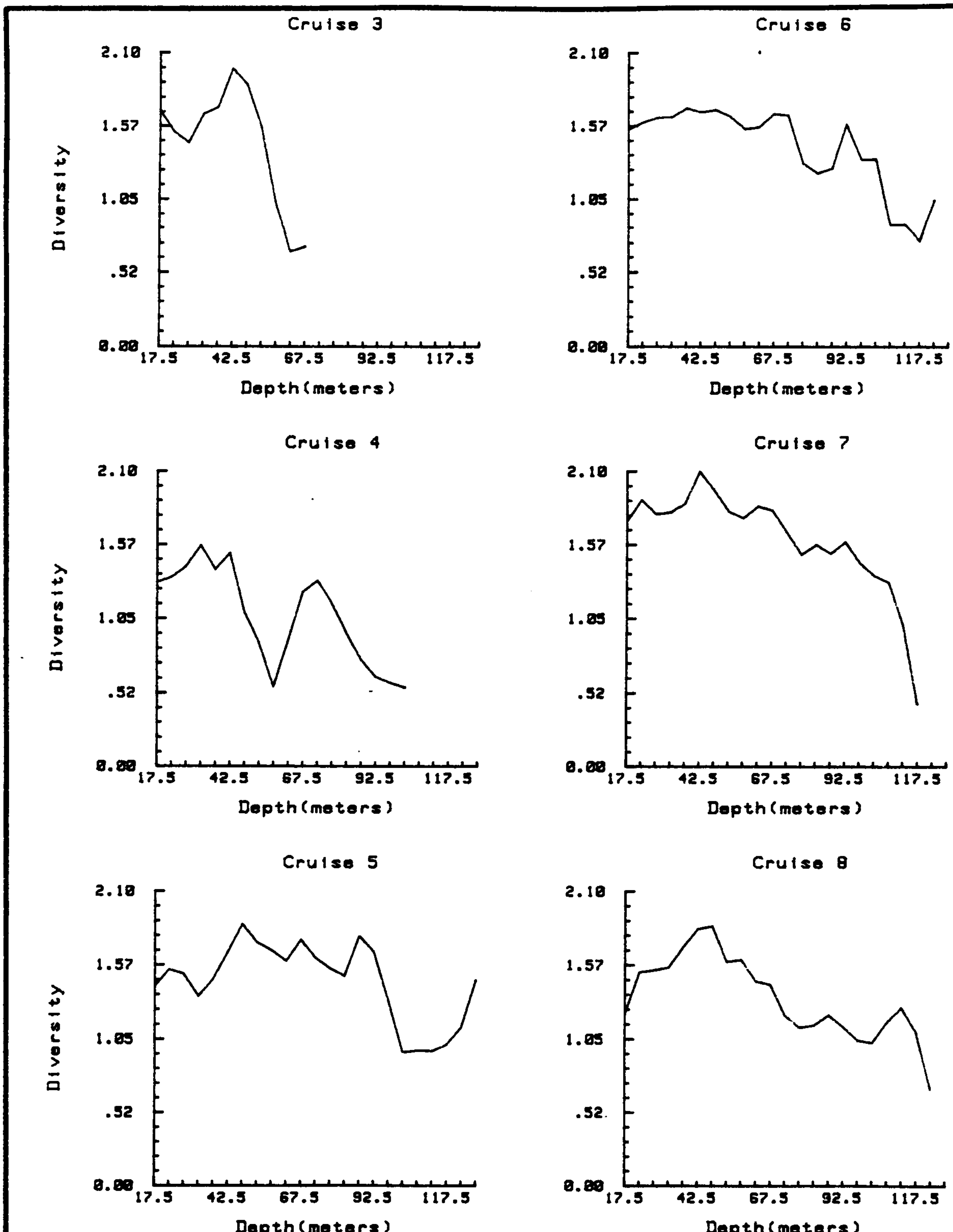


Fig. 6-26. Smoothed diversity ($\hat{H}'$) by depth for Cruises 3-8, East Flower Garden Bank.

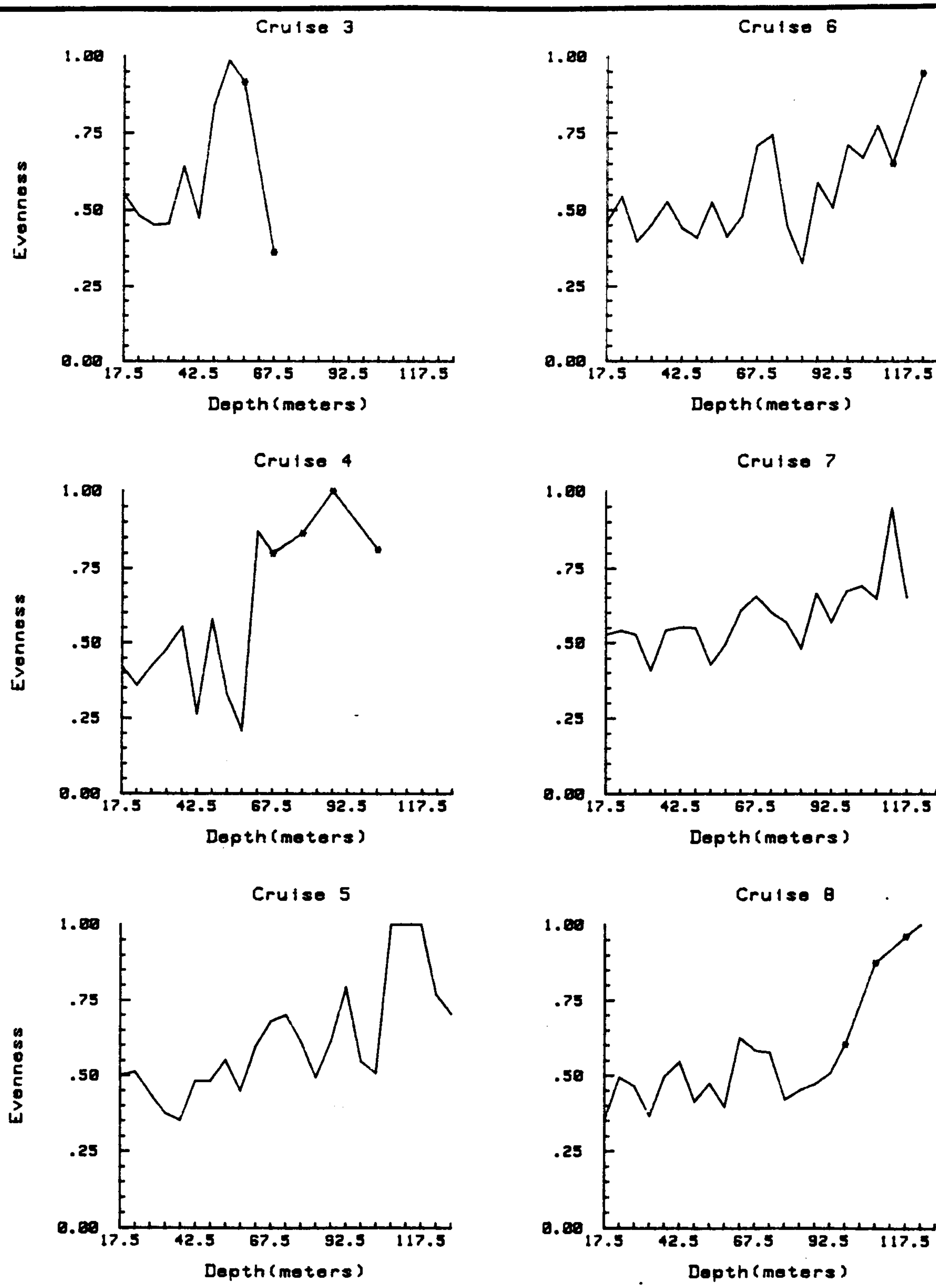


Fig. 6-27. Evenness ($\hat{V}'$) by depth, Cruises 3-8, East Flower Garden Bank. Values between dots are interpolated.

the impression that $\hat{V}'$ fluctuated rapidly between high values and low values, for the same reason given above. Figure 6-28, a smoothed version of Figure 6-27, illustrates a 3-point moving average for $\hat{V}'$, and similarly indicates a gradual increase in evenness with depth or fairly constant values with depth, depending on the cruise.

Diversity and evenness varied substantially from one habitat type to the next (Figs. 6-29 and 6-30). Table 6-7 lists the averages of $\hat{H}'$ and $\hat{V}'$ cruise means by habitat type, in order of decreasing area surveyed. $\hat{H}'$ and $\hat{V}'$ are tabulated by habitat type and cruise number in Table 6-8, and the number of taxa identified in each habitat type are listed on a cruise-by-cruise basis in Table 6-9. Where no fish were sighted, $\hat{H}'$ and $\hat{V}'$ were not calculated since the indices are undefined for zero densities (e.g. for Habitat Type 5 [Deep Transition Zone], although over 27,040 m^2 were surveyed).

Habitat Type 4 (Transition Zone) had the highest average values for both $\hat{H}'$ and $\hat{V}'$ (1.94 and 0.84, respectively), even though only 26 taxa were identified there. Habitat Type 1 (Coral Reef Bank), and Habitat Type 72 (Shallow Drowned Reef), with 89 and 85 taxa, respectively, both had just slightly lower $\hat{H}'$ values (1.92 and 1.90), ranking second and third overall in average diversity. Coral Reef Bank and Shallow Drowned Reef had much lower $\hat{V}'$ values (0.47 and 0.56), however, ranking sixth and fifth overall. The lowest mean diversity ($\hat{H}'$ = 1.05) was seen for Habitat Type 2, Coral Rubble and Detritus, where only seven taxa were identified (the least for any of the habitat types where fish were seen). As mentioned above, evenness values tended to be inversely proportional to the number of taxa present; mean $\hat{V}'$ for Habitat Type 2 was 0.94, the highest recorded. Similarly, $\hat{V}'$ for Habitat Type 4 was the second highest, while the number of taxa in Habitat Type 4 was second lowest.

Statistical comparisons have not been made between habitat types for diversity and evenness indices. Numerous studies have shown that community summary indices such as diversity and evenness can rarely be compared meaningfully between different habitat types or for different groups of species (see Boesch 1977, and Gonor and Kemp 1978 for reviews) even though the indices may be corrected for unequal numbers of individuals. This may be verified subjectively by reference to Table 6-6 and 6-8, which emphasize that both $\hat{H}'$ and $\hat{V}'$ are relatively independent of

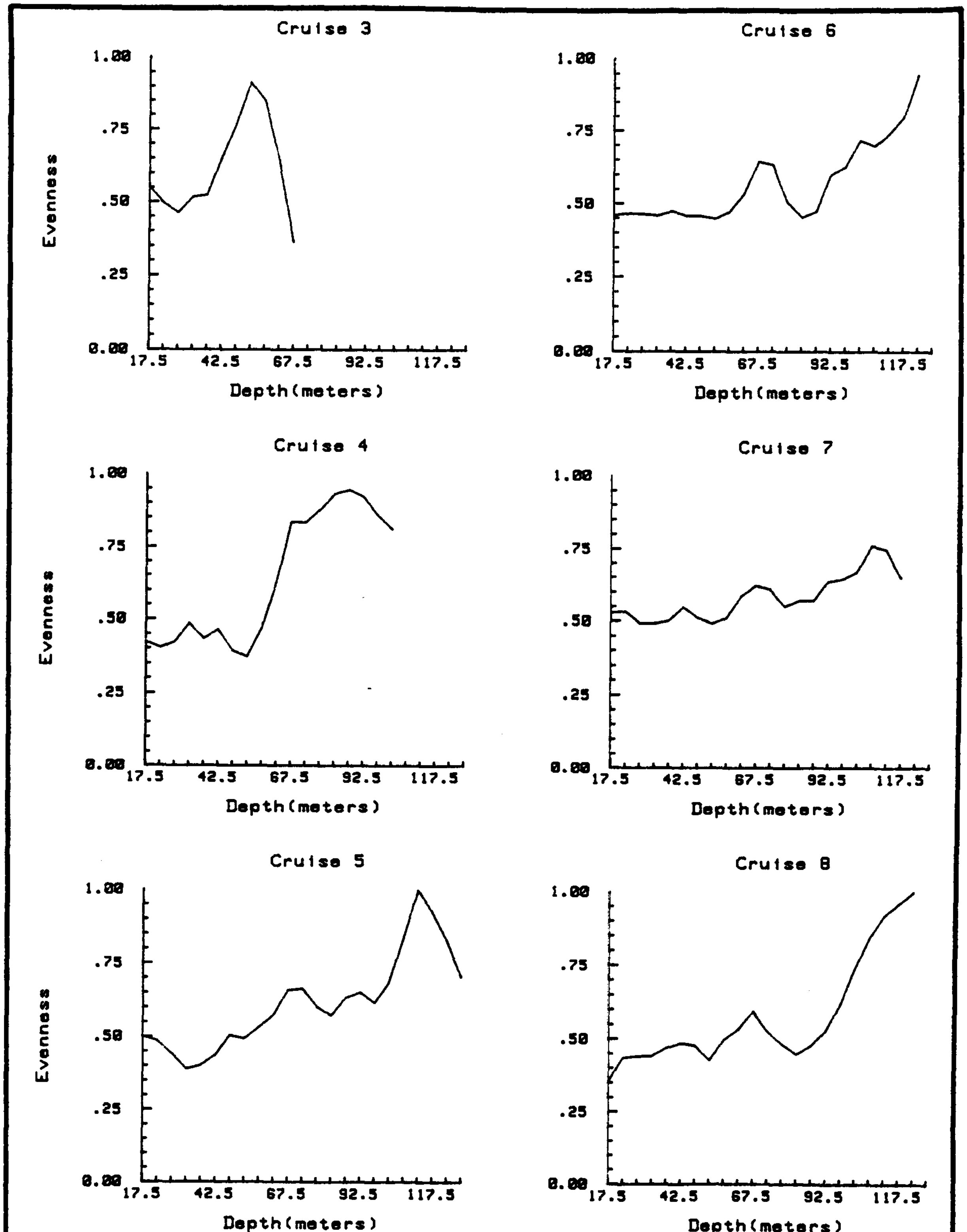


Fig. 6-28. Smoothed evenness ($\hat{V}'$) by depth, Cruises 3-8, East Flower Garden Bank.

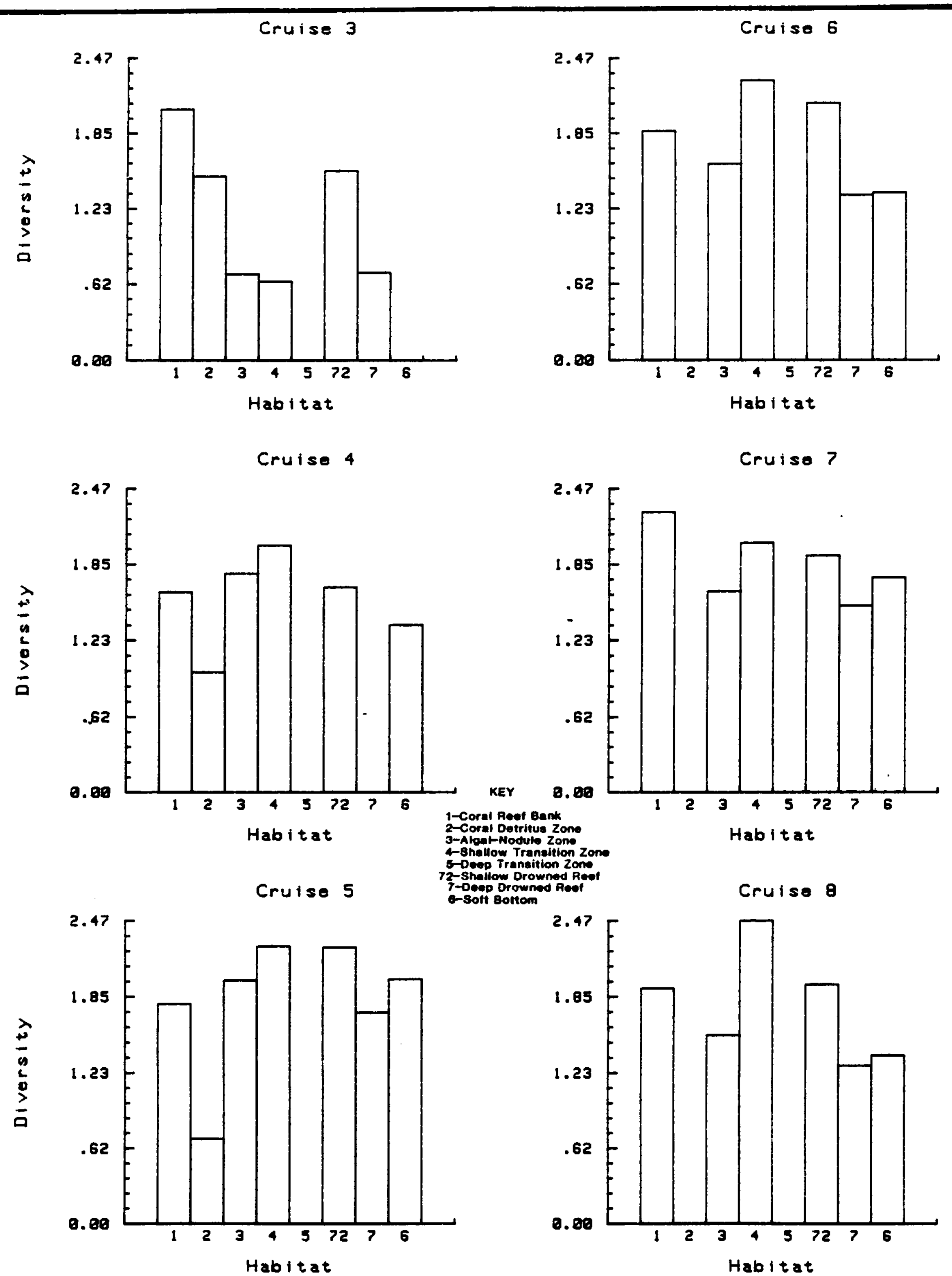


Fig. 6-29. Diversity ($\hat{H}'$) by habitat type, Cruises 3-8, East Flower Garden Bank.

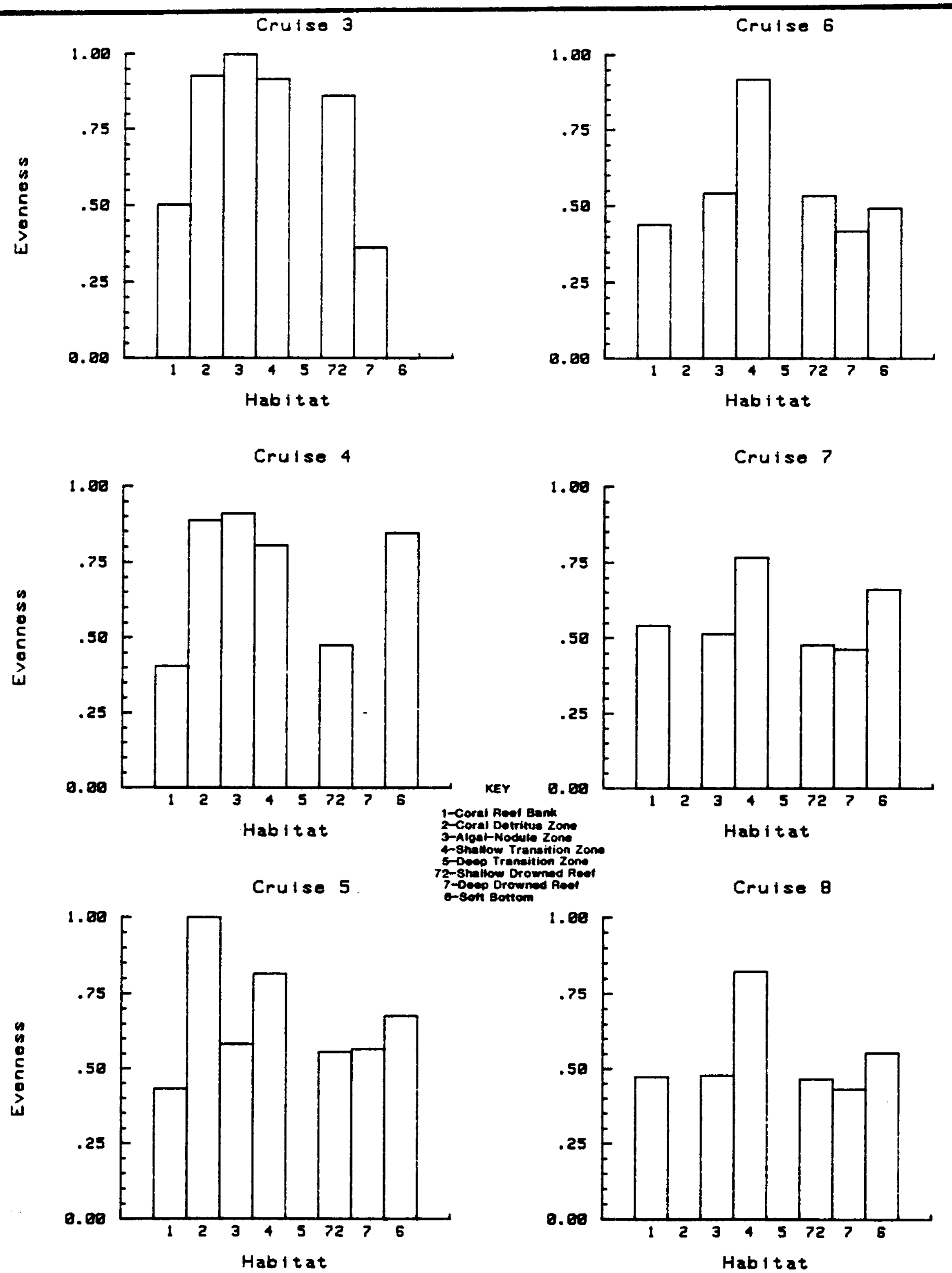


Fig. 6-30. Evenness ($\hat{V}'$) by habitat type, Cruises 3-8, East Flower Garden Bank.

Table 6-7. Diversity ($\hat{H}'$) and evenness ($\hat{V}'$), by habitat type for combined Cruises 3-8, East Flower Garden Bank.

Habitat Type*	Area Transected/ Cruise (mean, m^2)	$\hat{H}'$ (mean)	$\hat{V}'$ (mean)
1	64,458	1.92	0.47
72	51,354	1.90	0.56
3	43,647	1.54	0.67
4	19,125	1.94	0.84
6	15,653	1.57	0.64
7	5,627	1.31	0.45
2	1,120	1.05	0.94

*Habitat Type Key: 1 Coral Reef Bank; 2 Coral Detritus Zone; 3 Algal-Nodule Sponge Zone; 4 Shallow Transition Zone; 5 Deep Transition zone; 72 Shallow Drowned Reef; 7 Deep Drowned Reef; 6 Soft Bottom.

Table 6-8. Diversity ($\hat{H}'$) and evenness ($\hat{V}'$) by habitat type and cruise number, East Flower Garden Bank. (Blanks indicate no fish were seen and therefore $\hat{H}'$ and $\hat{V}'$ were not calculated.)

Diversity ($\hat{H}'$)

Habitat Type*	Cruise 3	4	5	6	7	8	Mean	Min	Max
1	2.05	1.62	1.79	1.87	2.28	1.92	1.92	1.62	2.28
2	1.49	0.97	0.69	-	-	-	1.05	0.69	1.49
3	0.69	1.77	1.98	1.60	1.63	1.54	1.54	0.69	1.98
4	0.64	2.00	2.26	2.28	2.02	2.47	1.94	0.64	2.47
5	-	-	-	-	-	-	-	-	-
6	-	1.36	1.99	1.36	1.74	1.38	1.57	1.36	1.99
7	0.71	-	1.72	1.34	1.51	1.29	1.32	0.71	1.72
72	1.54	1.66	2.25	2.10	1.92	1.95	1.90	1.54	2.25

Evenness ($\hat{V}'$)

Habitat Type*	Cruise 3	4	5	6	7	8	Mean	Min	Max
1	0.50	0.40	0.43	0.44	0.54	0.47	0.47	0.40	0.54
2	0.93	0.89	1.00	-	-	-	0.94	0.89	1.00
3	1.00	0.91	0.58	0.54	0.51	0.48	0.67	0.48	1.00
4	0.92	0.81	0.82	0.92	0.77	0.82	0.84	0.77	0.92
5	-	-	-	-	-	-	-	-	-
6	-	0.84	0.68	0.49	0.66	0.55	0.65	0.49	0.84
7	0.36	-	0.57	0.42	0.46	0.43	0.45	0.36	0.57
72	0.86	0.48	0.56	0.53	0.48	0.46	0.56	0.46	0.86

*Habitat Type Key: 1 Coral Reef Bank; 2 Coral Detritus Zone; 3 Algal-Nodule Sponge Zone; 4 Shallow Transition Zone; 5 Deep Transition Zone; 72 Shallow Drowned Reef; 7 Deep Drowned Reef; 6 Soft Bottom.

Table 6-9. Number of fish taxa identified by habitat type and cruise number, East Flower Garden Bank.

Habitat Type*	Cruise 3	4	5	6	7	8	Total
1	55	50	59	65	62	60	89
2	5	3	2	0	0	0	7
3	2	7	29	19	24	29	48
4	2	9	9	10	11	13	26
5	0	0	0	0	0	0	0
6	1	5	18	14	13	11	32
7	7	0	21	24	26	20	41
72	6	32	55	49	53	64	85
TOTAL	79	68	92	90	93	93	127

*Habitat Type Key: 1 Coral Reef Bank; 2 Coral Detritus Zone; 3 Algal-Nodule Sponge Zone; 4 Shallow Transition Zone; 5 Deep Transition Zone; 72 Shallow Drowned Reef; 7 Deep Drowned Reef; 6 Soft Bottom.

the number of species present. While this community-independent feature of diversity and evenness indices is usually considered a desireable trait, it can lead to intuitive disparities between index values and typical usage. The term "diversity" is frequently used indiscriminately to describe habitats in a qualitative fashion (e.g., coral reefs are often called "highly diverse"), whatever their $\hat{H}'$ or $\hat{V}'$ values.

Although $\hat{H}'$ and $\hat{V}'$ calculations were based upon densities, which should produce comparable, area-independent estimates of fish abundance, the likelihood of seeing a large number of species has been shown to increase asymptotically with increasing area surveyed or numbers of individuals collected (e.g. Sanders 1968). This could lead to artificially low $\hat{H}'$ values if the area surveyed is well below the asymptotic portion of a species/area curve but the effect would be very difficult to quantify except by rarefaction analysis and/or complete defaunation (not possible in this program). Nonetheless, a test for internal consistency was performed in order to confirm the theoretical demonstration of Lyons (1981) that using weighted or scaled counts in most data sets should not affect diversity statistics, which are asymptotically normally distributed. There was not a statistically significant correlation between area surveyed and $\hat{H}'$ computed from densities (Tau, $p > 0.10$), nor was there a significant correlation between area surveyed and $\hat{V}'$. The lack of correlation indicated that normalizing abundance and computing $\hat{H}'$ and $\hat{V}'$ from density was probably a reasonable way to handle the data. Had there been a statistically significant correlation between area surveyed and either $\hat{H}'$ or $\hat{V}'$, the use of normalized values would not have been valid.

Only two habitat types (Coral Reef Bank and Deep Drowned Reef) showed statistically significant differences ($p < 0.05$) in diversity across cruises, and no significant differences in evenness were seen. Not all habitat types could be tested for all cruises, since the numbers of replicates varied greatly depending on the path of each transect. $\hat{H}'$ for Habitat Type 1 (Coral Reef Bank) did not differ significantly between Cruises 3, 5, 6, 7, and 8, nor between 3, 4, 6, and 8. The only differences in $\hat{H}'$ for Habitat Type 1 were for Cruise 4 (summer) vs. Cruises 5 (fall) and 7 (summer) . $\hat{H}'$ for Habitat Type 7 (Deep Drowned Reef) did not differ significantly between Cruises 4, 5, 6, and 7, nor between 6; 7, and 8. The only differences in H' for Habitat Type 7 were between Cruises 8 (fall) vs. 4 (summer) and 5 (fall). In other words, there was no evidence that pre- vs. post-drilling diversity and evenness indices for fishes in all habitat types on the East Flower Garden Bank differed significantly, nor was there any evidence of seasonal variability in either H' or V'.

TAXA ACCOUNTS

Individual accounts are provided below for 16 of the 141 distinct fish taxa observed during the course of the remote sensing effort. These taxa were selected based upon either their numerical abundance, fidelity to a habitat and/or their direct value to man (e.g. red snapper). In each account we first provide some background information about the taxon with regards to its distribution, food habits, etc., drawing largely from Randall (1968), Hoese and Moore (1977) and Bohlke and Chaplin (1968). This introductory material is followed by a description of the seasonal distribution patterns on the East Flower Garden Bank with regard to depth and habitat type. Summaries of density levels for all species by habitat type and depth are provided in Appendices 6-6 and 6-7, respectively. The distributional patterns are based upon data obtained during Cruises 3-8. Of these, Cruises 3 (April), 4 (July) and 5 (October-November) represent a 1981 baseline prior to any drilling activity adjacent to the East Flower Garden Bank. Cruises 6 (April-May), 7 (July-August) and 8 (October) represent corresponding periods of 1982 during which drilling activities were being conducted.

In the graphics depicting density distributions by habitat type, the numerical codes are used to designate the specific habitat types. In review, the codes and corresponding habitat types are:

1 - Coral Reef Bank	5 - Deep Transition Zone
2 - Coral Detritus Zone	72 - Shallow Drowned Reef
3 - Algal-Nodule Sponge Zone	7 - Deep Drowned Reef
4 - Shallow Transition Zone	6 - Soft Bottom

Following the descriptions of the observed distributions, we provide an estimate of the total standing stock of the taxa on the bank for each of Cruises 5-8, all characterized by having large sample sizes. Whereas the number of replicates obtained for Cruises 3 and 4 were (with some exceptions) generally adequate for ANOVA purposes, they were typically of insufficient numbers to allow for the numerical maximization procedures involved in deriving the maximum likelihood population estimates. The total standing stock estimates were obtained by summing the maximum likelihood estimates for each habitat used in a major way by the taxa in question. The individual estimates for each habitat and corresponding 95% confidence intervals upon which the standing stock estimates are based are presented in Appendix 6-8. A total of 132 individual population estimates were made. Of these, 46 estimates (35%) had 95% confidence intervals between 10 to 50% of the maximum likelihood estimate. An additional 30 estimates (23%) had 95% confidence intervals ranging between 50 to 75% of the maximum likelihood estimate.

The final section of each account represents an impact assessment. Results of ANOVA comparing densities observed in each important habitat during 1981 to those observed in the same habitat during 1982 are first described, and are then supplemented by comparisons of densities on an areal basis (see Fig. 3-11 for quadrat array) to determine if any observed changes in abundance appeared related to the presence of the drilling platform (see Appendix 6-9 for discussion and results of ANOVA's).

We begin with the serranids, the numerically-dominant group of fishes on the banks, which are followed by descriptions for an array of species roughly ordered by high to low densities starting with the shallow habitats and proceeding down the reef.

Creole-fish (*Paranthias furcifer*)

The creole-fish, the only representative of the genus *Paranthias*, is a small (maximum length about 30 cm) grouper which is quite different from other groupers in both appearance and habitats. In the western Atlantic, it is known from Bermuda to Florida, the Gulf of Mexico, throughout the Antilles and Panama to Brazil. In the Pacific, it is found from lower California to Peru and around the Galapagos Islands. Creole-fish are typically associated with reefs and are seen either singly or in aggregations, swimming close to or within a few meters of the substrate.

Creole-fish are planktivorous. They feed while hovering above the reef, chasing each food organism individually (Randall 1967). Randall (1967) found that 67% of the food volume taken by creole-fish was represented by copepods. Likewise, the principle food of creole-fish at the Flower Gardens was found to have been calanoid copepods, although a variety of other foods were also taken (Russell Nelson, NMFS, Beaufort, N.C., pers. comm. 1983).

Seasonal Abundance and Distribution - The creole-fish was strongly associated with Upper Coral Reef Habitat, although it was commonly encountered in relatively low densities in Shallow Drowned Reef Habitats (Fig. 6-31). Only occasionally was it observed over the Algal-Nodule Sponge Zone or in Deep Drowned Reef Habitat. Overall, creole-fish were observed between depths of 17-80 m, but peak densities were generally observed at 25- to 30-m depths (Fig. 6-32). Secondary density peaks between 60- and 80-m depths shown on Figure 6-32 reflect the occurrence of creole-fish in Shallow Drowned Reef Habitat.

Peak densities of creole-fish in Upper Coral Reef Habitat occurred during summer of 1981 (Cruise 4) and during fall of 1982 (Cruise 8). The density level observed during Cruise 4 was significantly higher ($\alpha = 0.05$) than was observed for any other cruise, and densities measured during Cruise 8 were significantly greater ($\alpha = 0.05$) than levels observed during Cruises 5, 6 and 7. Within Shallow and Deep Drowned Reef Habitats, variation in density levels among cruises was not significantly different.

Based upon data for the two years combined, densities of creole-fish in Upper Coral Reef Habitat were significantly greater ($\alpha = 0.01$) in summer than in the spring and fall seasons, with the latter seasons being not significantly different from each other. In contrast, density in Shallow Drowned Reef Habitat was significantly higher ($\alpha = 0.01$) in fall than in spring but no other significant differences were observed (Appendix 6-9). No significant seasonal differences in creole-fish density levels were observed for Deep Drowned Reef Habitat.

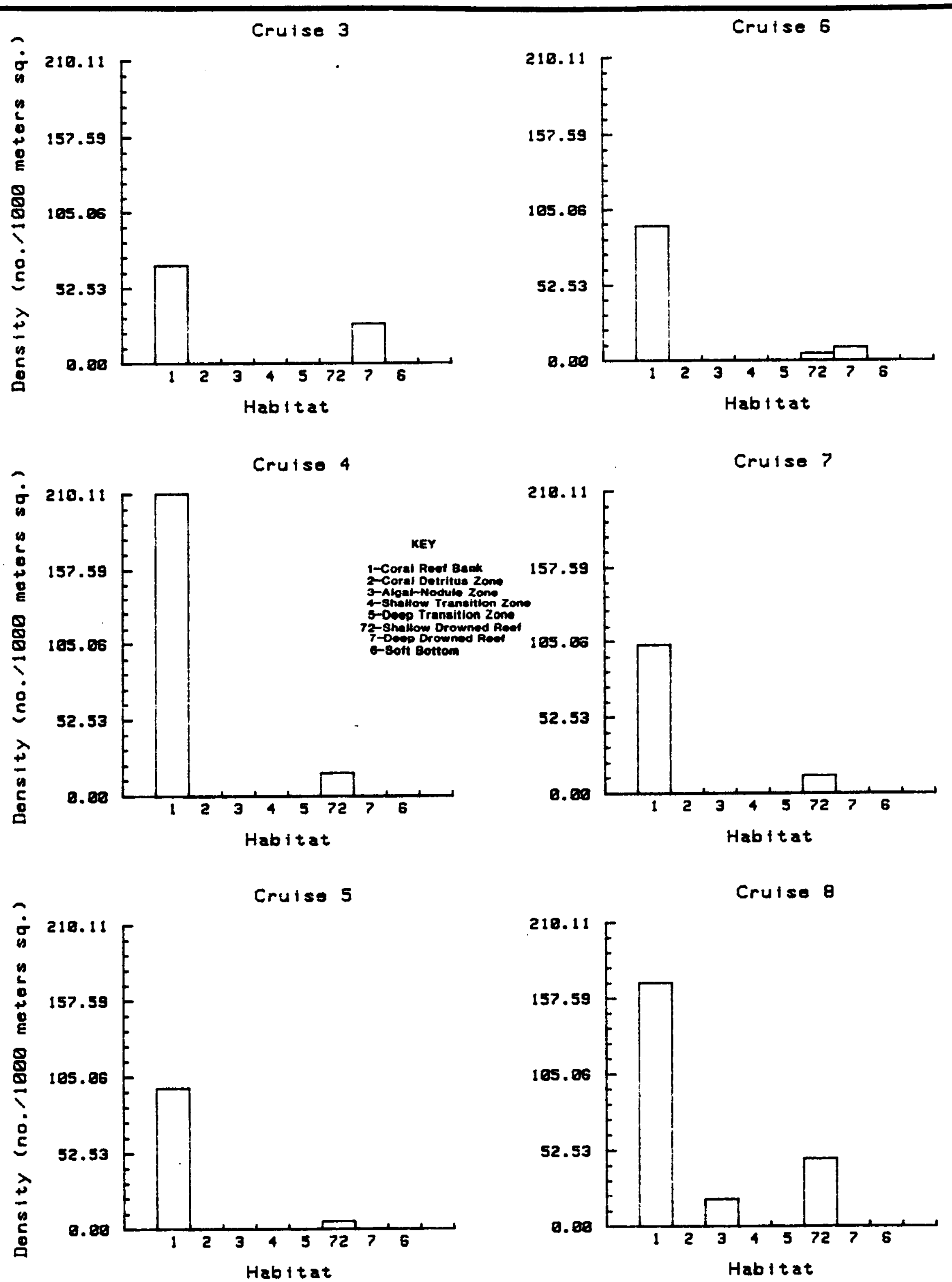


Fig. 6-31. Raw density by habitat for <u>Paranthias furcifer</u>, creole-fish. Cruises 3-8 East Flower Garden Bank.

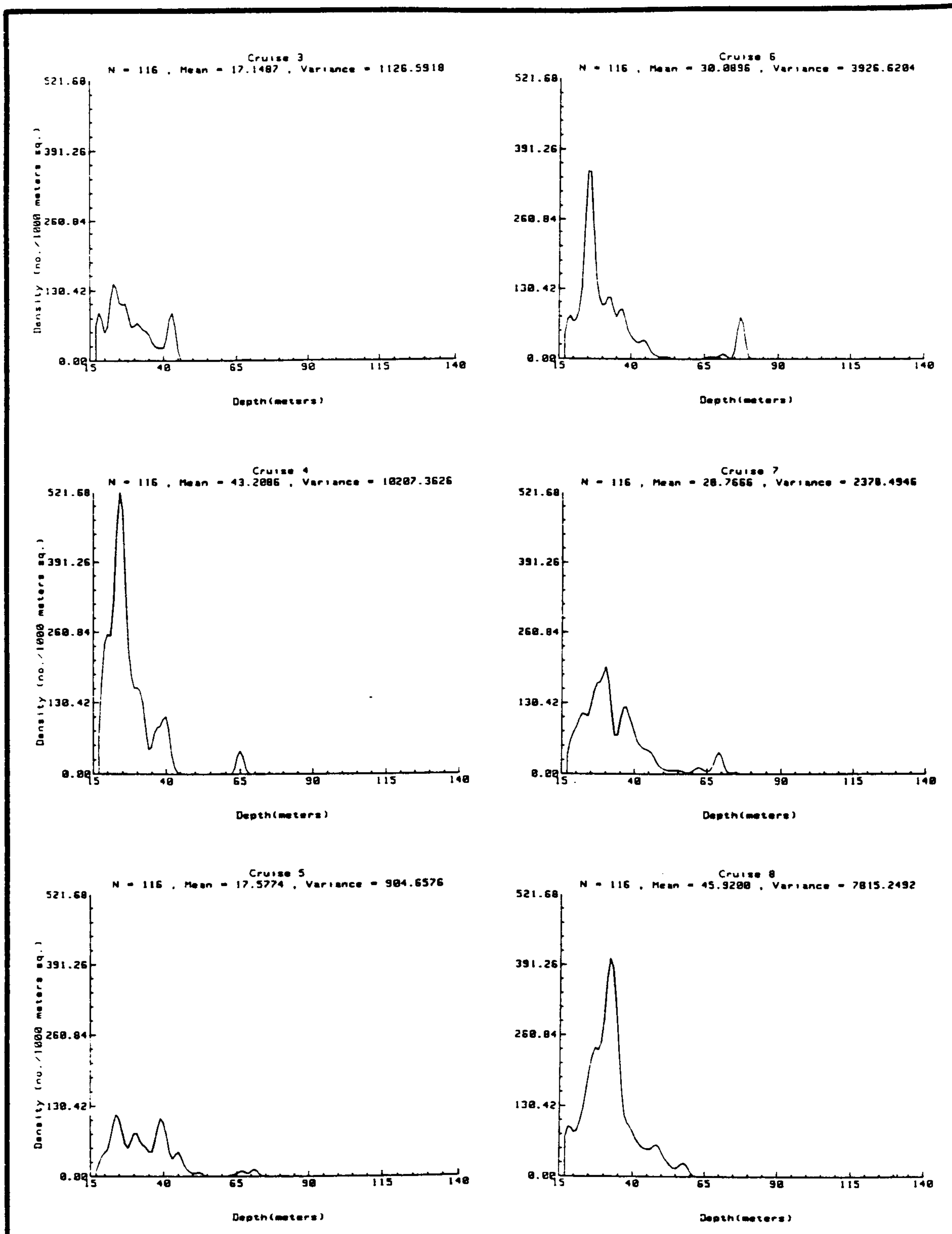


Fig. 6-32. Raw density by depth for Paranthias furcifer, creole-fish. Cruises 3-8 East Flower Garden Bank.

Standing Stocks - The density measures obtained during Cruises 5-8 were used to estimate standing stocks of creole-fish during these periods (Fig. 6-33; also see Appendix 6-8). Standing stock levels were relatively constant from fall 1981 through summer 1982, ranging from 442,441 to 531,964 fish. The population then increased to some 993,948 fish in fall 1982. Based upon the density estimates, an even greater standing stock of creole-fish was likely present during the summer of 1981 than was evident during fall of 1982. These data suggest that recruitment of creole-fish at the Flower Garden Banks occurs as a short-term pulse which is followed by a period of high mortality. The population apparently returns to an equilibrium level within a month or so following recruitment, and this level is maintained over the balance of the year until the next recruitment period. Recruitment of creole-fish apparently occurs during either summer or fall periods.

Mean lengths of fish in the samples are also shown on Figure 6-33. We do not believe the samples of measured fish to have been large enough to be certain that they are representative of the population. However, the decrease in mean length associated with the increase in population size that occurred between summer and fall 1982 does suggest recruitment.

Impact Assessment - Results of ANOVA's comparing creole-fish abundance between 1981 (baseline) and 1982 (treatment) periods showed no significant differences in the annual abundance levels in Deep Drowned Reef Habitat, significantly ($\alpha = 0.05$) higher abundance during 1982 than in 1981 in Shallow Drowned Reef Habitat and significantly ($\alpha = 0.01$) higher abundance in 1981 than in 1982 in Upper Coral Reef Habitat (Appendix 6-9). Further, there were no significant differences in abundance among spatial areas or quadrats within any of the habitats or seasons tested. Based upon these results and the upper water column distributional pattern of creole-fish, we conclude that the observed changes in abundance were little, if any, associated with the bottom-water discharge of drill muds and cuttings.

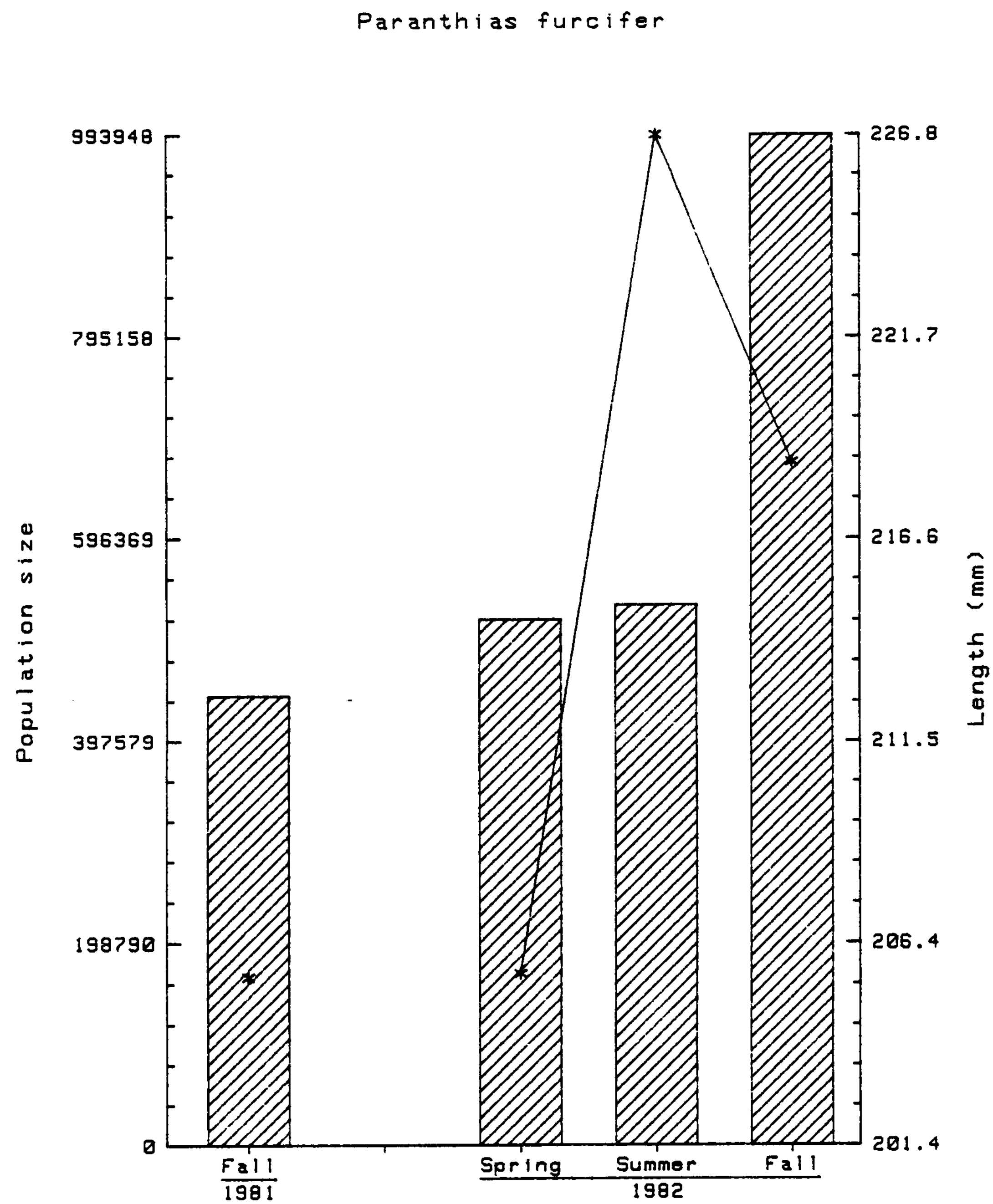


Fig. 6-33. Standing stock and mean length* estimates for creole-fish, Paranthias furcifer, East Flower Garden Bank.

Groupers (*Mycteroperca* spp.)

Mycteropercid groupers range from moderate to large in size. In appearance, the dorsal profile is more strongly arched than the ventral. Caudal fins are square or lunate. There are 13 American species of *Mycteroperca* of which eight occur in the western Atlantic (Smith 1971). All are highly prized as food and/or sports fish.

Atlantic species of *Mycteroperca* have been divided into two weakly differentiated species groups (Smith 1971). Species within each group are closely related and closely resemble each other. On the Flower Garden Banks, the principal species represented were the scamp, *Mycteroperca phenax*, and the yellowmouth grouper, *M. interstitialis*. Based upon collections, both of these species were common on the banks, but it was impossible to differentiate between them based upon video images. Also included in this grouping, but comprising only a small part of the data, were two relatively rare species, the black grouper, *M. bonaci*, and tiger grouper, *M. tigris*, not previously reported from the Flower Gardens.

Mycteropercid groupers are strongly stereotactic with a requirement for cover like most other groupers. They are seldom seen far from a hole or crevice in which they seek shelter at the approach of danger. These species are typically solitary but several individuals may occur together in a small area. Breeding aggregations comprised of very large numbers of epinephelids have been observed on occasion (Smith 1972), but were not seen in this study.

Seasonal Abundance and Distribution - Although mycteropercid groupers were observed in every habitat with the exception of the Deep Transition Zone (Habitat Type 5), they were most commonly associated with the Upper Xoral Reef, Shallow Drowned Reef and Deep Drowned Reef Habitats (Fig. 6-34). Typically the highest density levels were observed in Deep Drowned Reef Habitats. Density by depth patterns were highly variable, but in general highest densities were observed at depths below 40 m, excepting Cruises 3 and 4 (Fig. 6-35). The observed habitat and depth differences are likely related, in large part, to distributional differences among the individual species lumped within this taxonomic grouping.

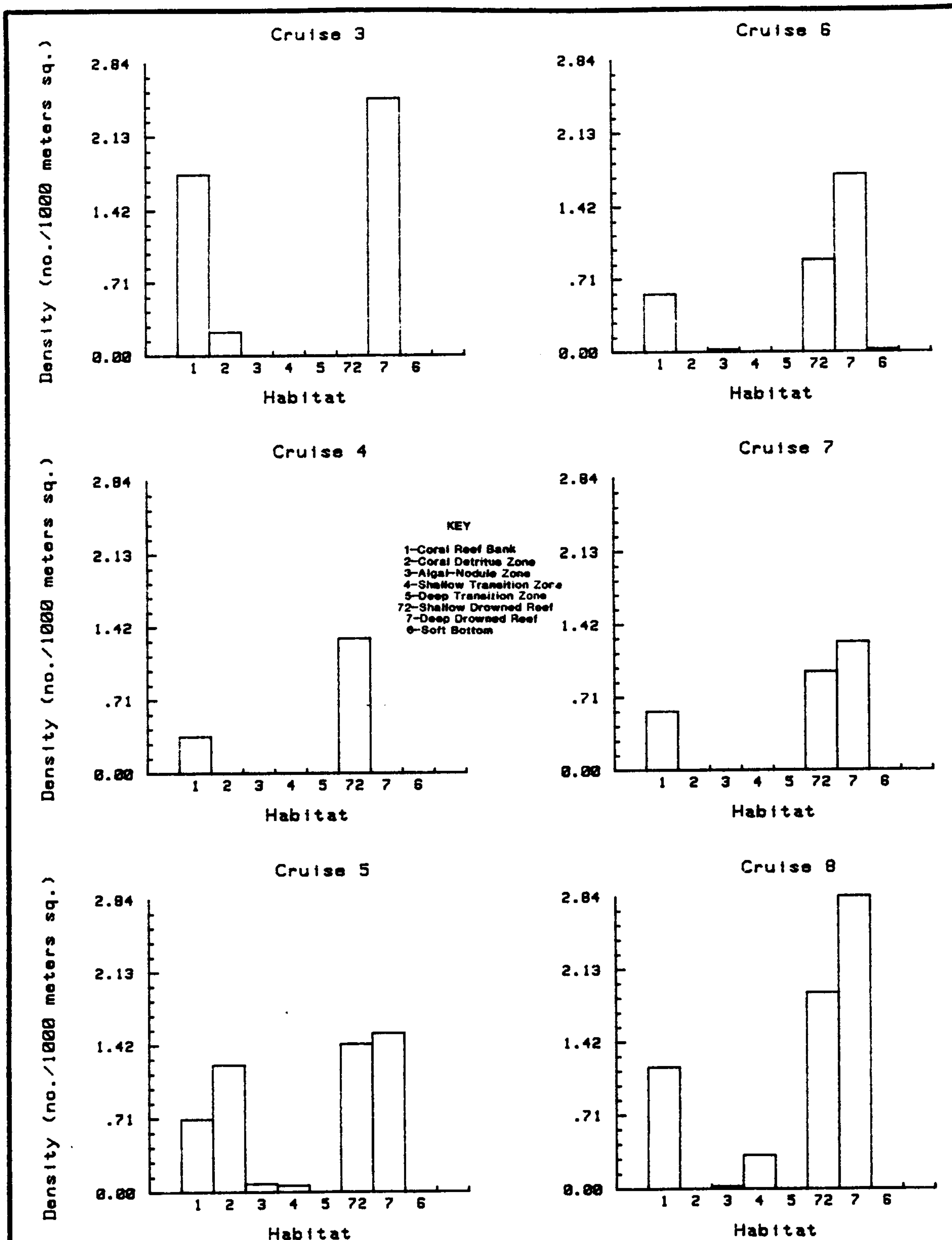


Fig. 6-34. Raw density by habitat for *Mycteroperca* spp., groupers. Cruises 3-8 East Flower Garden Bank.

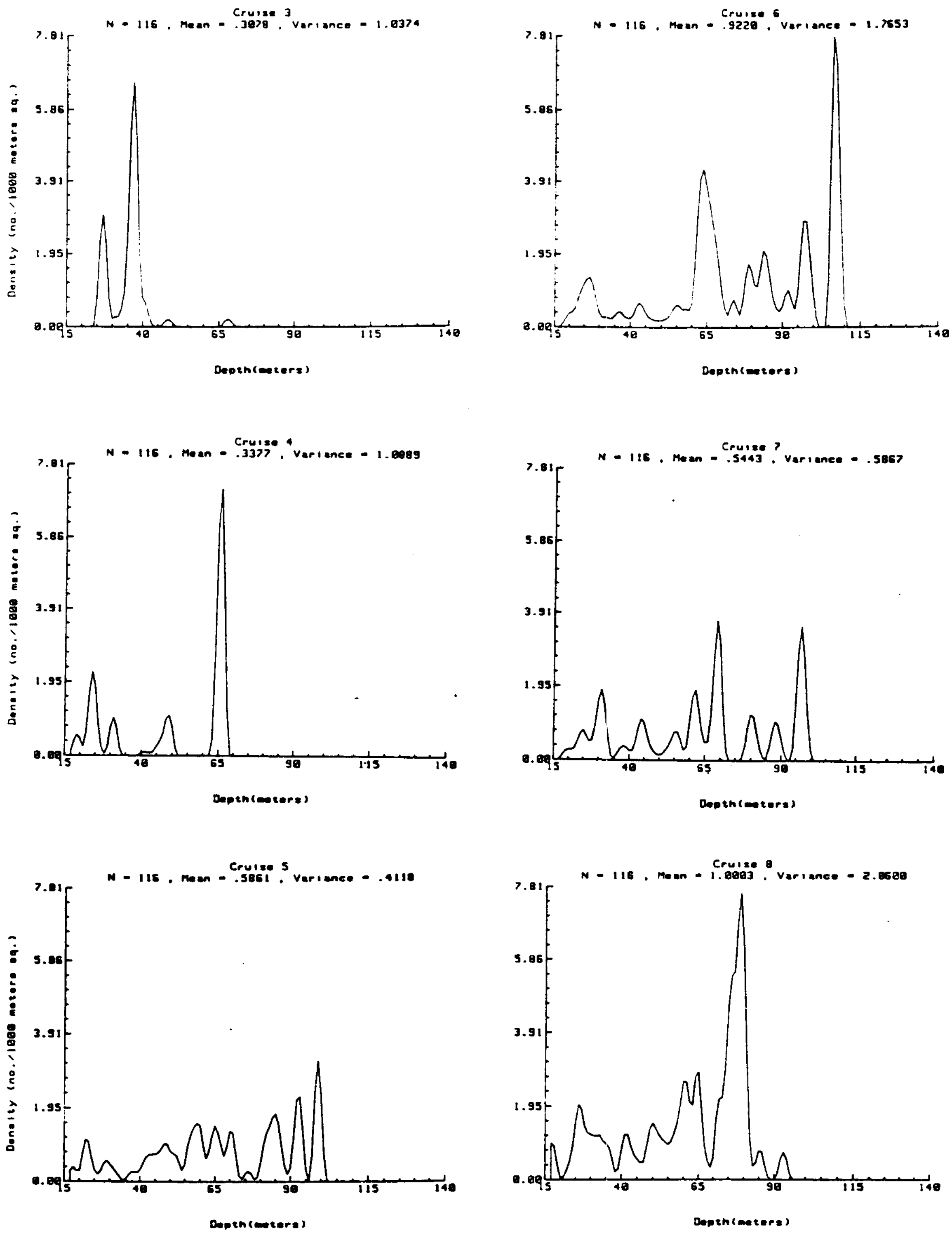


Fig. 6-35. Raw density by depth for *Mycteroperca* spp., groupers. Cruises 3-8 East Flower Garden Bank.

Within both the Deep and Shallow Drowned Reef Habitats, none of the seasonal density levels were significantly different. Within the Upper Coral Reef Zone, both spring ($\alpha = 0.05$) and fall ($\alpha = 0.01$) density levels were significantly higher than summer levels but not different from each other (Appendix 6-9).

Standing Stocks - Mycteropercid grouper populations on the East Flower Garden Bank during Cruises 5-8 were estimated to range between about 20,000 to over 47,000 fish, with the individuals measured averaging about 0.4-0.5 m in length (Fig. 6-36; Appendix 6-8). The high population level observed during fall 1982 coincides with a decrease in mean length between summer and fall 1982, suggesting recruitment occurred between those seasons.

Impact Assessment - Results of ANOVA's comparing density levels between 1981 and 1982 reflected no significant differences in abundance within any of the habitats in which groupers were abundant. Likewise, none of the spatial comparisons of density yielded any significant differences. Thus, there was no evidence suggesting the discharge of drill muds and cuttings affected grouper density levels at the East Flower Garden Banks.

Roughtongue Bass (*Holanthias martinicensis*)

The roughtongue bass is a small serranid from the western Atlantic which is known to occur from North Carolina to southern Brazil, including Bermuda, West Indies, Gulf of Mexico and the Caribbean Sea. It is not included in any of the comprehensive taxonomic keys for fishes of the Gulf of Mexico (e.g. Gallaway et al. 1972, Walls 1975, Hoese and Moore 1977) and little seems to be known about its life history and food habitats. Anderson and Heemstra (1980) report its depth distribution to be 65-230 m. We found this relatively deep-water bass to have been the dominant fish around deep drowned reefs located below 60 m in depth. It is typically aggregated above rock outcrops, with the aggregations resembling a "cloud" or "halo" of fish floating immediately above the outcrop. It is likely an

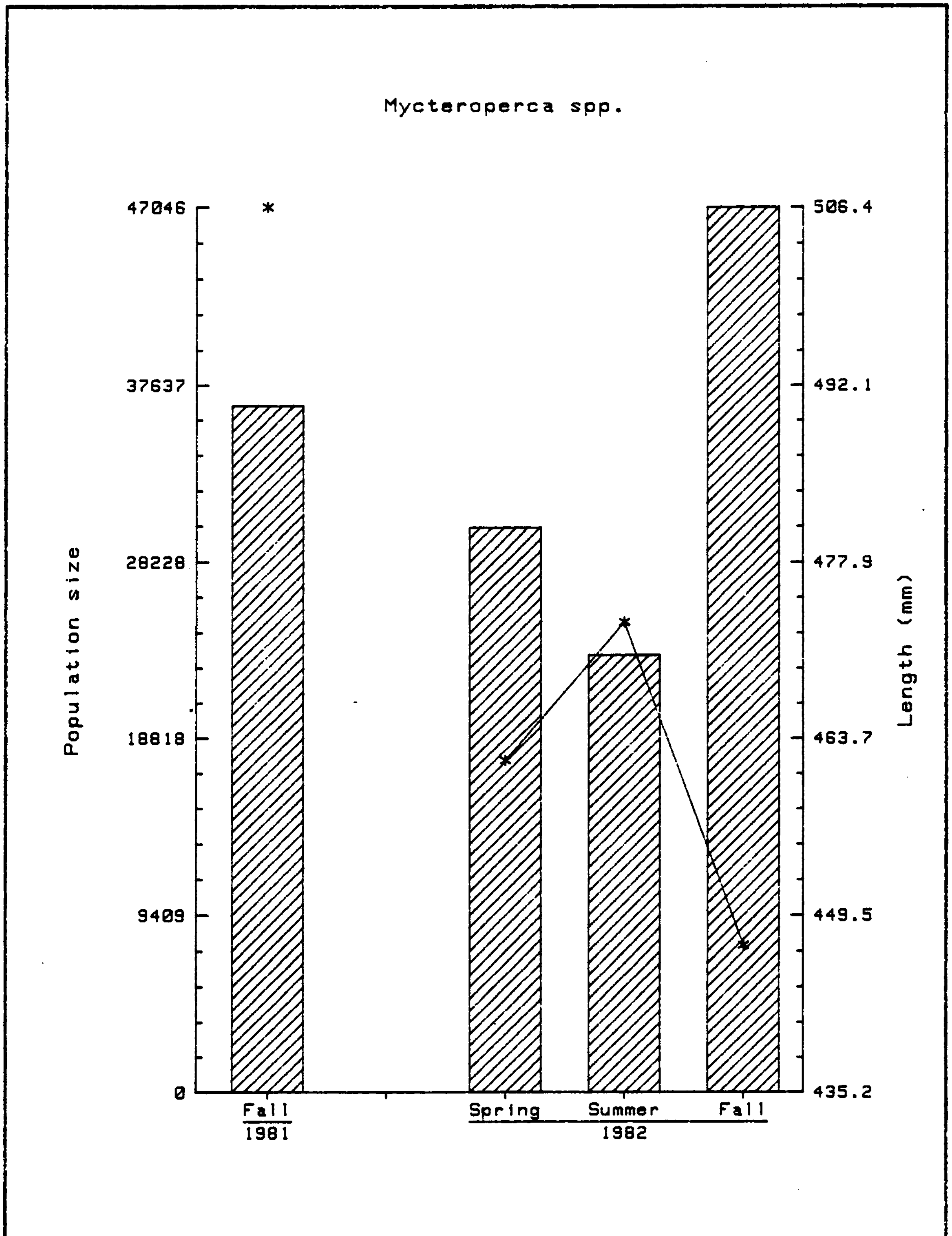


Fig. 6-36. Standing stock and mean length* estimates for groupers, *Mycteroperca* spp., East Flower Garden Bank.

opportunistic predator feeding on large zooplankton and other prey passing close to the bottom.

<u>Seasonal Abundance and Distribution</u> - As shown by Figure 6-37, high densities of roughtongue bass were largely restricted to Deep Drowned Reef Habitats although they also occurred in low density over some Shallow Drowned Reefs. Their depth distribution ranged between 65 and 105 m with the maximum densities usually occurring at about 75-80 m (Fig. 6-38). The paucity of data for Cruises 3 and 4 for this species primarily resulted from the low level of survey sampling effort expended in deep-water habitats on the East Flower Garden Bank during these Phase I cruises. Results of ANOVA's comparing seasonal density levels for Cruises 5-8 yielded no significant differences.

<u>Standing Stocks</u> - Standing stocks were rather stable in Deep Drowned Reef Habitat over the periods investigated, ranging from a low of 432,292 in fall 1981 to a high of 710,658 fish in spring 1982 (Fig. 6-39; also see Appendix 608). Standing stocks during summer and fall of 1982 were estimated to have been 540,760 and 588,396 fish, respectively. Mean lengths of fish in the stocks ranged between about 100 and 135 mm. Mean lengths of roughtongue bass during the periods having the highest abundance levels (spring and fall 1982) were smaller than was observed for the other seasons (fall 1981, summer 1982).

<u>Impact Assessment</u> - Because of its abundance and apparent dependence on a well-defined benthic habitat which was represented at the depth and in the vicinity of the discharge site, the roughtongue bass should provide an excellent indicator upon which to gauge the population-level impacts of the drill muds and cuttings discharge. Results of ANOVA's based upon data for Cruises 5-8 yielded no significant differences between 1981 and 1982 abundance levels.

Results of ANOVA performed on the spatial abundance data based upon the quadrat design yielded no significant differences in abundance among the quadrats before or after the placement and operation of the platform in quadrat 3 (see Fig. 3-11). These results indicate that if any reductions in roughtongue bass density levels resulted from the discharge

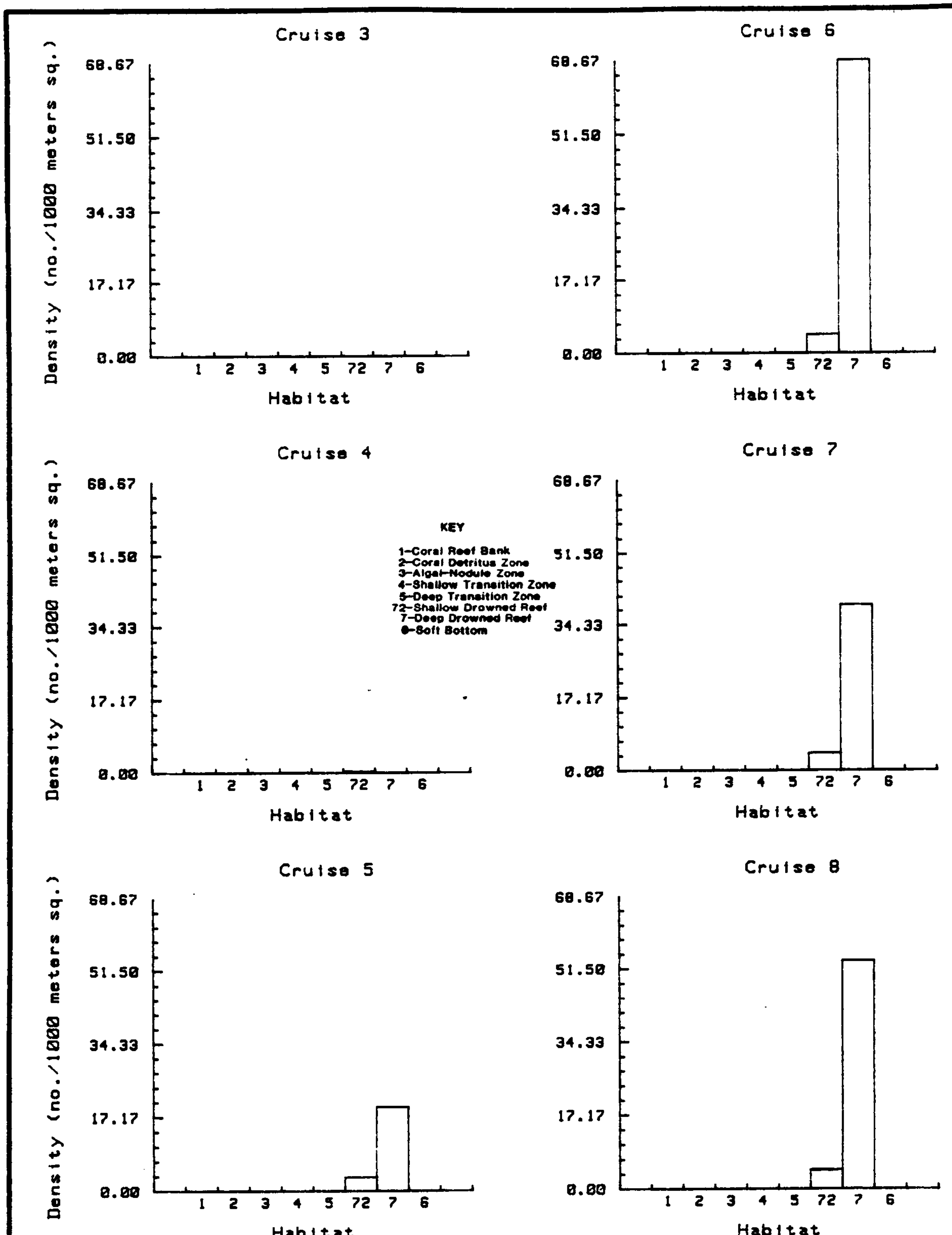


Fig. 6-37. Raw density by habitat for Holanthias martinicensis, roughtongue bass. Cruises 3-8 East Flower Garden Bank.

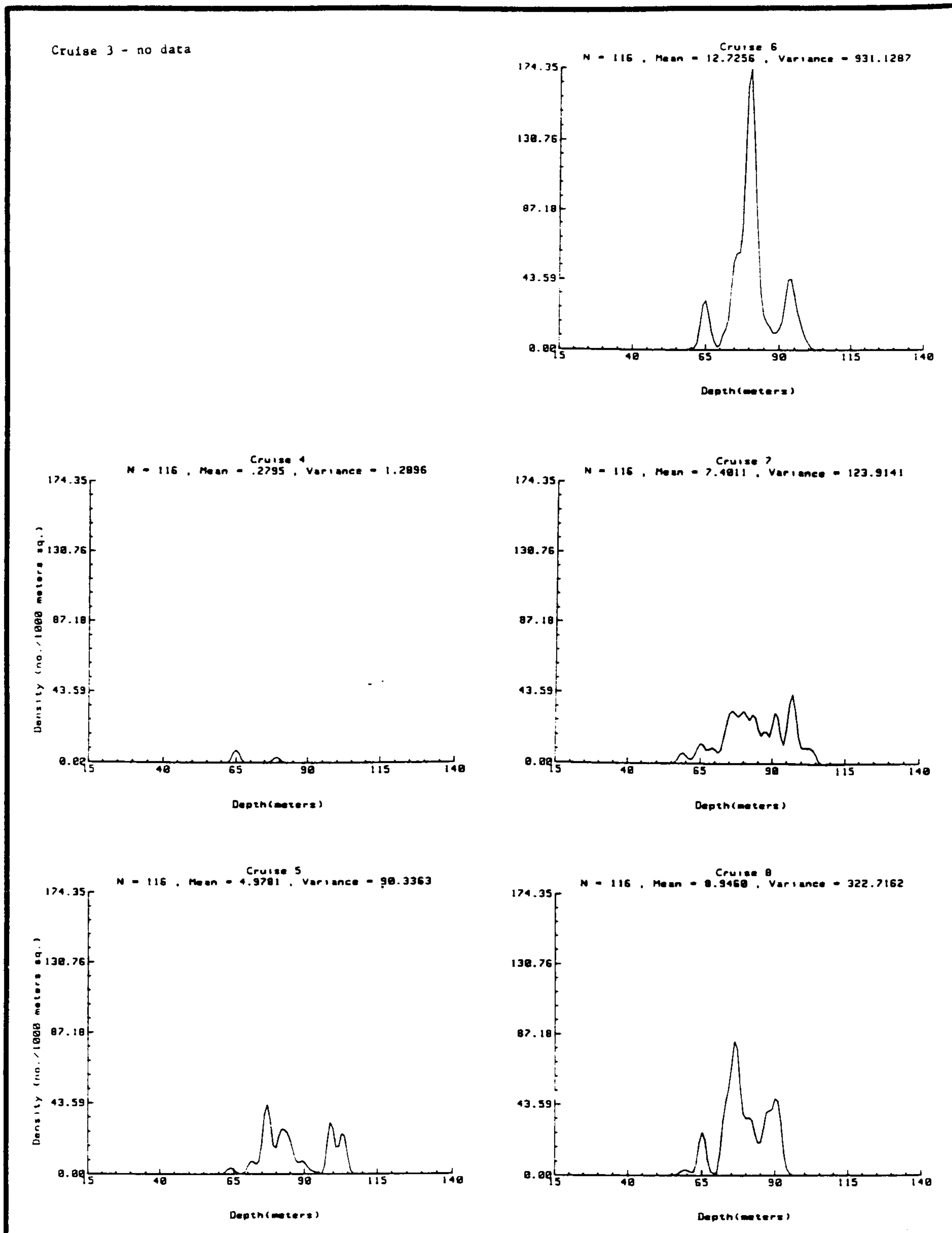


Fig. 6-38. Raw density by depth for <u>Holanthias martinicensis</u>, roughtongue bass. Cruises 3-8 East Flower Garden Banks.

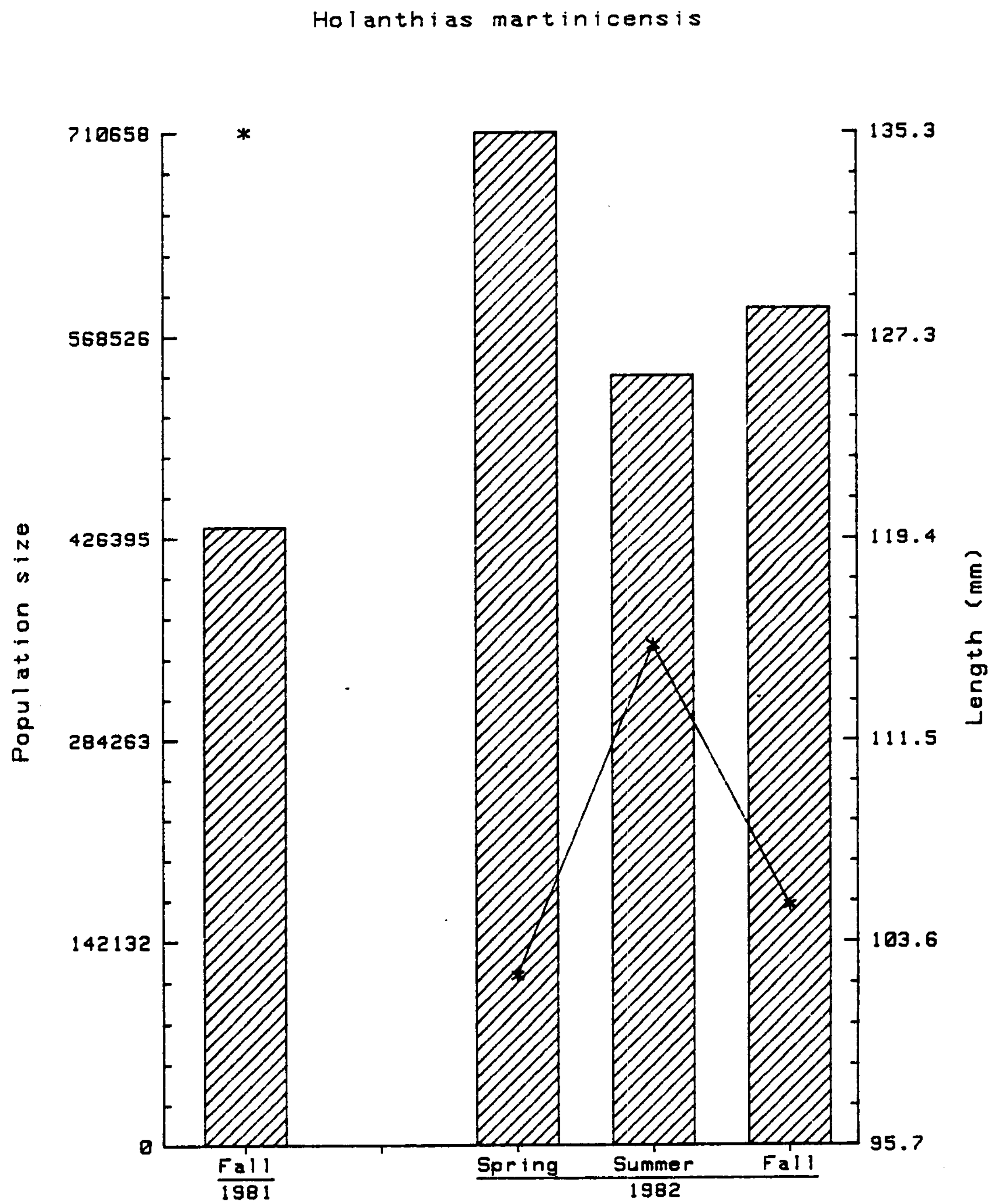


Fig. 6-39. Standing stock and mean length* estimates for roughtongue bass, Holanthias martinicensis, East Flower Garden Bank.

of drill muds and cuttings, they must have been quite restricted in terms of areal extent, as no significant reduction in density was observed within the overall area of the quadrat. The roughtongue bass would represent a good species upon which to base a monitoring study to evaluate any long-term effects of the drilling and production activities. This species is highly visible and is the principal species represented in Deep Drowned Reef Habitat.

Barred Sea Bass Group (Family Serranidae)

A group of visually-similar, small serranid species was very characteristic of deep-water, soft-bottom habitats around the Flower Gardens. Due to the restricted visibility in deep water and the similar appearance of several of the banded or barred serranids, several genera and species are likely represented within this taxon. Based upon the catch composition of the trawl samples, the species comprising this group include the blackear bass, *Serranus atrobranchus* (Cuvier); the tattler, *S. phoebe* (Poey); the rock sea bass, *Centropristis philadelphica* (Linnaeus); and possibly the dwarf sand-perch, *Diplectrum formosum* (Linnaeus). All but the rock sea bass attain a maximum length of about 15 cm. The rock sea bass is not much larger, attaining a maximum length of about 20 cm. All are predators and lie on the bottom when not swimming.

This group was the only taxon which had representatives consistently seen within the nepheloid layer, and, as a whole, the group showed high fidelity to the soft-bottom habitat. Other common deep-water species which were obtained by trawling (such as wenchman, longspine porgy and hake) but not videotaped, may have avoided the video frame and light, maintaining themselves outside the limited range of visibility in this habitat.

The blackear bass occurs throughout the Northern Gulf of Mexico through the Caribbean to Brazil. The similar tattler is found in the Gulf and also occurs in Bermuda, South Carolina and Florida through the Caribbean to Brazil. The rock sea bass, is very common in the northwestern Gulf of Mexico on sandy or muddy bottoms (Hoese and Moore 1977). It is also found throughout the Gulf and around Florida to the

Carolinas. The dwarf sand perch also frequents muddy bottoms. It occurs from North Carolina throughout the Gulf to the Northern Caribbean.

Seasonal Abundance and Distribution - As shown by Figures 6-40 and 6-41, barred sea basses were primarily associated with soft-bottom habitats over a depth range of 75-128 m. Data for Cruises 3 and 4 were scarce due to a low level of sampling effort in deep zones around the East Flower Garden Banks, but barred serranids were abundant during all other cruises. Maximum observed density for this taxa was 20 individuals/1000 m^2 which was recorded during Cruise 8 for the 110-m depth contour. Results of ANOVA indicated that the abundance levels of barred serranids over soft-bottom habitat which were observed during fall 1982 (Cruise 8) were significantly greater than abundance during other seasons (Appendix 6-9).

Standing Stocks - Standing stock estimates were not made for this group as they are not reef fishes *per se*, and placement of the bounds for soft-bottom habitat would be entirely arbitrary.

Impact Assessment - Results of the ANOVA's indicated that the overall abundance of barred serranids was greater in 1982 than in 1981. Results of ANOVA's performed on the spatial distributional data did not indicate any significant differences between the quadrat in which the platform was located (quadrat 3) versus other quadrats. Using density as an indicator of effects, barred serranids did not appear to be affected by the drilling operations which occurred in 1982.

Brown and Blue Chromis (*Chromis* spp.)

Brown (*Chromis multilineatus*) and blue (*C. cyaneus*) chromis are small, territorial damsel fishes which typically hover above coral heads oriented into the current. They are zooplankton feeders, picking individual copepods and other planktonic crustaceans from the passing water. The brown chromis differs from the blue chromis in distribution only in that it occurs in Bermuda. Both species occur off Florida, through the Gulf of Mexico and into the Caribbean.

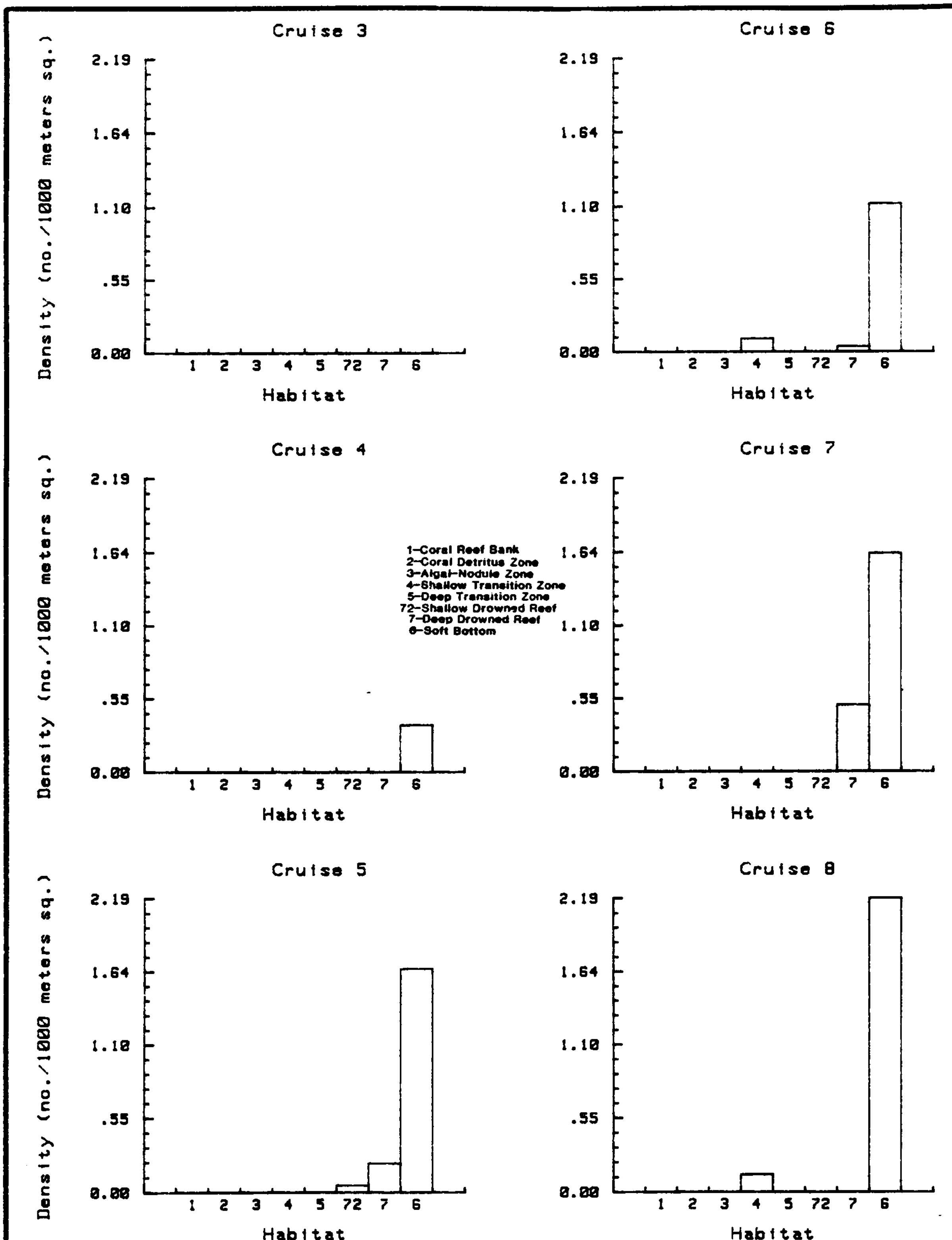


Fig. 6-40. Raw density by habitat for Family Serranidae (barred) sea basses. Cruises 3-8 East Flower Garden Bank.

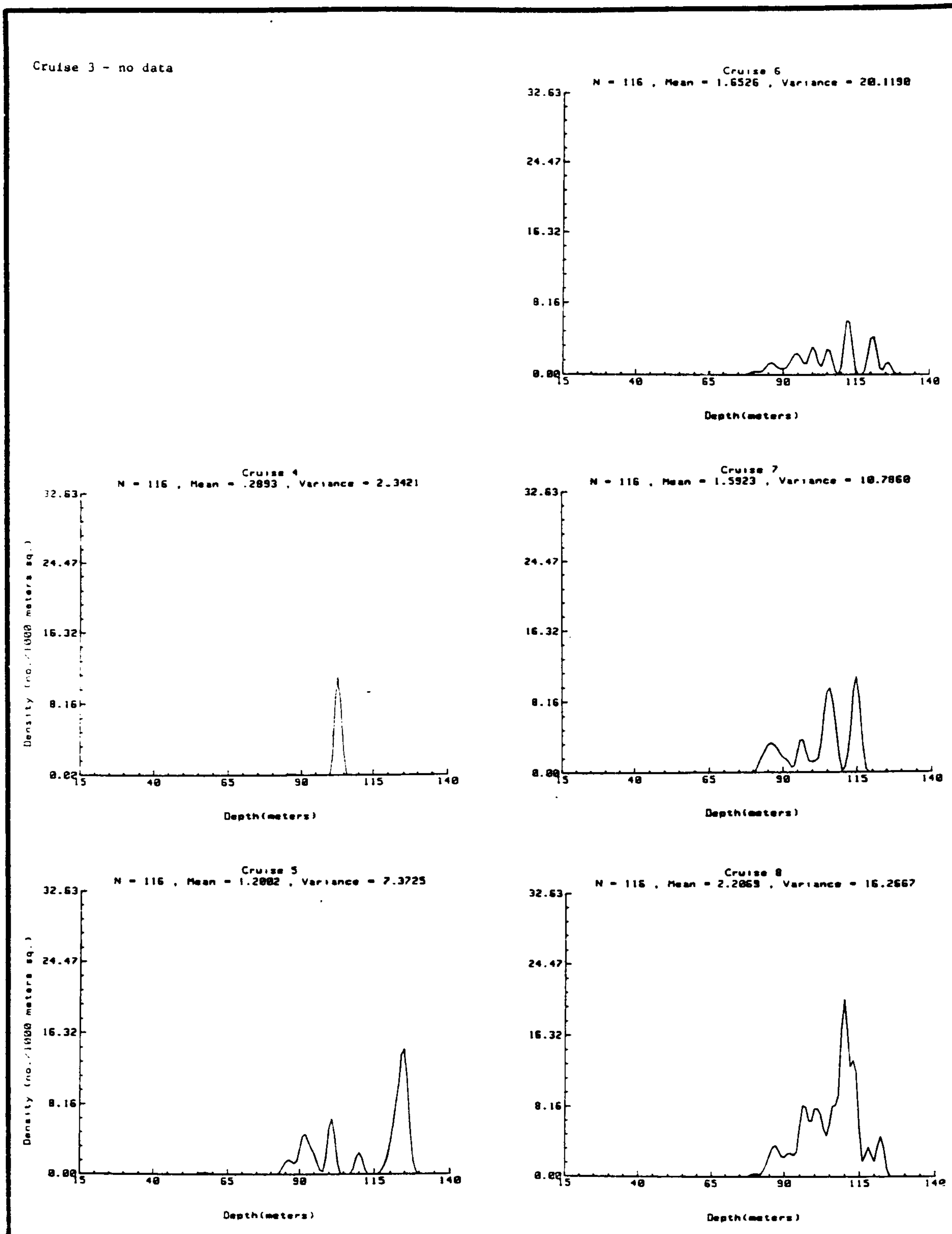


Fig. 6-41. Raw density by depth for Family Serranidae (barred) sea basses. Cruises 3-8 East Flower Garden Bank.

Although both species occur and are common at the Flower Garden Banks, we believe after many dives that the brown chromis outnumbers the blue chromis by about 10 to 1, but have no hard data to support this assumption. We could not reliably separate these two species on videotapes when they occurred more than about 2 m away from the cameras or when schools of both juveniles and adults of both species would intermix. Therefore, the two species have been combined for the analyses.

Seasonal Abundance and Distribution. These two species of chromis were entirely restricted to the upper coral reef zone and to depths shallower than 45 m (Figs. 6-42 and 6-43). Maximum densities were typically associated with the shallowest portion of the reef, from 17 to 25 m. Peak densities of chromis were observed during Cruise 4 (summer 1981), with the levels during this period being markedly and significantly higher ($\alpha = 0.05$) than the densities observed for any other season or cruise. Primarily because of this 1981 peak, mean summer density levels were significantly higher than mean densities observed for both the spring and fall ($\alpha = 0.01$) seasons (Appendix 6-9).

Standing Stocks - The standing stock of chromis in fall 1981 was estimated to have been 72,551 fish (Fig. 6-44). During spring of the following year the stock had increased to 152,589 and the increase in stock continued into the summer (222,953) and fall (357,736) seasons (Appendix 6-8, Table 1). Given the observed level of density which had occurred in summer 1981, exceedingly high mortality of chromis must have occurred during the period between summer and fall of 1981. A similar abundance pattern was noted above for creole-fish (compare Figs. 6-31 and 6-42 and Figs. 6-33 and 6-34). Mean lengths of chromis ranged between about 90 and 104 mm.

Impact Assessment - Considering data from all of Cruises 3-8, density of chromis was significantly higher during the baseline year (1981) than during 1982 when drilling activities were underway. This difference was primarily attributable to the peak density levels observed during summer 1981 after which the population markedly declined. Results of the ANOVA's performed on the distributional data showed no significant differences in

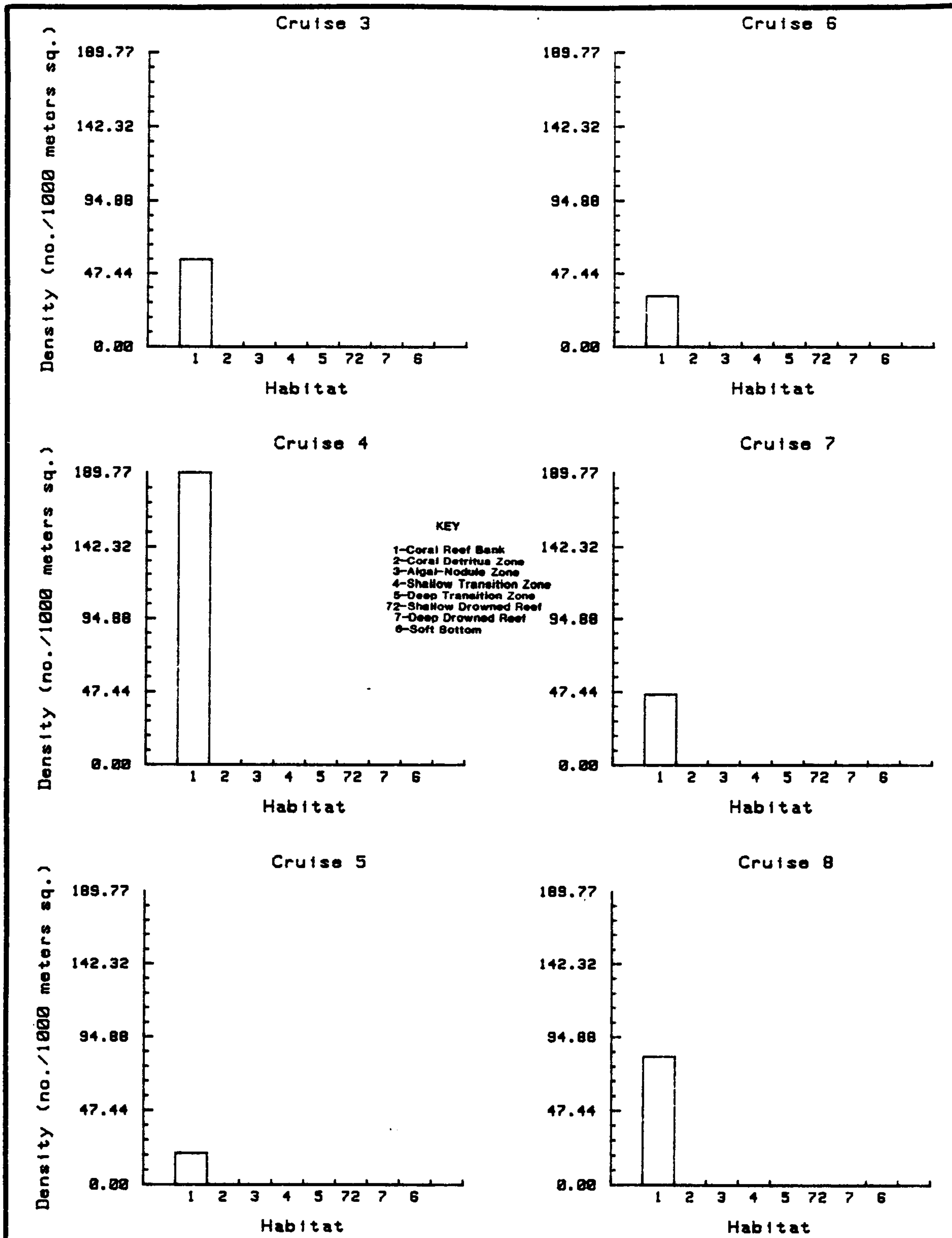


Fig. 6-42. Raw density by habitat for Chromis spp., brown and blue chromis. Cruises 3-8 East Flower Garden Bank.

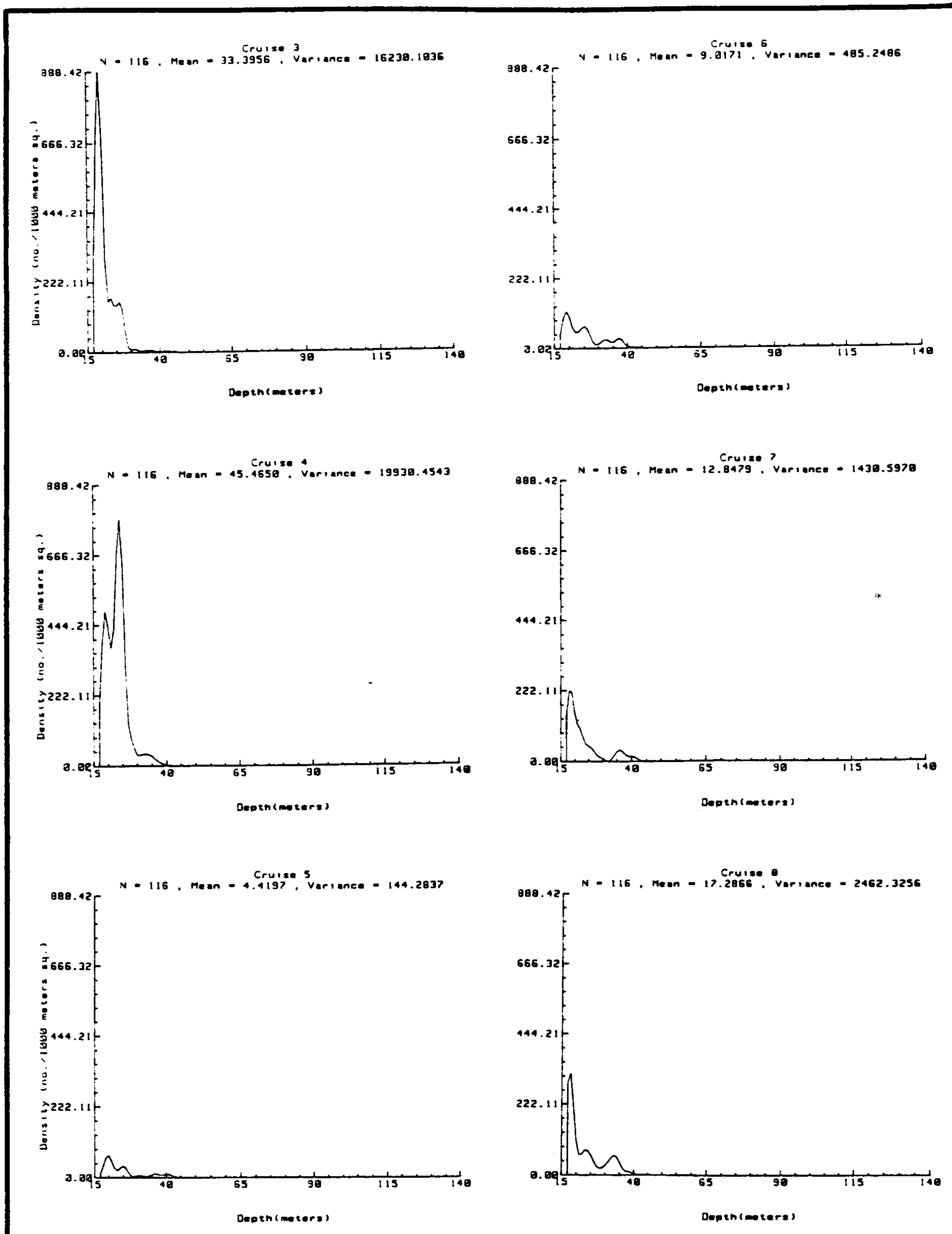


Fig. 6-43. Raw density by depth for *Chromis* spp., brown and blue chromis. Cruises 3-8 East Flower Garden Bank.

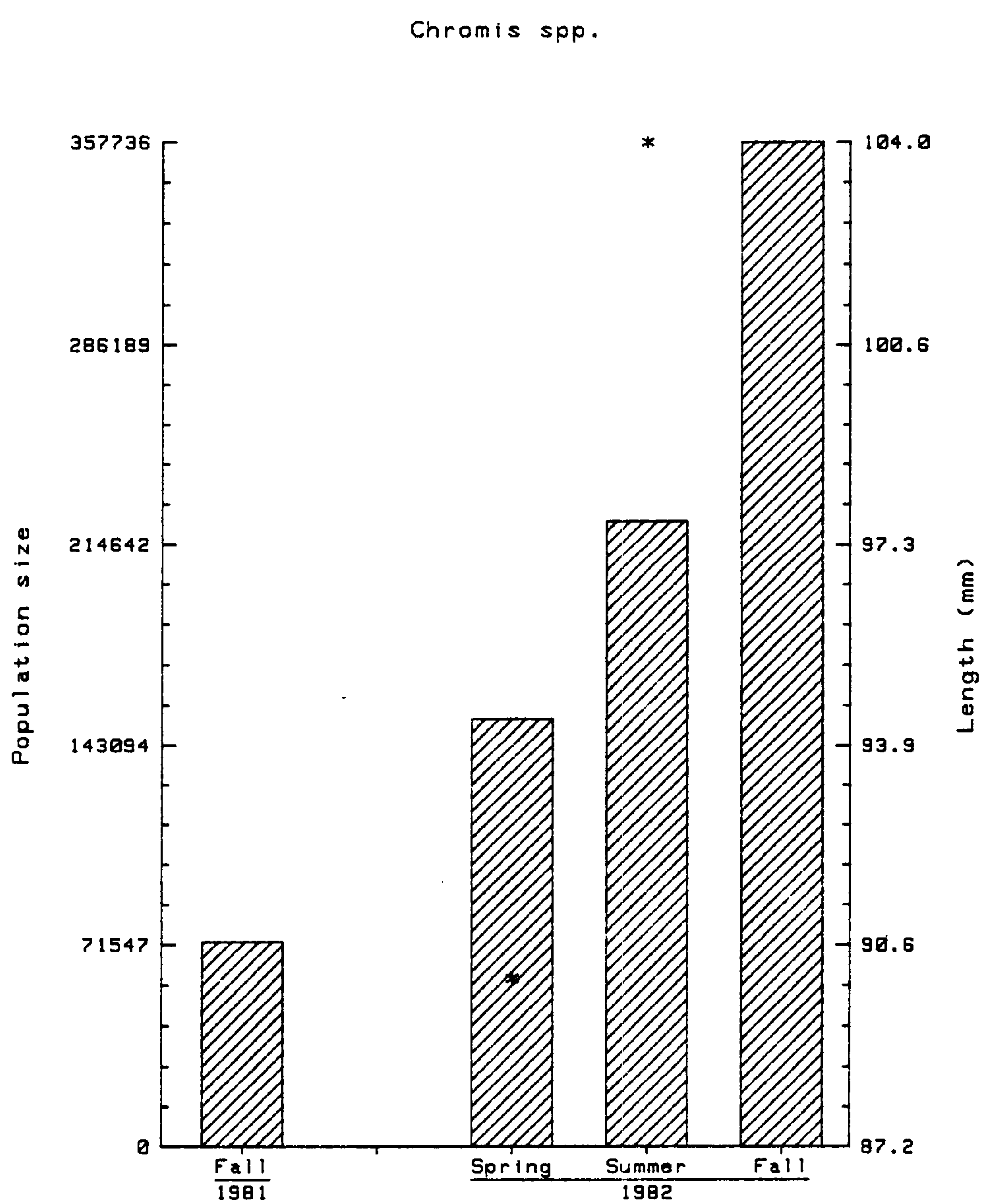


Fig. 6-44. Standing stock and mean length* estimates for brown and blue chromis, _Chromis_ spp., East Flower Garden Bank.

chromis abundance among the quadrats having Coral Reef Habitat either before or after installation and operation of the platform. We do not believe any of the observed variations in the abundance of chromis were attributable to effects from the drilling activities.

Creole Wrasse (*Clepticus parrai*)

The creole wrasse, occurring in Bermuda and the Bahamas and from Florida through the Gulf of Mexico to the West Indies, is the only wrasse completely adapted to an open water mode of existence. Much like chromis, it schools above reef outcrops and feeds on passing plankton. Foods include copepods, small jellyfishes, pteropods, pelagic tunicates and various invertebrate larvae (Randall 1968). The creole wrasse obtains a maximum length of about 300 mm. Its persistent use of the pectoral fins for swimming provided a good visual clue for making *in-situ* identifications.

Seasonal Abundance and Distribution - The creole wrasse was the third ranking numerical dominant on the bank and was generally restricted in distribution to the Upper Coral Reef Zone from 15 to about 45 m in depth (Figs. 6-45 and 6-46). The seasonal abundance pattern of the creole wrasse, although not as pronounced, was much like that which was described above for both the creole-fish and chromis species. Peak density during summer 1981 was significantly different from all other seasons ($\alpha = 0.05$) and was followed by a marked decline in abundance between the summer and fall seasons of 1981 (Fig. 6-46). During 1982, highest abundance was observed in fall. Overall, mean summer densities were significantly higher ($\alpha = 0.01$) than mean densities for the spring and fall seasons (Appendix 6-9), and the differences between the latter two seasons were not significant.

Standing Stocks - The standing stock levels of creole wrasse during fall 1981 and spring, summer and fall of 1982 were 81,380, 136,930, 141,410 and 226,081, respectively (Fig. 6-47; also see Appendix 6-8). Mean lengths of creole wrasse which were measured ranged from about 225 to

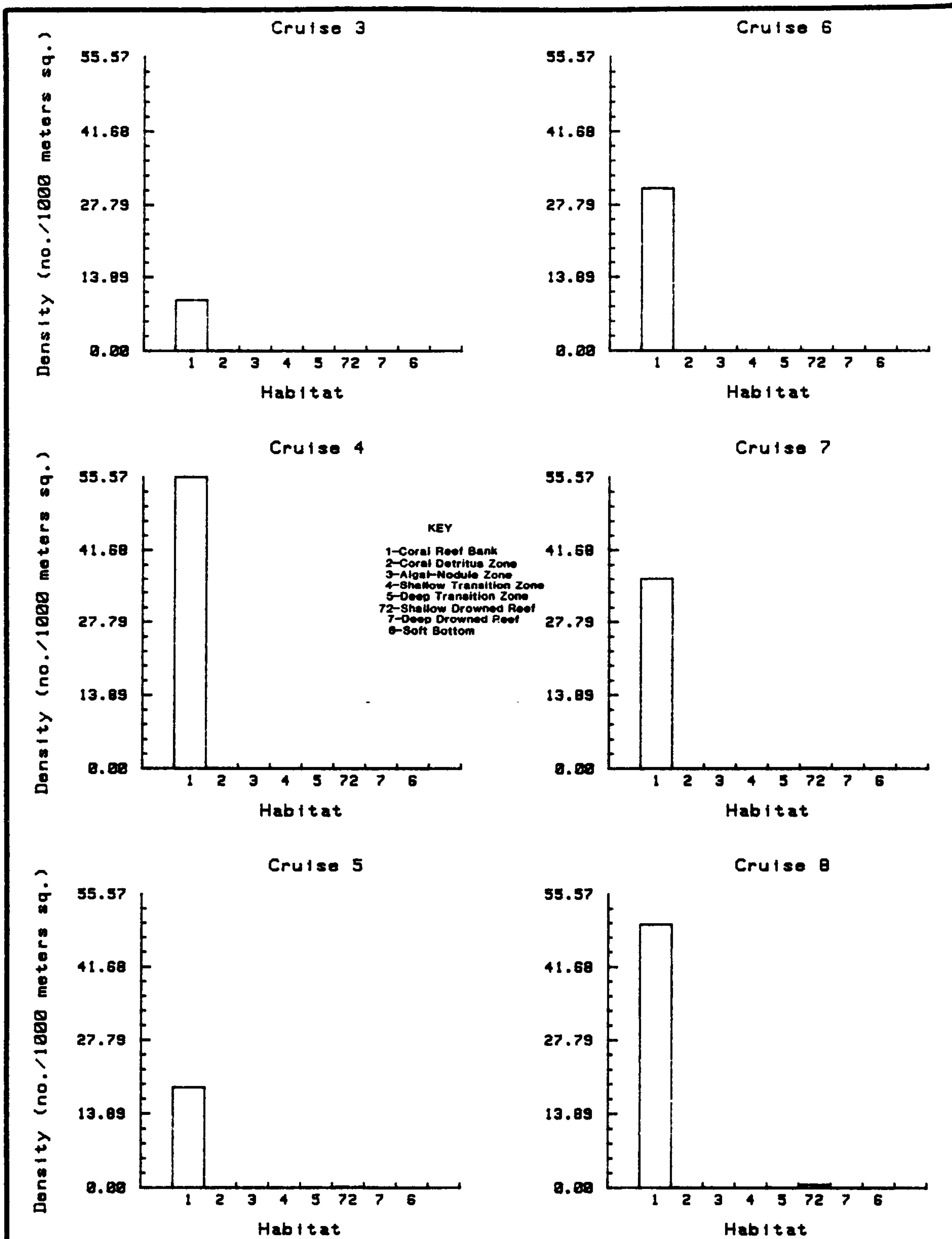


Fig. 6-45. Raw density by habitat for Clepticus parrai, creole wrasse. Cruises 3-8 East Flower Garden Bank.

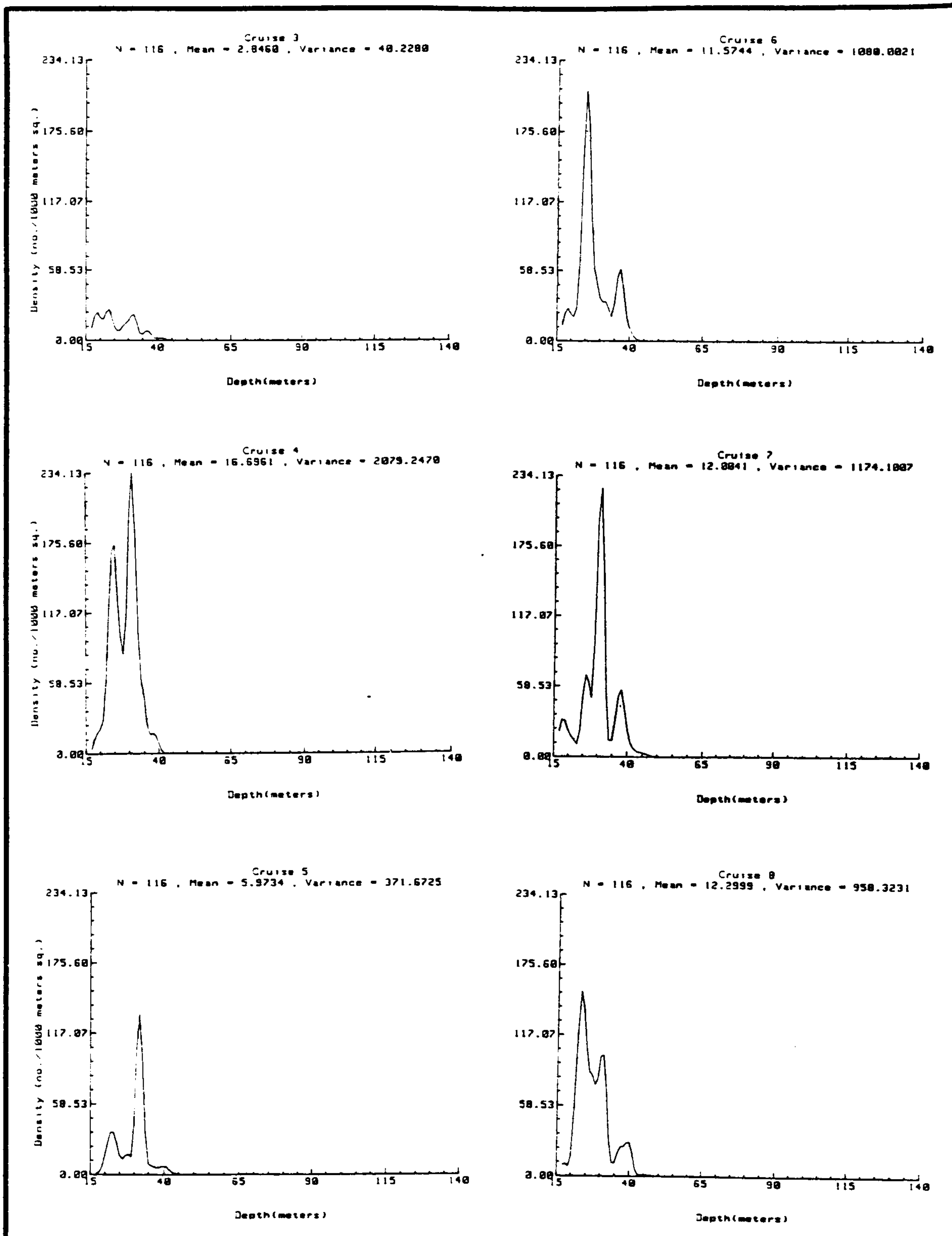


Fig. 6-46. Raw density by depth for Clepticus parrai, creole wrasse. Cruises 3-8 East Flower Garden Bank.

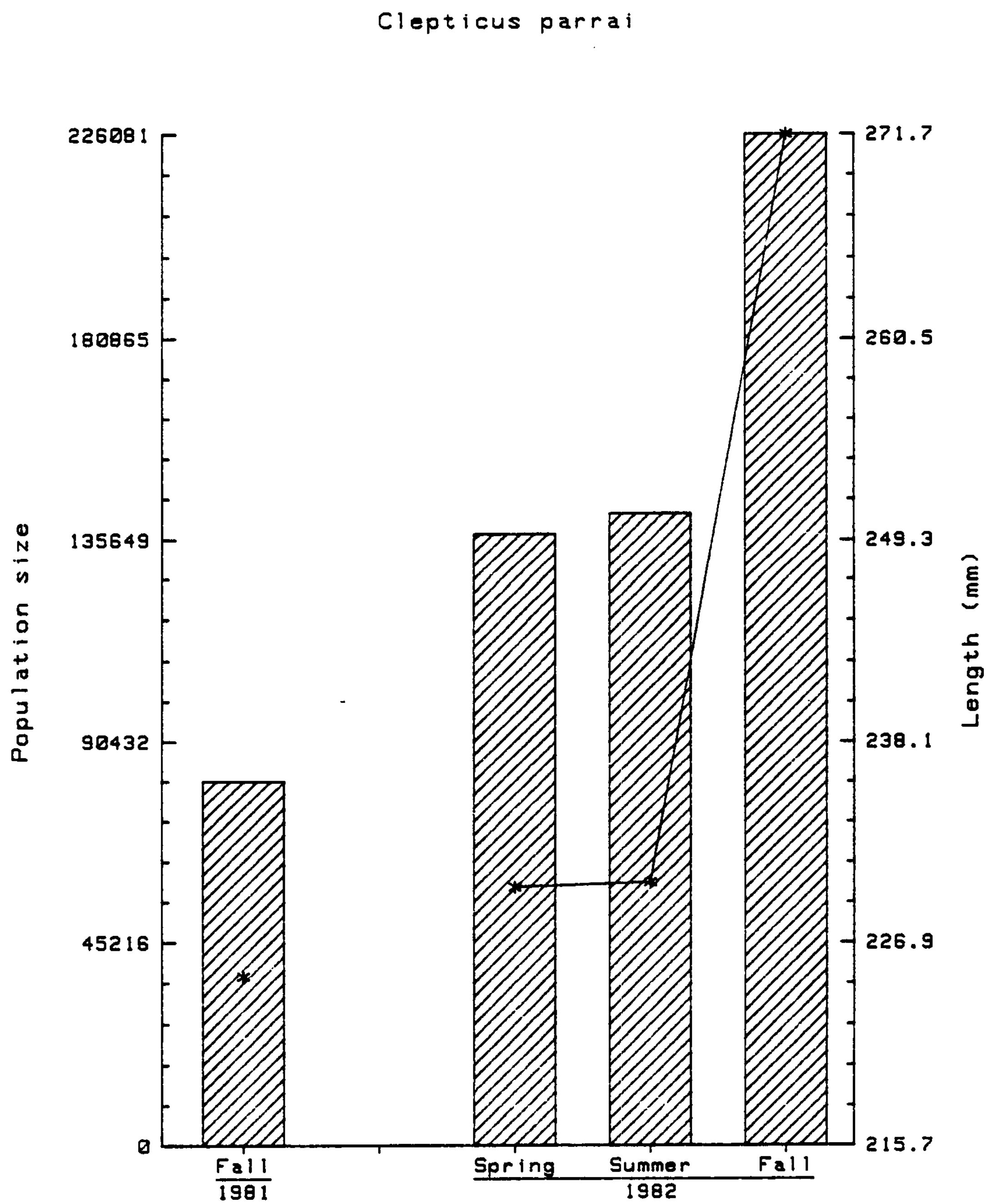


Fig. 6-47. Standing stock and mean length* estimates for creole wrasse, Clepticus parrai, East Flower Garden Bank.

272 mm. Mean length of creole wrasse during fall 1981 was markedly lower than during fall 1982.

Impact Assessment - Mean abundance of creole wrasse during 1982 (during drilling) was not significantly different from mean abundance observed during 1981 (before drilling). Results of ANOVA indicated no significant differences in spatial abundance among quadrats having Coral Reef Habitat either before or after installation and operation of the platform. Based upon these data, we conclude that impacts on populations of creole wrasse which could be attributable to the platform and its operations were unlikely.

Cottonwick (Haemulon melanurum)

The cottonwick is a member of the grunt family (Pomadasyidae), a group closely related to the snappers. This species is reported from Bermuda, the Bahamas and the northern Gulf of Mexico through the Caribbean to Brazil. Individuals, based on results of this study, attain maximum lengths of at least 395 mm. The dominant prey items of cottonwick in the Flower Gardens were fish, fish eggs, ophiuroids and molluscs (Nelson 1981).

Cottonwick, although the most abundant fish taken in trap and hook-and-line collections made at night, was only sporadically encountered on the daytime video transects. When encountered it was usually seen in dense aggregations at the edge of the Coral Reef Bank or along Shallow Drowned Reefs (Fig. 6-48). The depth distribution also reflects the daylight distributional pattern of seclusion along the edge of the Coral Reef Bank or in the "shadow" of Shallow Drowned Reefs (Fig. 6-49). The standing stock estimates for cottonwick are provided in Fig. 6-50. Highest populations were present during spring and summer periods of 1982. However, review of the individual population estimates for cottonwick shows that the confidence interval for these estimates ranged from a minimum of ± 80% to ± 346% of the maximum likelihood estimate (Appendix 6-8, Tables 1 and 3).

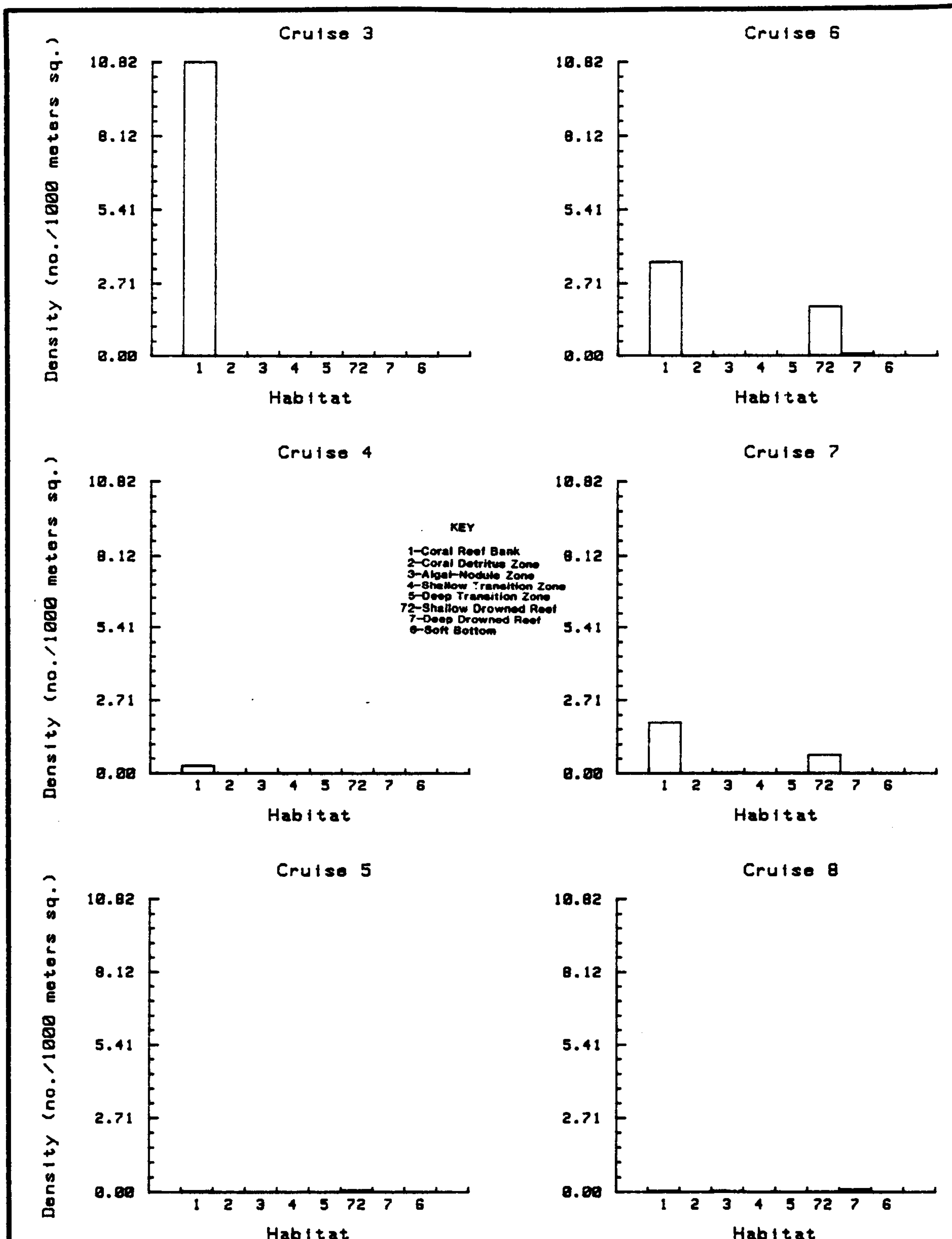


Fig. 6-48. Raw density by habitat for Haemulon melanurum, cottonwick. Cruises 3-8 East Flower Garden Bank.

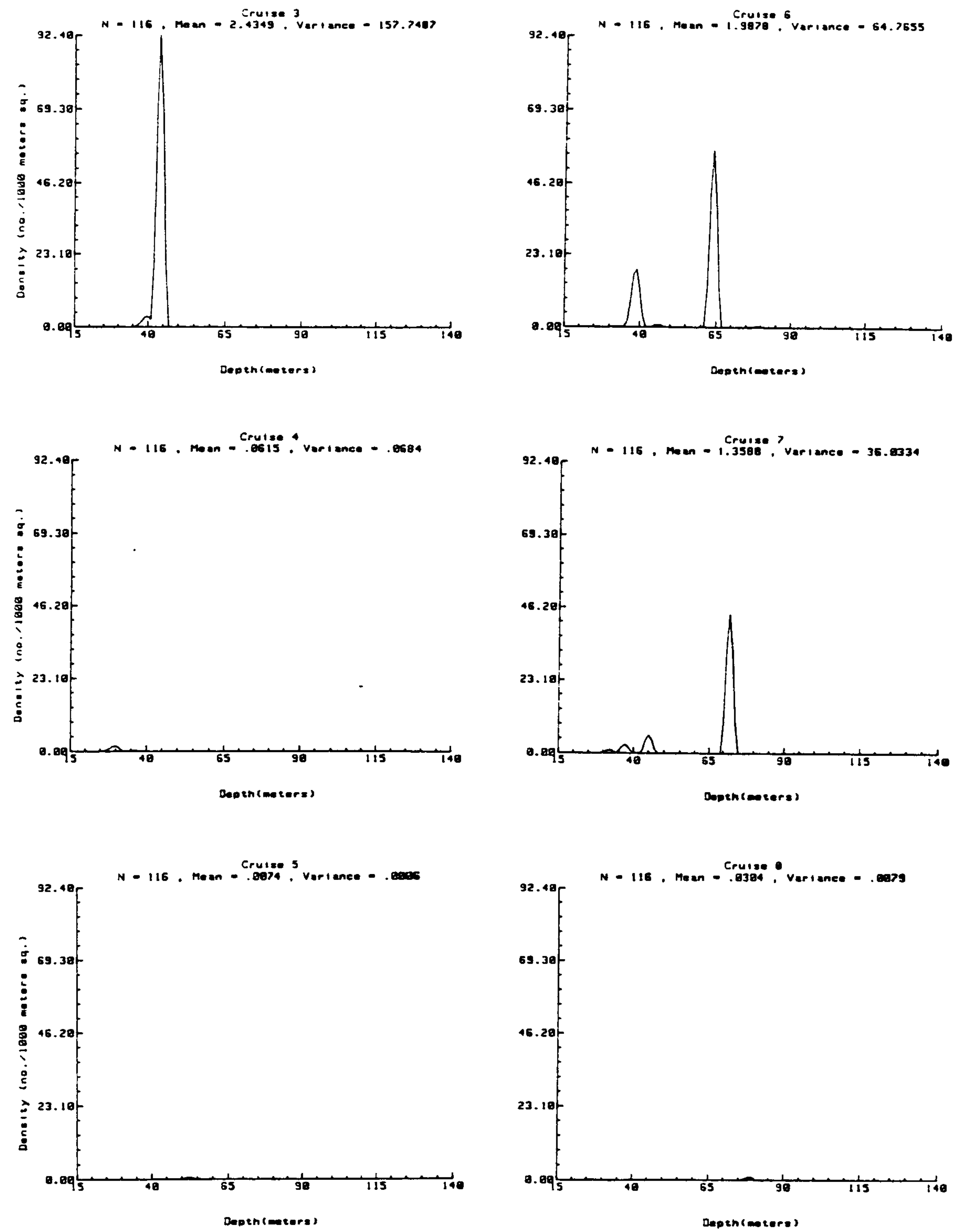


Fig. 6-49. Raw density by depth for <u>Haemulon</u> <u>melanurum</u>, cotton-wick. Cruises 3-8 East Flower Garden Bank.

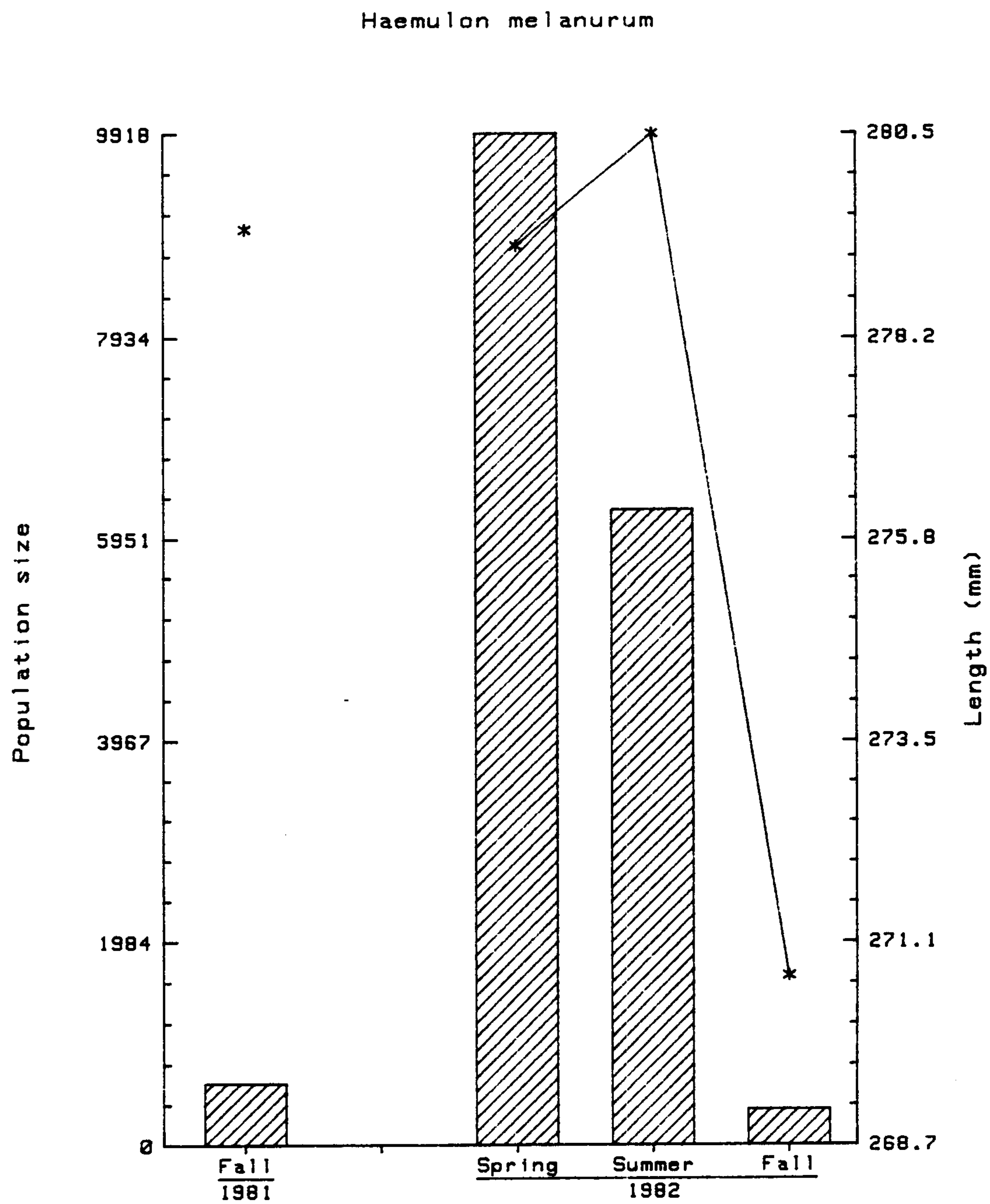


Fig. 6-50. Standing stock and mean length* estimates for cottonwick, *Haemulon melanurum*, East Flower Garden Bank.

Yellowtail Reeffish (*Chromis enchrysurus*)

This small (maximum length of about 10 cm) damsel fish is much less well known than its shallow-water counterparts, the blue and brown chromis. Emery and Smith-Vaniz (1982) report its range as being Bermuda and North Carolina to mid-Brazil, including the Gulf of Mexico and western Caribbean. It is more characteristic of small outcrops of sponge or coral rock in deep areas than of large areas of shallow coral reef. The yellowtail reeffish occupies water of greater depths that the other damsel fish at the Flower Garden Banks. Emery and Smith-Vaniz (1982) describe its reported depth range as being from 5 to 146 m.

The colonial yellowtail reeffish is strongly associated with structure, forming a "cloud" of fish above an occupied outcrop or sponge. Emery and Smith-Vaniz (1982) reported seeing adults rise as much as 2 m from the substrate during feeding; we never observed them more than about 1 m from the substrate. They feed in the same manner as the other chromis, facing into the current and picking plankton from the water.

Seasonal Abundance and Distribution - The yellowtail reeffish was the numerically-dominant taxon in the Shallow Drowned Reef Habitat during most cruises. It was most commonly associated with this habitat type but also occurred in low densities in Habitats 1, Coral Reef Bank; 3, Algal-Nodule Zone; and 4, Shallow Transition Zone (Fig. 6-51). Distribution by depth ranged from 17 m to 95 m but the majority of fish were seen between 40 m and 80 m (Fig. 6-52). Generally, the 75- to 80-m boundary between Shallow and Deep Drowned Reefs also correlated with the disappearance of yellowtail reeffish, being replaced on Deep Drowned Reefs by the roughtongue bass. On a seasonal basis, abundance during both the summer ($\alpha = 0.05$) and fall ($\alpha = 0.01$) seasons was significantly greater than abundance during spring (Appendix 6-9).

Standing Stocks - Standing stock levels of yellowtail reeffish over Cruises 5-8 ranged from a low of about 93,000 fish in Spring of 1982 to almost 433,000 fish in fall of the same year (Fig. 6-53; also see Appendix 6-8). The fall 1981 standing stock was appreciably lower than the level observed during the same season of 1982.

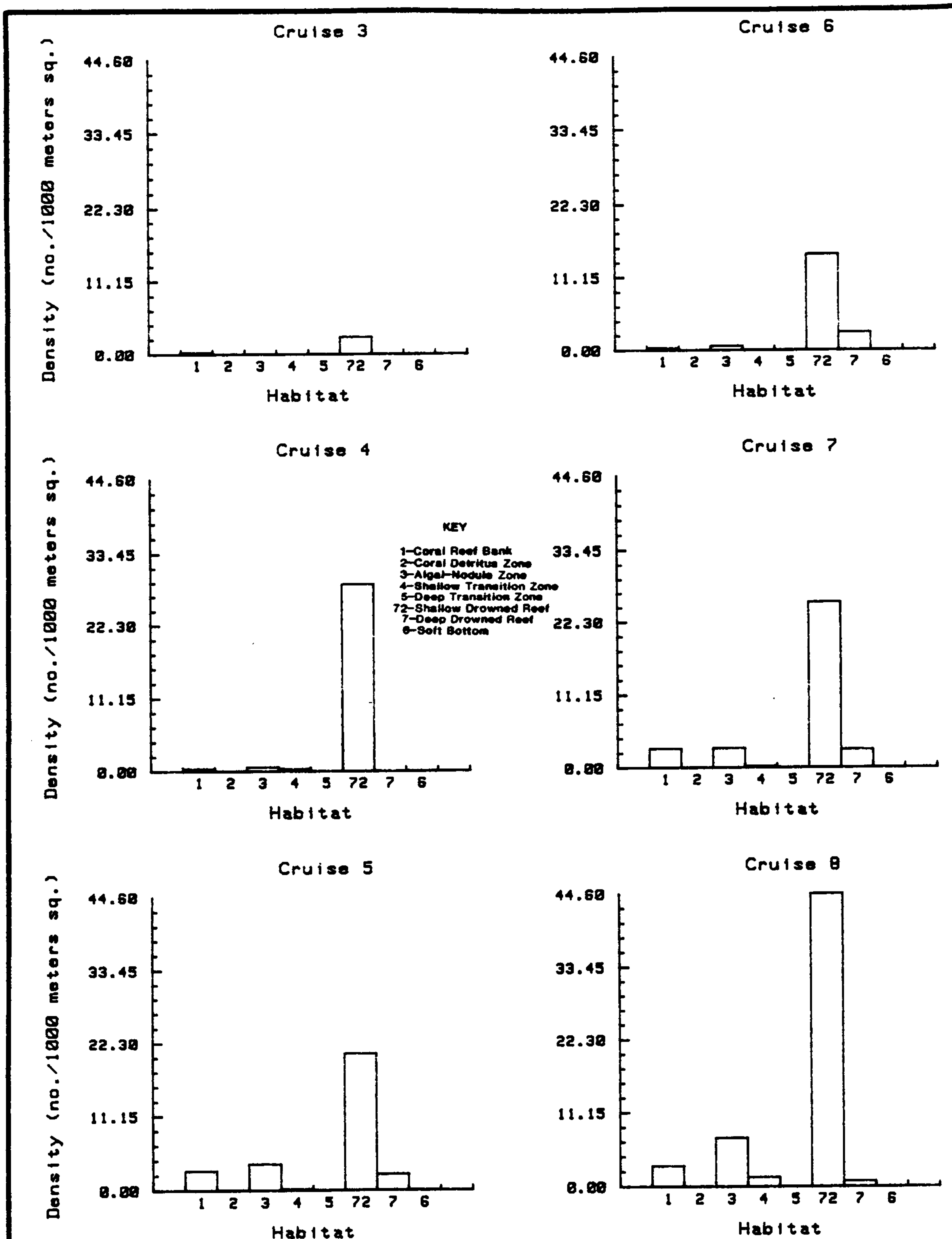


Fig. 6-51. Raw density by habitat for *Chromis enchrysurus*, yellowtail reeffish. Cruises 3-8 East Flower Garden Bank.

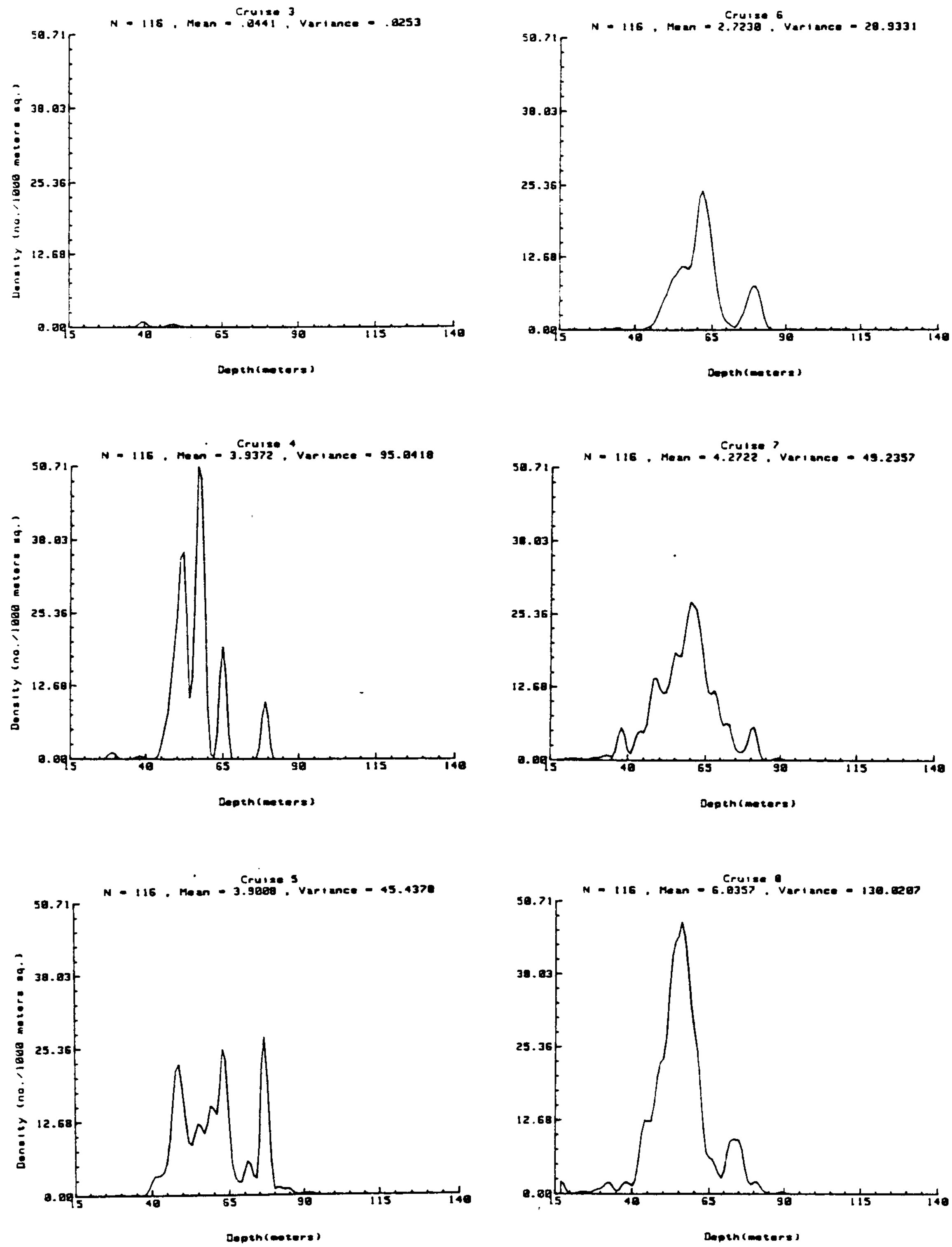


Fig. 6-52. Raw density by depth for Chromis enchrysurus, yellowtail reeffish. Cruises 3-8 East Flower Garden Bank.

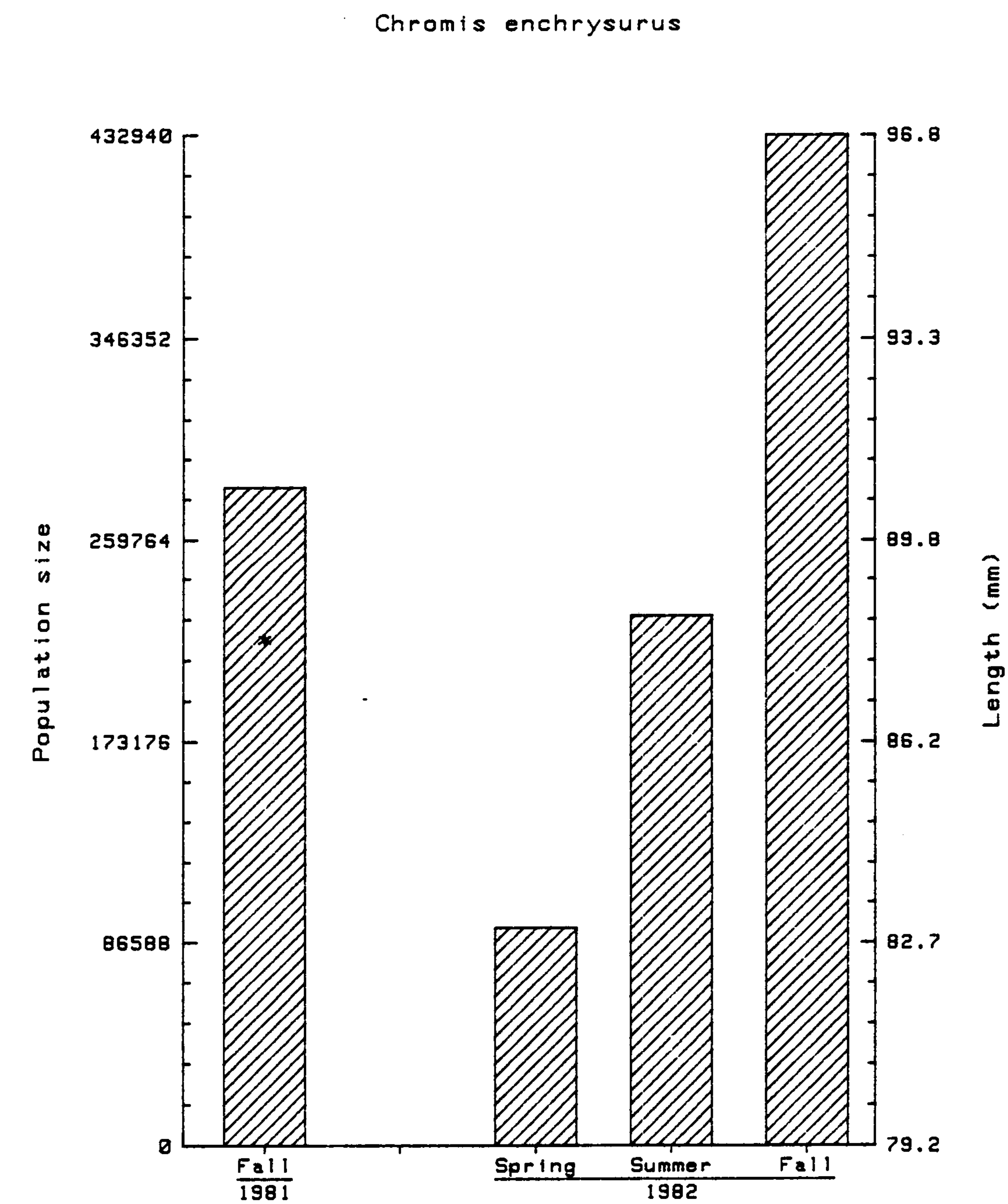


Fig. 6-53. Standing stock and mean length* estimates for yellowtail reeffish, Chromis enchrysurus, East Flower Garden Bank.

Impact Assessment - Total abundance of yellowtail reeffish on the bank during 1982 was not significantly different than the abundance levels which had been observed during 1981 prior to installation and operation of the drilling platform. However, significant differences were noted in the spatial abundance patterns of this species.

As shown by Fig. 3-11, the inner row of quadrats (6-10) all contained areas of Shallow Drowned Reef Habitats, zones which were used extensively by yellowtail reeffish. Of these quadrats, the central one (number 8), was closest to the platform site, being flanked to either side by quadrats 6 and 7 and 9 and 10, respectively. During fall of 1981, significantly higher densities ($\alpha = 0.01$) of yellowtail reeffish occurred in quadrat 10 than in the other quadrats, with none of the other differences among quadrat density levels being significant. In fall of 1982, density in quadrat 8 was significantly greater ($\alpha = 0.01$) than densities observed in all of the other quadrats, none of which were significantly different from each other (Appendix 6-9).

Seasonal abundance patterns within the quadrat also differed significantly. In quadrat 8 (closest to the platform), abundance during fall 1982 was significantly greater ($\alpha = 0.01$) than abundance levels observed in fall of 1981 and spring and summer of 1982 (Appendix 6-9). In the adjacent or "control" areas located to either side of quadrat 8, none of the differences in seasonal abundance levels were significant.

It would appear, based upon these results, that quadrat 8 was in some way enhanced as habitat during 1982 as compared to 1981, particularly during the fall. Whether this apparent enhancement was in anyway related to the coincident drilling activities is unknown. Although the Shallow Drowned Reefs in quadrat 8 were closer to the platform than any other areas of this habitat type, at the closest point, they were located about a kilometer away from the platform. From our work at other platforms in the Gulf, we would consider this distance to be outside of the zone of direct influence of the platform and its operations.

Spotfin Hogfish (*Bodianus pulchellus*)

The spotfin hogfish is a conspicuous and common wrasse occuring throughout several habitat types of the Flower Gardens. In distribution, it is found from Bermuda, South Carolina to southern Florida, the northern Gulf of Mexico and through the Caribbean. It is also recorded from Ascension Island and St. Helena in the mid-Atlantic. Attaining a maximum length of about 30 cm, the spotfin hogfish is a benthic predator which maintains a close association with the reef. It is rarely seen more than a meter from some kind of outcrop. Prey items include small molluscs, crustaceans and other invertebrates which can be crushed by using its well-developed pharyngeal teeth (Randall 1968). Juvenile individuals will act as "cleaners", supplementing their diet by cleaning larger fish of external parasites (Thresher 1980).

Seasonal Abundance and Distribution - The spotfin hogfish was observed in a variety of habitats but was most prevalent in the Upper Coral Reef and Shallow Drowned Reef Habitats (Fig. 6-54). Its distribution over depths ranged from 17 to 85 m (Fig. 6-55). Within this depth range, peak densities were highly variable over the seasons sampled exhibiting no consistent trends. In Upper Coral Reef Habitat, abundance of spotfin hogfish was significantly greater ($\alpha = 0.01$) in the fall than in the spring season, based upon data from both years combined (Appendix 6-9). No other seasonal contrasts were significantly different within this habitat. In Shallow Drowned Reef Habitat, both fall and summer abundance levels were significantly greater ($\alpha = 0.05$) than spring levels but not different from each other.

Standing Stock - Seasonal standing stock levels of spotfin hogfish on the East Flower Garden Bank during cruises 5-8 are shown by Fig. 6-56. Population size was estimated to range between about 14,000 to over 25,000 spotfin hogfish (see Appendix 6-8),.

Impact Assessment - Abundance of spotfin hogfish in Upper Coral Reef Habitat was significantly greater ($\alpha = 0.01$) during 1982 than during 1981, and no significant differences in abundance were observed between years for hogfish occupying the shallow drowned reef habitats. None of the areal contrasts suggested any impacts from the drilling operations.

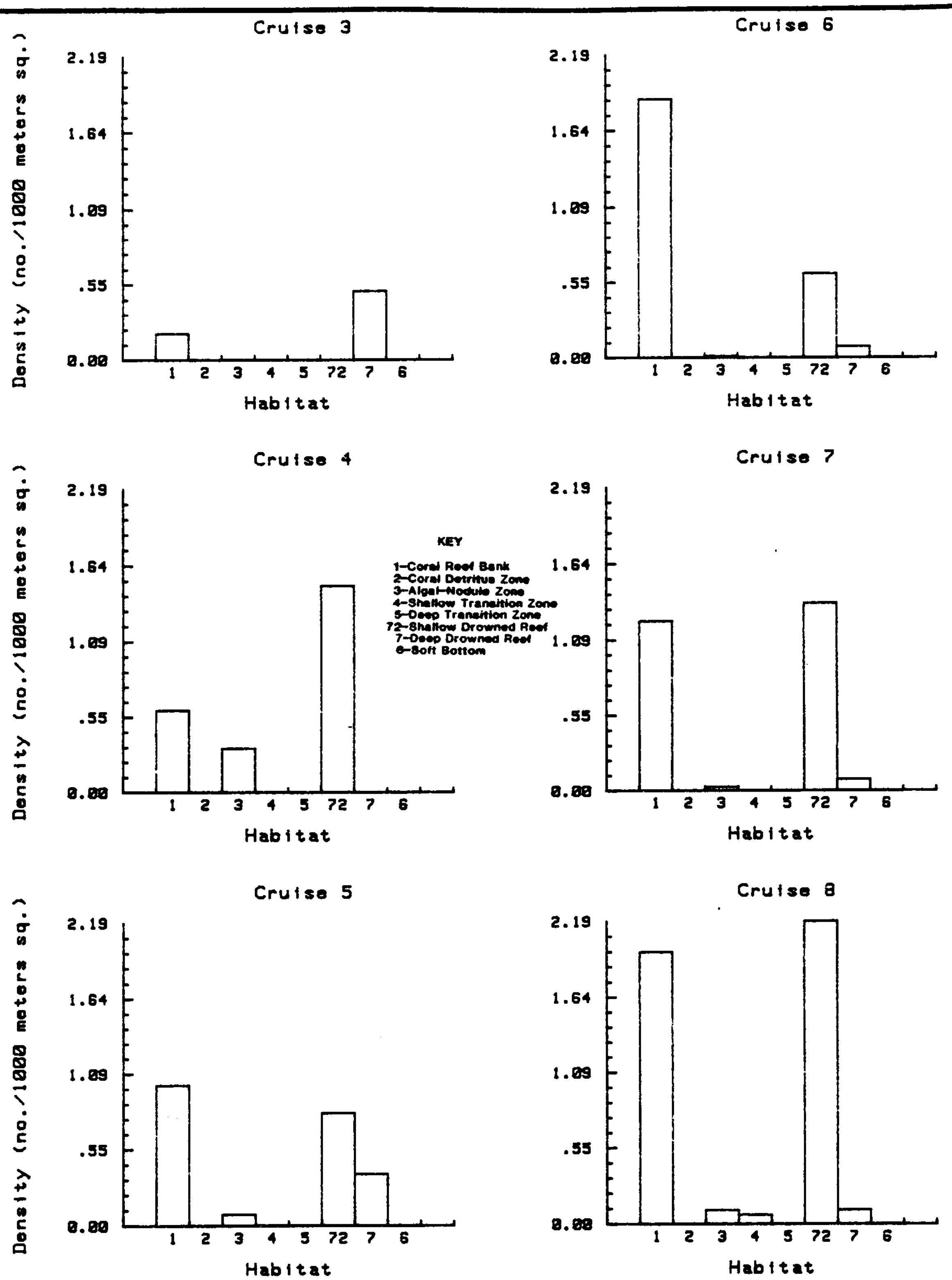


Fig. 6-54. Raw density by habitat for Bodianus pulchellus, spotfin hogfish. Cruises 3-8 East Flower Garden Bank.

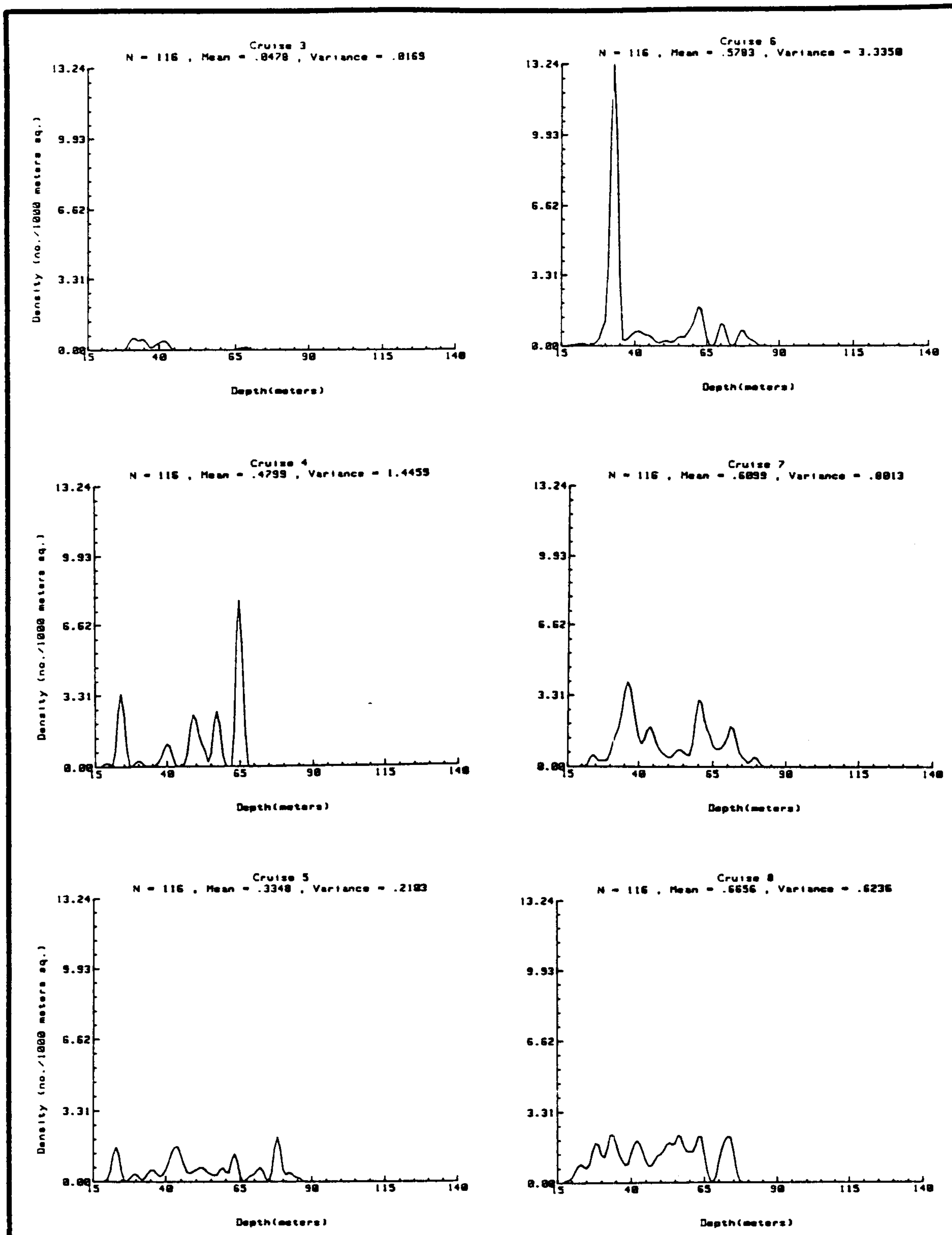


Fig. 6-55. Raw density by depth for <u>Bodianus pulchellus</u>, spotfin hogfish. Cruises 3-8 East Flower Garden Bank.

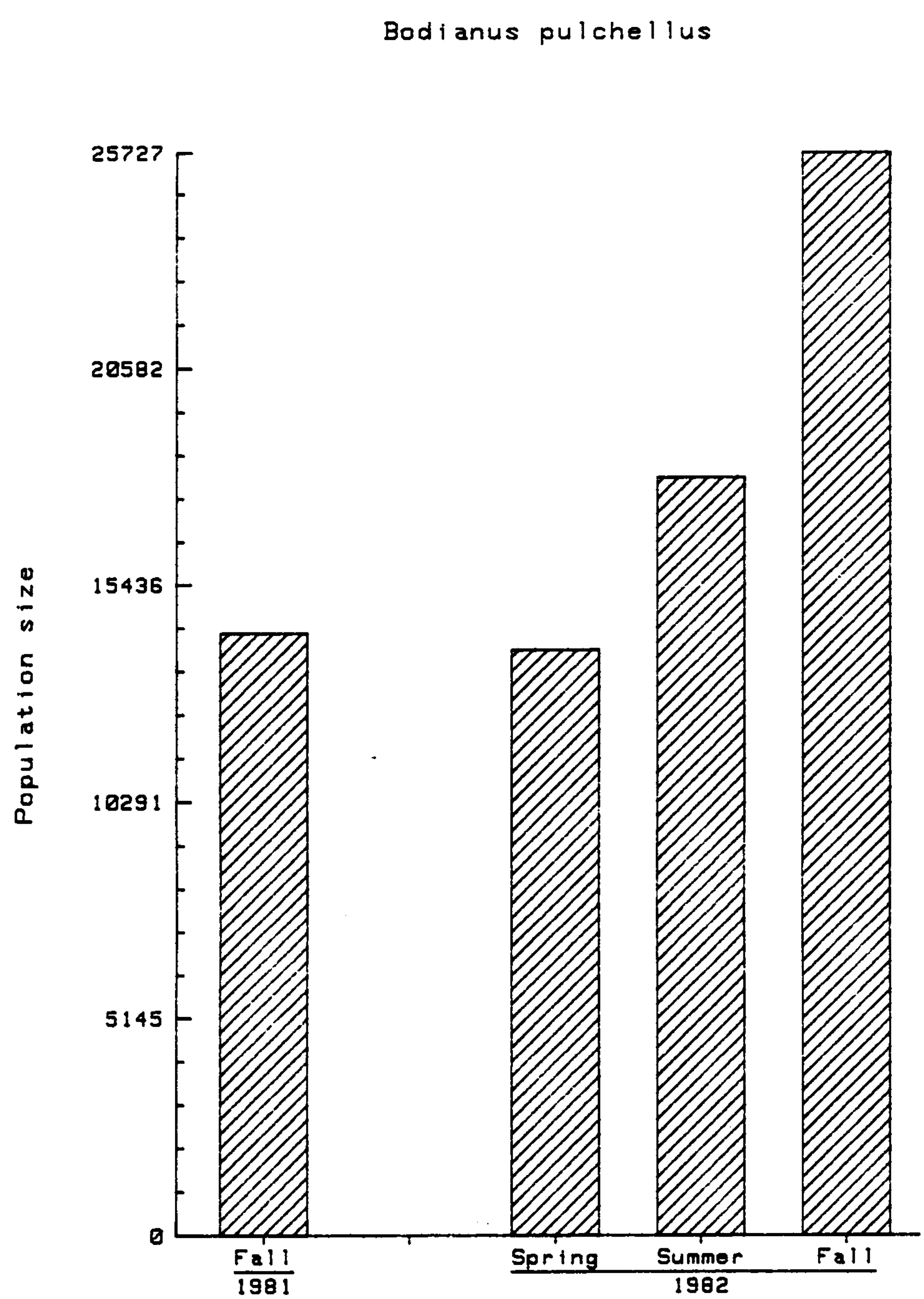


Fig. 6-56. Standing stock estimates for spotfin hogfish, *Bodianus pulchellus*, East Flower Garden Bank.

Red Snapper (*Lutjanus campechanus*)

Life history information for the red snapper was provided above in Section 5. At the Flower Garden Banks, red snapper were observed in both Shallow and Deep Drowned Reef Habitats, as well as over soft bottoms (Fig. 6-57). Red snapper were observed in habitats as shallow as 40 m and as deep as 120 m (Fig. 6-58). Red snapper were only sporadically encountered, and were typically traveling in small schools of rather large individuals (mean lengths ranged from about 36 to 48 cm).

The estimated standing stock levels of red snapper on the East Flower Garden Bank were low (Fig. 6-59; also see Appendix 6-8). During fall 1981, the population size was estimated to have been about 13,000 fish, increasing to about 19,000 to 20,000 during the spring and summer of 1982, respectively. During each of these seasons, the density of red snapper in Deep Drowned Reef Habitat was markedly higher than the density observed in Shallow Drowned Reef Habitat (Fig. 6-57). In fall 1982, the population (about 4000 fish) was markedly lower than had been present during summer; the mean length of fish was much smaller than had been observed during summer; and density in Shallow Drowned Reef Habitat was greater than the density observed in Deep Drowned Reef Habitat.

Although many explanations for the above patterns are possible (including sampling error), we believe a likely explanation might be that the reef was commercially fished between the two sampling cruises with most of the fish occupying deep drowned reefs being harvested. As described in Section 5, it is believed that the reefs were heavily exploited for red snapper during the late 1950's, perhaps being almost entirely harvested. We suggest that this may be a reoccurring phenomenon resulting from a density-dependent response on the part of fishermen. When the trial and error method of fishing indicates commercial levels of fish are present, once discovered, they may be almost entirely harvested. Red snapper are exceedingly vulnerable to angling, and fishing effort typically remains focused at a site as long as catch per effort is productive.

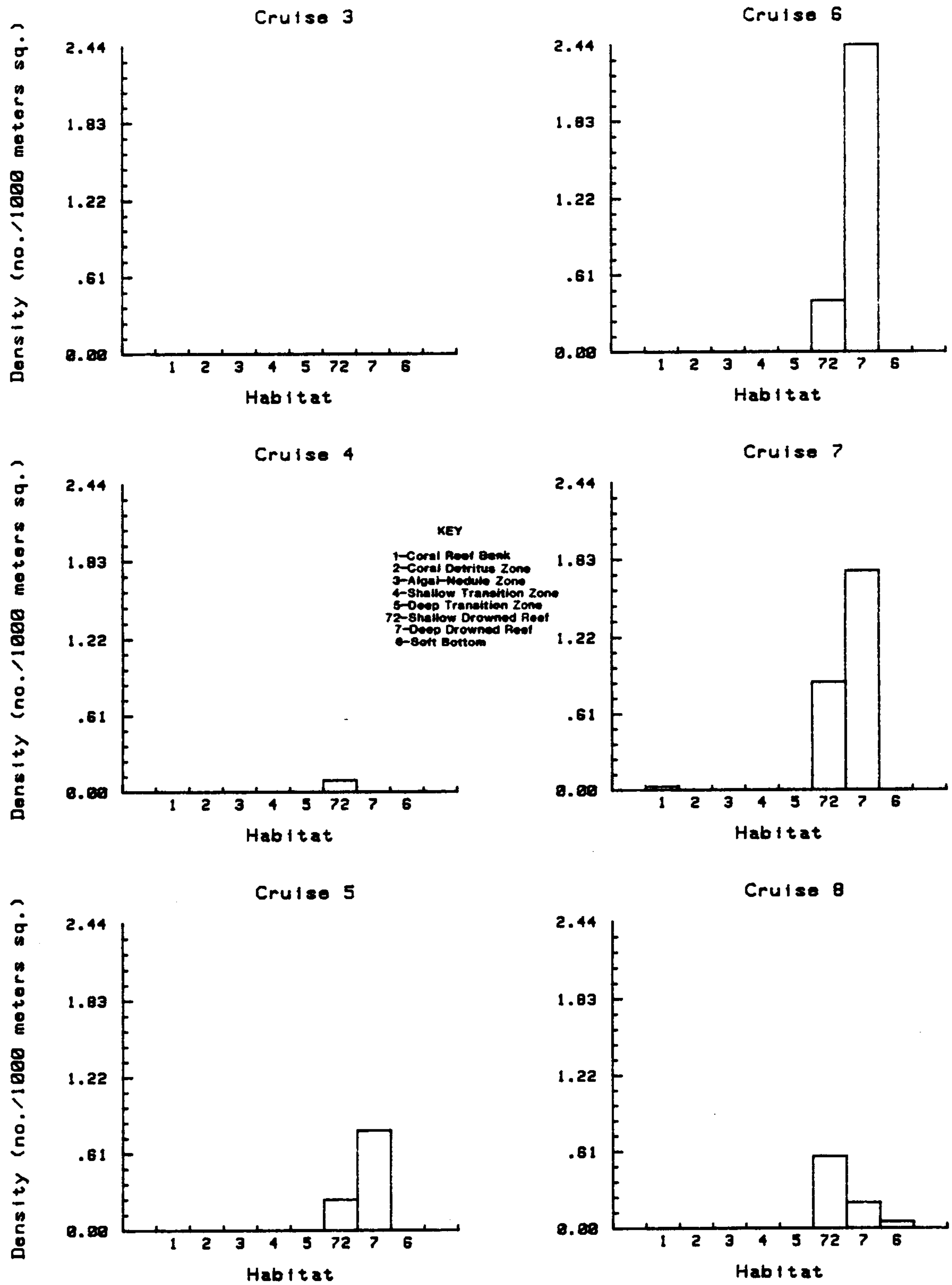


Fig. 6-57. Raw density by habitat for Lutjanus campechanus, red snapper. Cruises 3-8 East Flower Garden Bank.

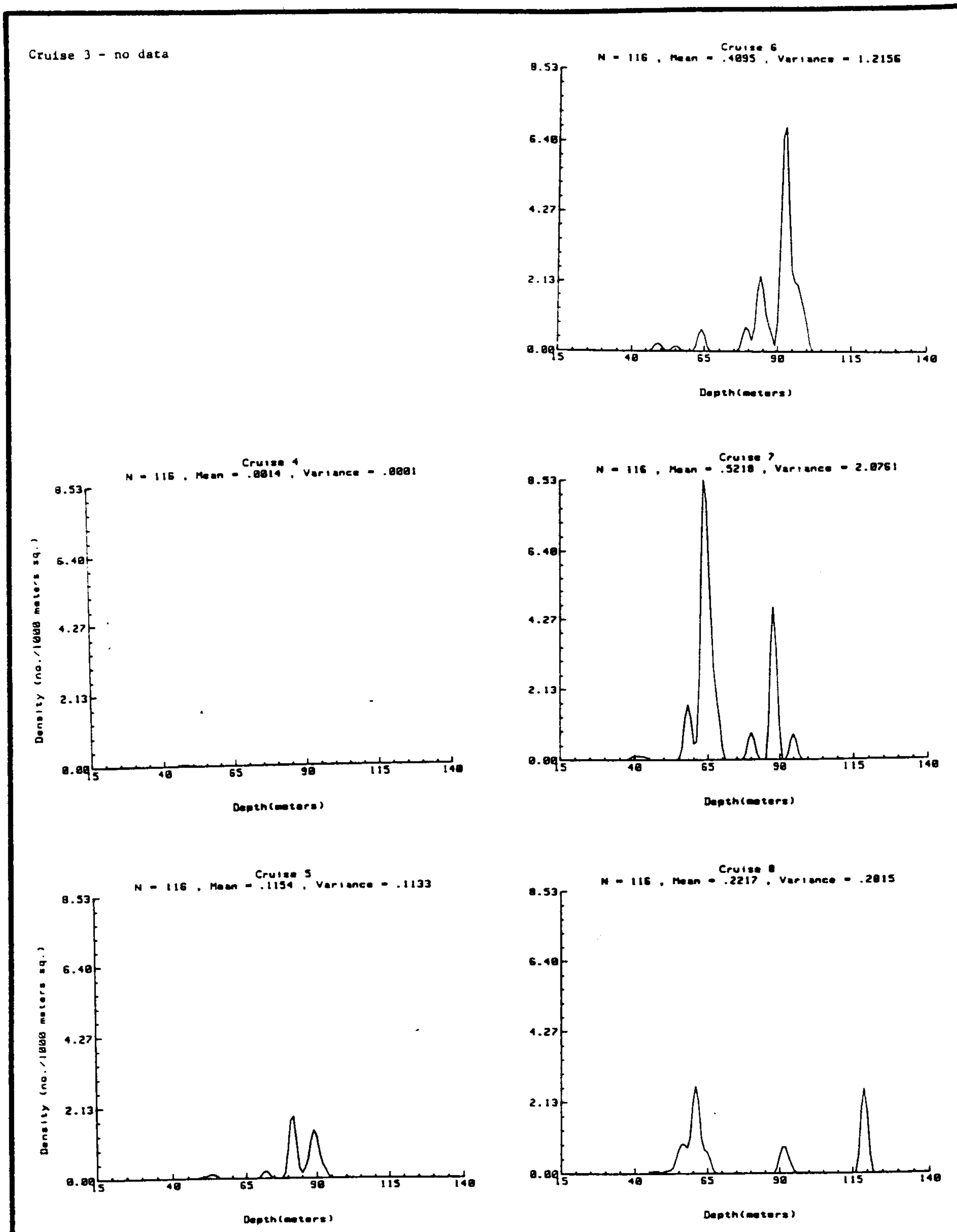


Fig. 6-58. Raw density by depth for Lutjanus campechanus, red snapper. Cruises 3-8 East Flower Garden Bank.

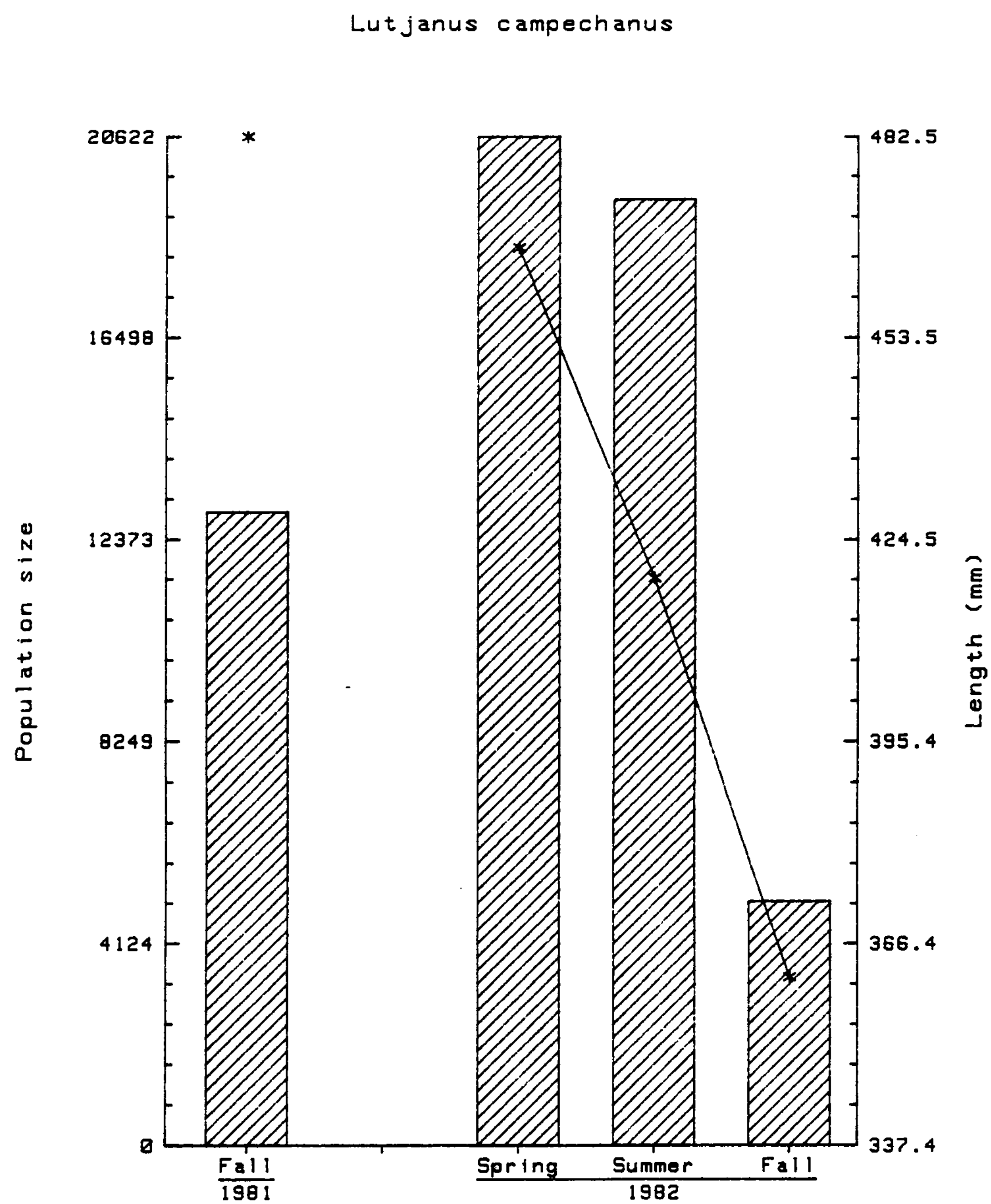


Fig. 6-59 . Standing stock and mean length* estimates for red snapper, Lutjanus campechanus, East Flower Garden Bank.

Bigeye (*Pricanthus arenatus*)

The bigeye is a deep-water species typically found over hard bottoms which attains a maximum length of about 30 cm. It occurs on both sides of the Atlantic, in the west Atlantic from New England and Bermuda to Argentina, including the Gulf of Mexico and Caribbean.

The bigeye is a nocturnal feeder preying upon large planktonic organisms such as ichthyoplankton, crabs, and shrimp. Randall (1967) reported the major food items of bigeyes are fish and fish larvae. They have been seen foraging a few feet off the bottom (Thresher 1980).

Although occasionally seen in other habitats, maximum densities of bigeye were typically associated with Deep Drowned Reefs (Fig. 6-60). Depth distribution ranged between 70 and 105 m, with the maximum abundances usually occuring at about 90 m (Fig. 6-61). The estimated population levels of bigeye indicated stocks to always have been in excess of 24,000 fish, ranging up to almost 56,000 fish (Fig. 6-62; also see Appendix 6-8). None of the analyses performed had results suggesting any impacts from the drilling operations which were conducted adjacent to the East Flower Garden Bank.

Reef Butterflyfish (*Chaetodon sedentarius*)

The butterflyfishes are very similar in appearance to the angelfishes, but a variety of work with the two groups supports the opinion that they should be in separate families (Thresher 1980). The reef butterflyfish, which grows to a length of about 15 cm, is a benthic species, usually occurring in pairs. Typically, it is closely associated with coral reef outcrops, but on the Flower Gardens it was also found on deep, drowned reefs and occasionally around sponge colonies and mounds of algal nodules. The tentacles of live coral may comprise an important food item for reef butterflyfish, but they also feed on worms, shrimp and other benthc invertebrates (Thresher 1980). The species occurs through the Caribbean into the Gulf of Mexico, and in the Atlantic from North Carolina to southern Florida.

Based upon abundance, important habitats for this species included the Coral Reef Bank, Algal-Nodule Zone, and both Shallow and Deep Drowned

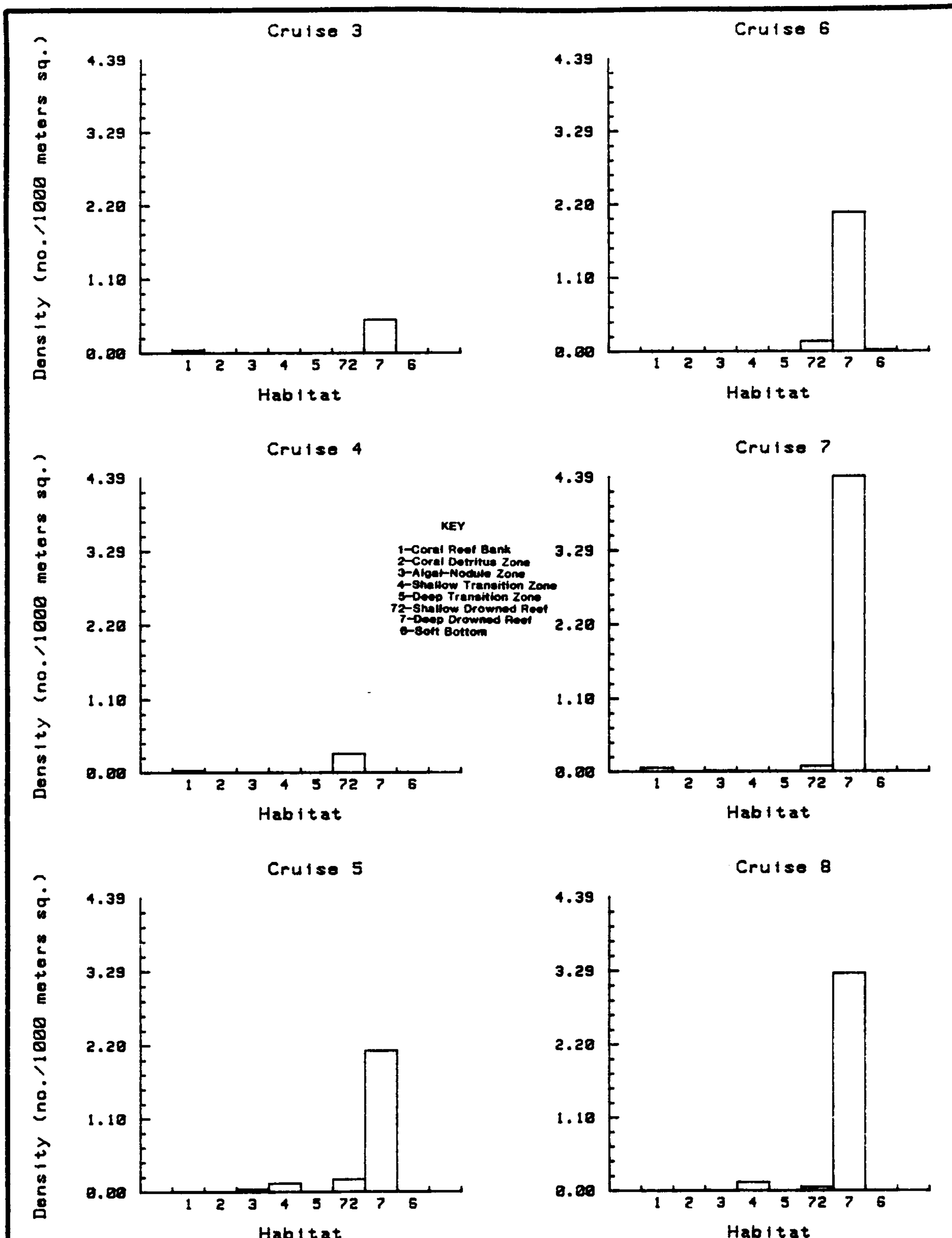


Fig. 6-60. Raw density by habitat for Priacanthus arenatus, bigeye. Cruises 3-8 East Flower Garden Bank.

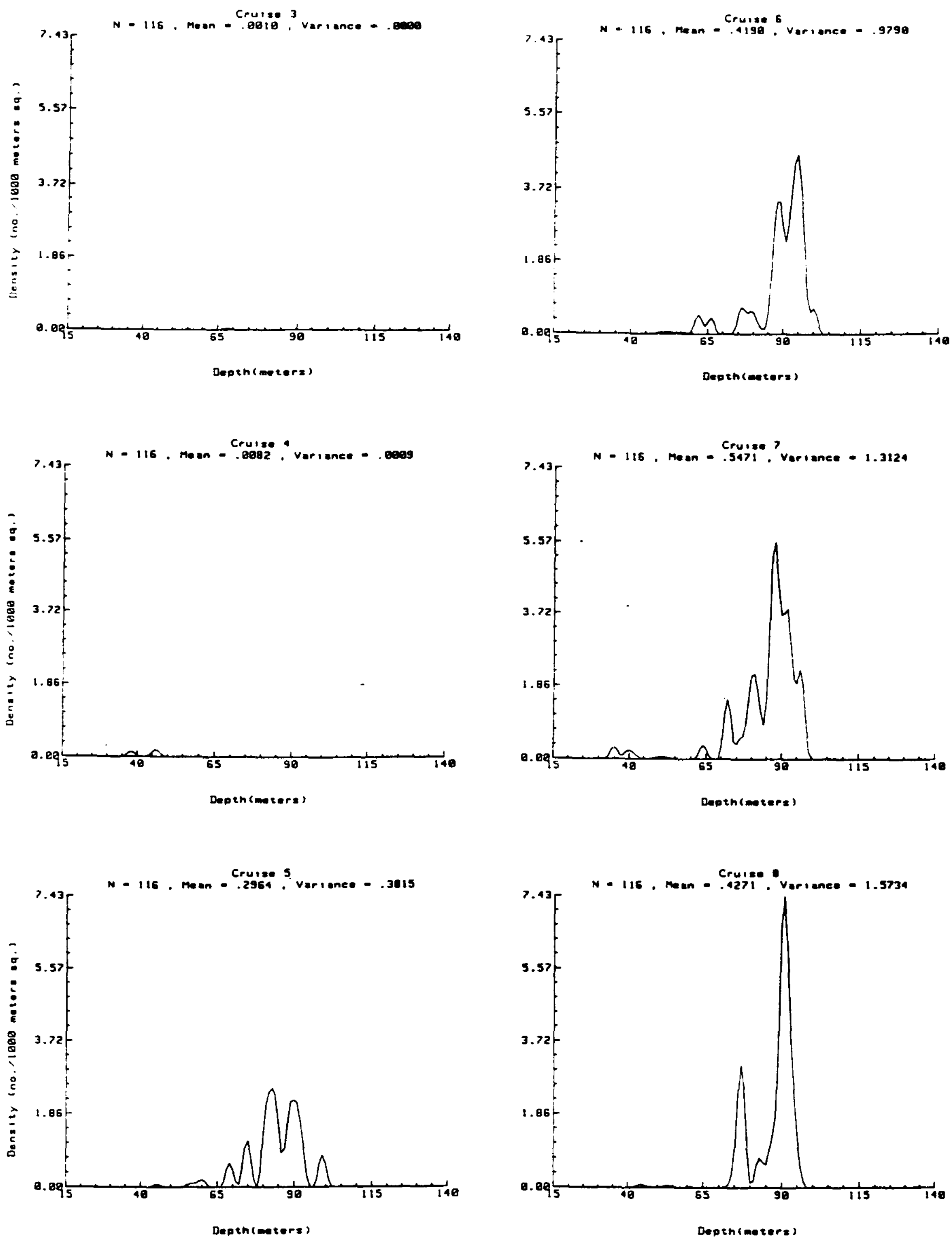


Fig. 6-61. Raw density by depth for Priacanthus arenatus, bigeye. Cruises 3-8 East Flower Garden Bank.

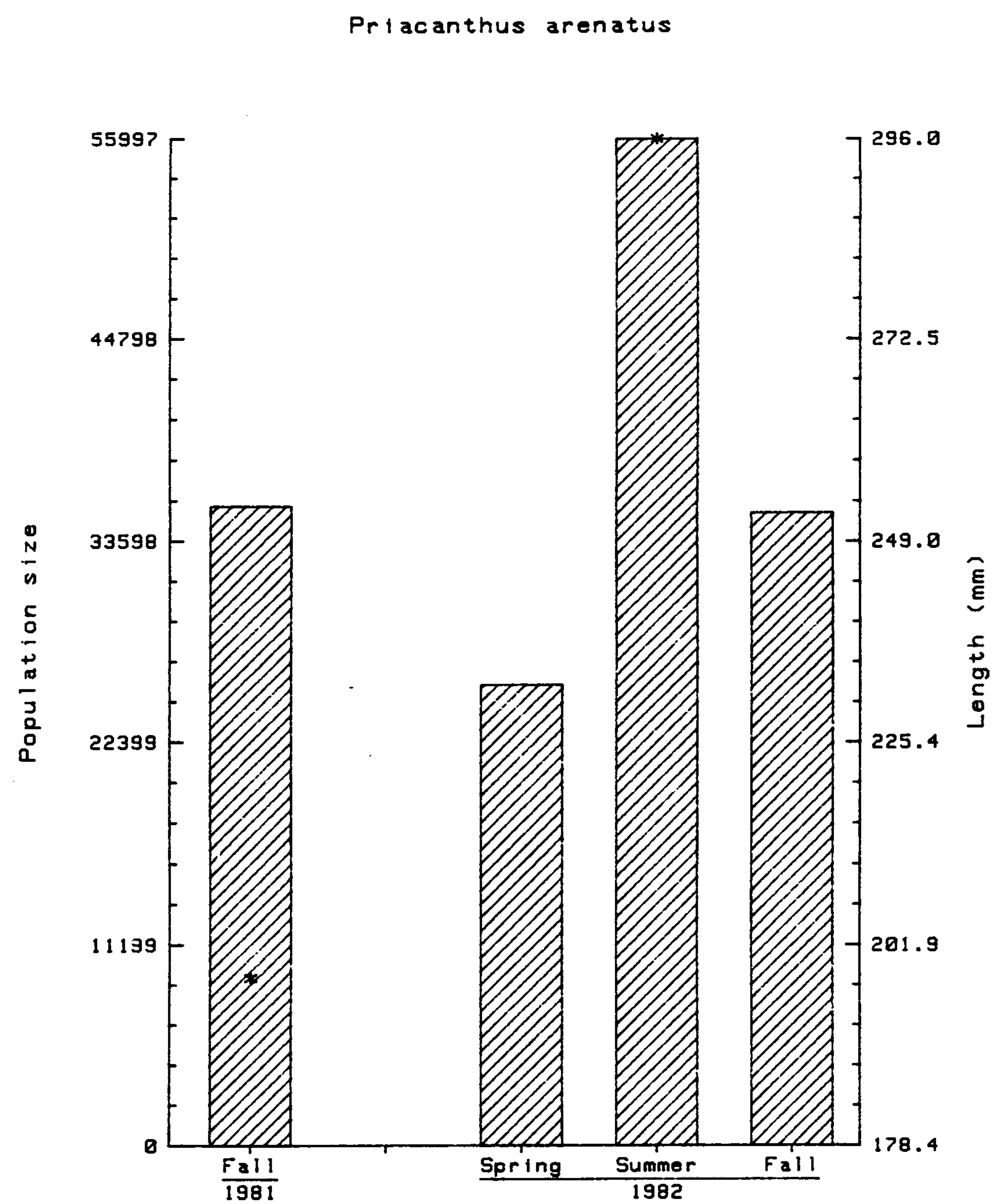


Fig. 6-62. Standing stock and mean length* estimates for bigeye, Priacanthus arenatus, East Flower Garden Bank.

Reefs (Fig. 6-63). Distribution by depth ranged from 17 m to 100 m (Fig. 6-64). Density maximums by depth were variable but two major peaks seemed evident in the majority of cruises, one on the Coral Reef Bank between 30 and 40 m, and another in the Shallow Drowned Reef Habitat at depths of 55 to 65 m.

Estimated standing stocks of reef butterflyfish on the East Flower Garden Banks ranged from about 30,000 to over 84,000 fish. Stock levels increased from spring to fall of 1982, with the fall level of 1982 being higher than the level which was estimated for fall 1981 (Fig. 6-65; also see Appendix 6-8).

Red Porgy (*Pagrus sedecim*)[1]

The red porgy, conspecific with *Pagrus pagrus* (Manooch et al. 1976), is found from New York to Argentina, excluding the West Indies. Common off the Florida panhandle, this species is considered rare in the western Gulf (Hoese and Moore 1977), and has not been previously reported from the Flower Gardens.

Representatives of red porgy were observed once in Upper Coral Reef Habitat (Cruise 3), twice in Deep Drowned Reef Habitat (Cruises 5 and 6) and twice in Shallow Drowned Reef Habitat (Cruises 6 and 7, Fig. 6-66). With the exception of the fish seen on Cruise 3 near the top of the reef, red porgy were usually sighted at depths between 65 and 90 m (Fig. 6-67).

Red porgy were never abundant, the maximum standing stock was estimated to have been about 5400 fish in fall of 1981 (Fig. 6-68; also see Appendix 6-8). In contrast, red porgy were not even observed in fall of 1982).

Knobbed Porgy (*Calamus nodosus*)

The knobbed porgy ranges from North Carolina to Yucatan, including the Gulf of Mexico. It attains a maximum length of about 61 cm. They are benthic feeders, preying upon invertebrates such as sea urchins, crabs and molluscs. While seldom abundant, they were seen on every cruise.

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[1] American Fisheries Society 1970 was current at start of project.

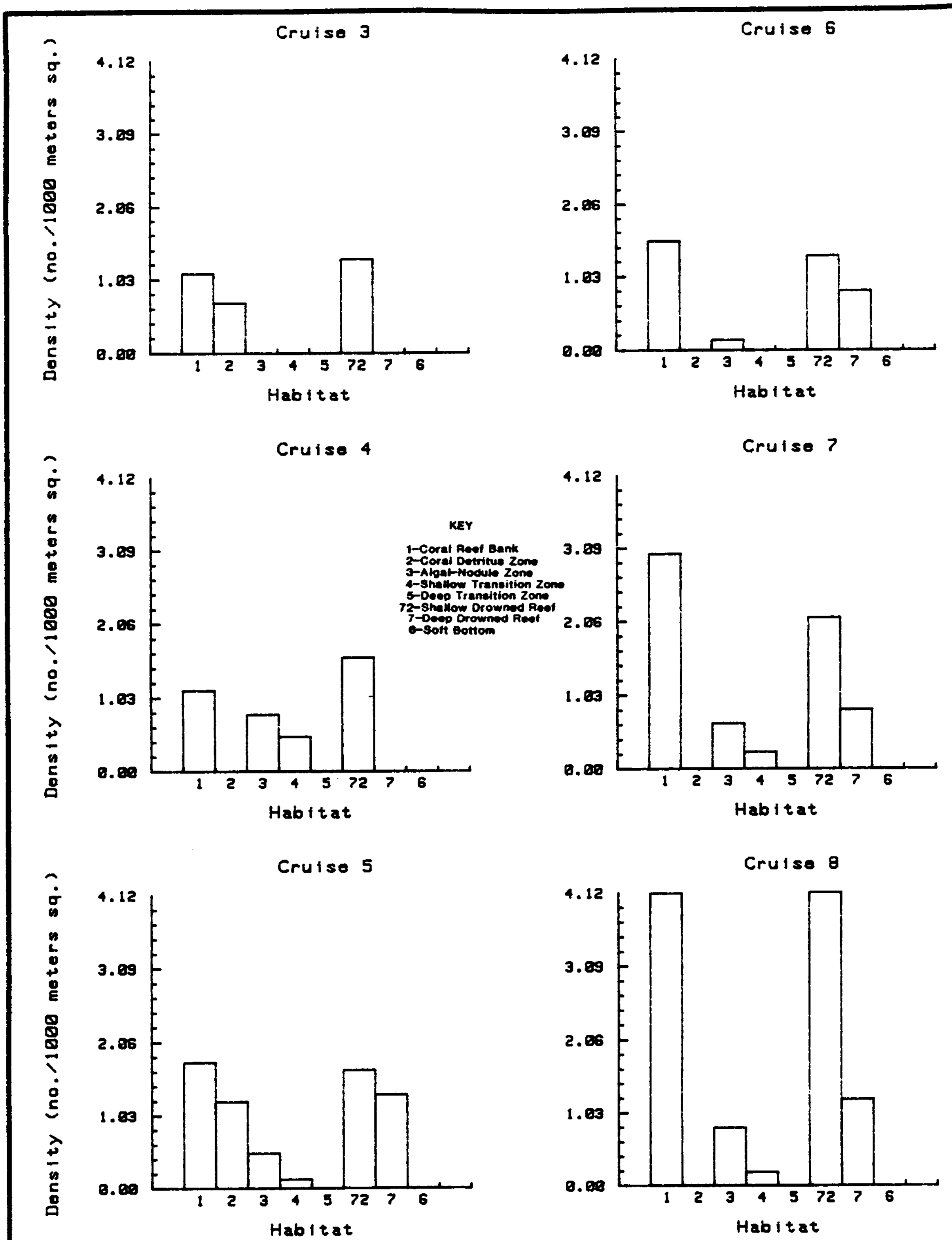

Fig. 6-63. Raw density by habitat for Chaetodon sedentarius, reef butterflyfish. Cruises 3-8 East Flower Garden Bank.

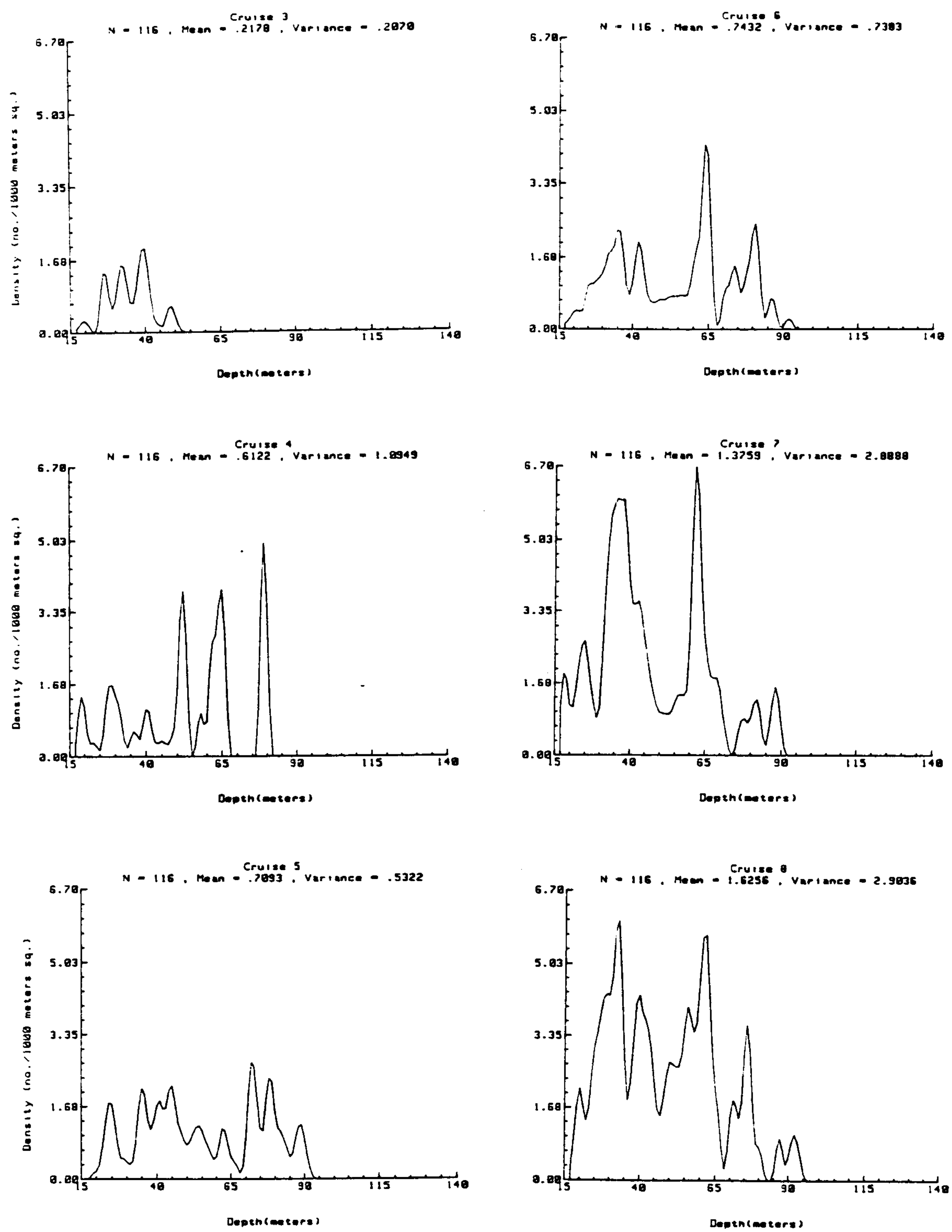

Fig. 6-64. Raw density by depth for Chaetodon sedentarius, reef butterflyfish. Cruises 3-8 East Flower Garden Bank.

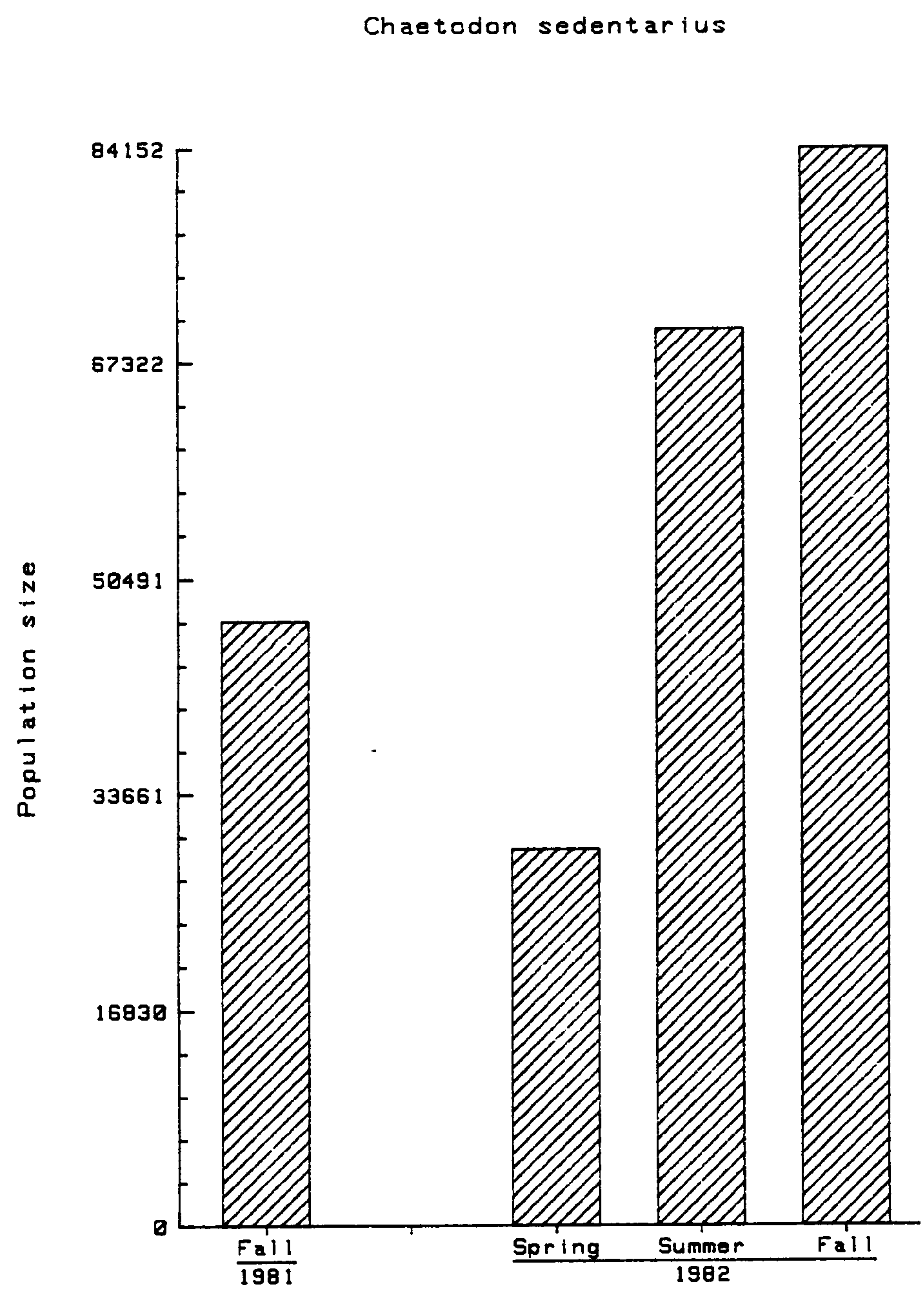

Fig. 6-65. Standing stock estimates for reef butterflyfish, Chaetodon sedentarius, East Flower Garden Bank.

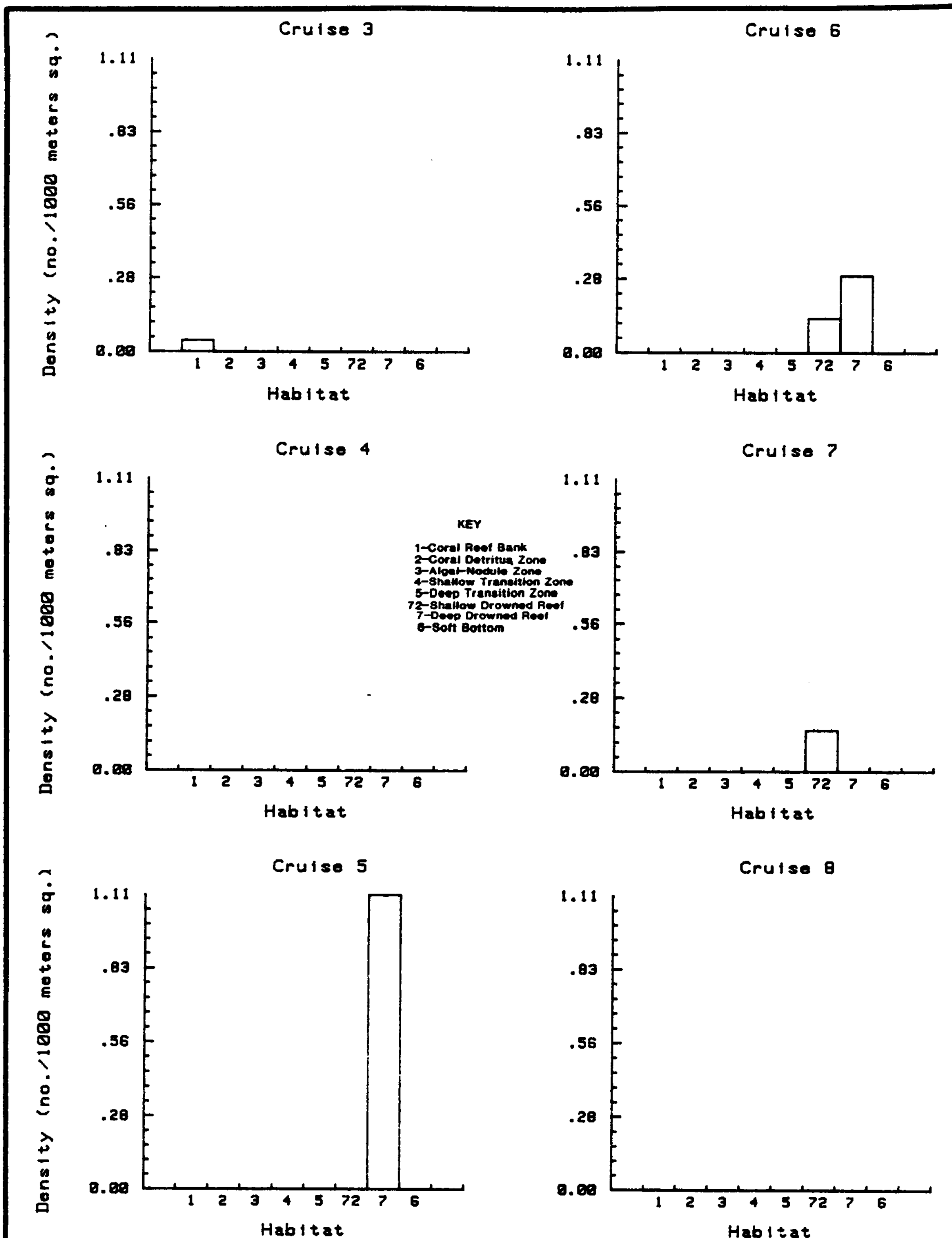

Fig. 6-66. Raw density by habitat for Pagrus sedecim, red porgy. Cruises 3-8 East Flower Garden Bank.

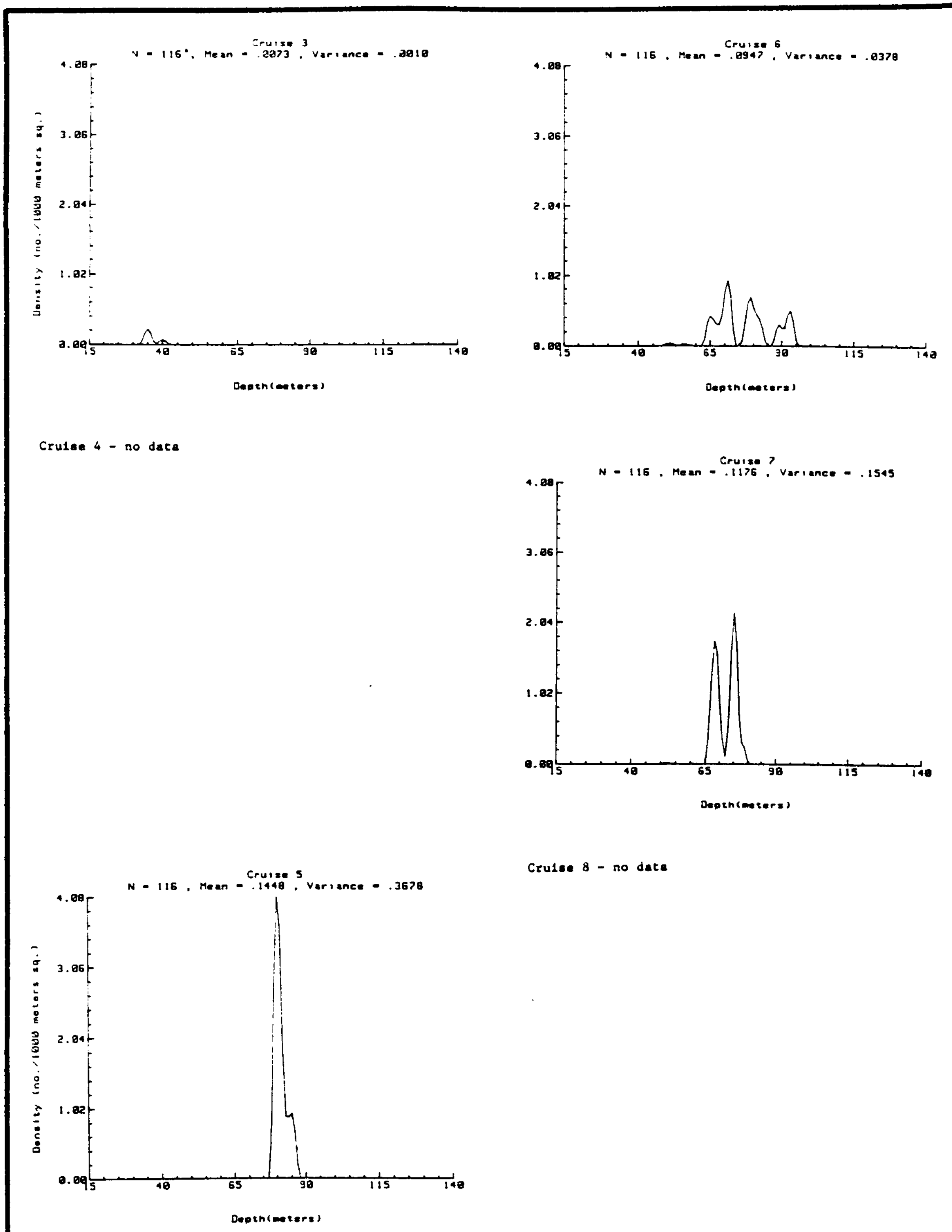

Fig. 6-67. Raw density by depth for Pagrus sedecum, red porgy. Cruises 3-8 East Flower Garden Bank.

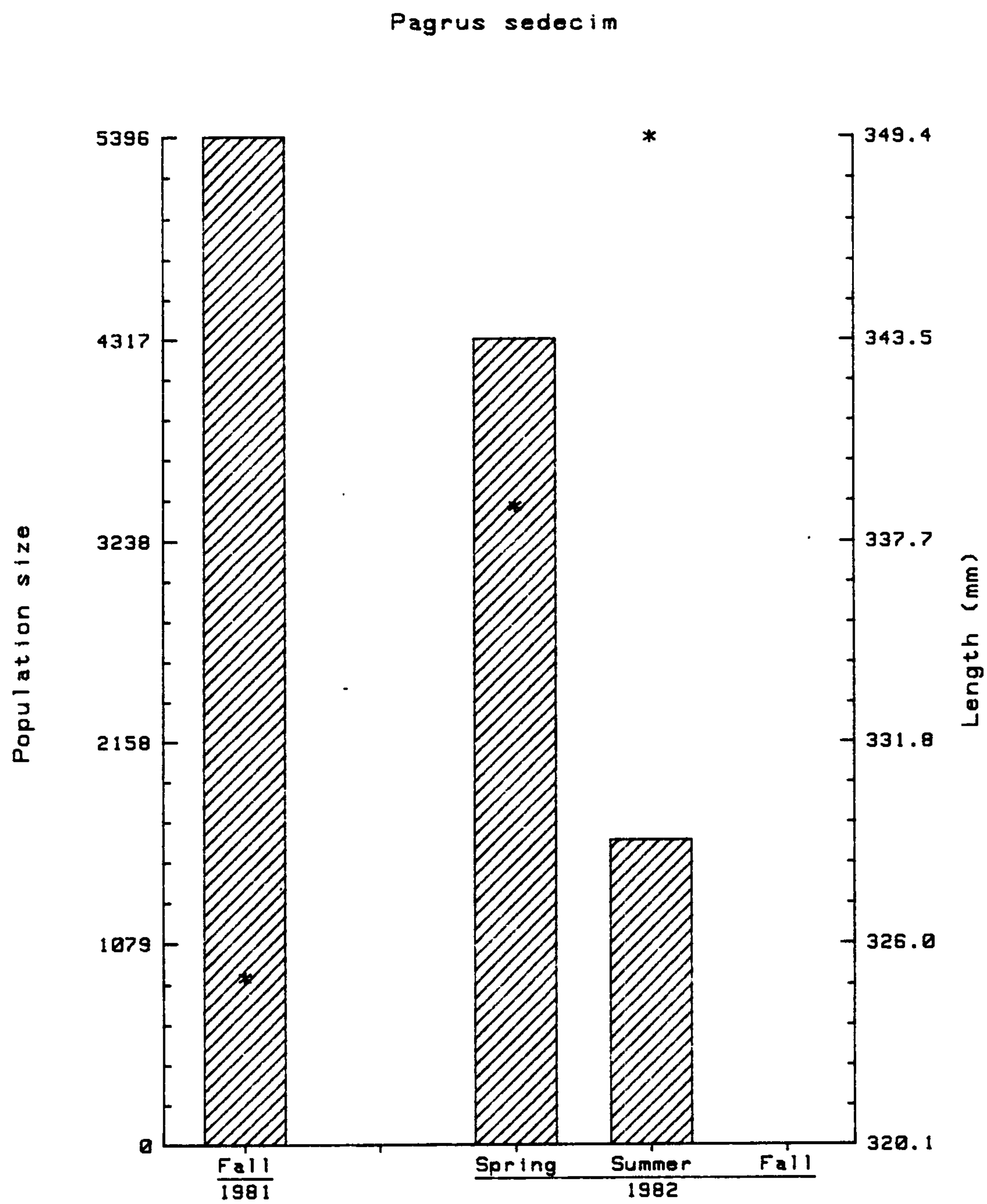

Fig. 6-68. Standing stock and mean length* estimates for red porgy, Pagrus sedecim, East Flower Garden Bank.

The knobbed porgy was primarily associated with Upper Coral Reef and Shallow Drowned Reef Habitats (Fig. 6-69). The density spike in Habitat Type 2 (Coral Detritus Zone) on Cruise 4 resulted from the presence of a few fish seen within a small area of transect.

The knobbed porgy was generally found in shallower depths than the red porgy. The maximum depth for the knobbed porgy was about 80 m but density peaks typically occurred much shallower, between 35 and 45 m for most cruises (Fig. 6-70). The shallowest observation was at about 20 m of depth and the maximum density encountered was about 1.7 individuals/1000 m^2 at 25 m of depth.

Estimated population sizes of knobbed porgy ranged from a low of about 2000 (spring 1982) to a high of nearly 6000 in fall of 1982 (Fig. 6-71; also see Appendix 6-8). The fall population of 1982 was indicated to have been much higher than the population which was present during fall of 1981 (not significant at $\alpha = 0.05$).

French Angelfish (Pomacanthus paru)

The French angelfish is found throughout the tropical Atlantic and, in the western Atlantic, from the Bahamas and Florida through the Caribbean to southeastern Brazil. It has also been introduced to Bermuda. It nearly always travels in pairs, as do all large angelfish species. French angelfish are known to cover large areas of a reef during a single day browsing for food (Thresher 1980). Sponges are reported to be the principle items in the diet of this, as well as other angelfishes. The diet of angelfishes also includes tunicates, zoantharians and algae (Randall 1967). Video observations from this study have shown French angelfish feeding on thick, green leafy algae on the Flower Garden nodule terrace. This species reaches a length of about 36 cm.

The primary habitat of the French angelfish on the Flower Garden Banks was the Algal-Nodule Sponge zone, including the associated transition areas (Habitat Types 2-5). Other habitats utilized by the French angelfish in a major way included the Upper Coral Reef and Shallow Drowned Reef Zones (Fig. 6-72).

The French angelfish was restricted to depths shallower than 70 m with peaks in density normally occurring between 30 and 40 m (Fig. 6-73).

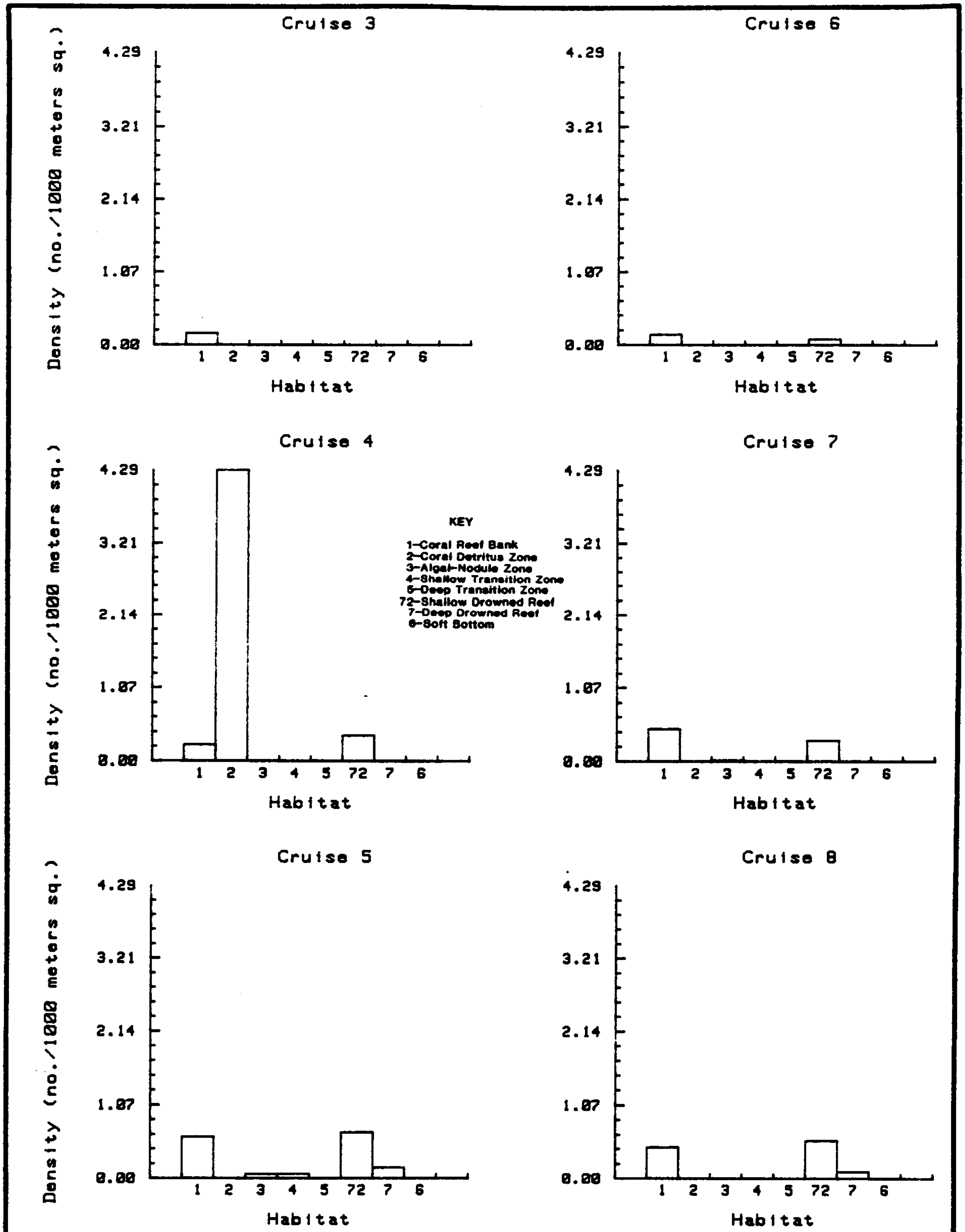

Fig. 6-69. Raw density by habitat for Calamus nodosus, knobbed porgy. Cruises 3-8 East Flower Garden Bank.

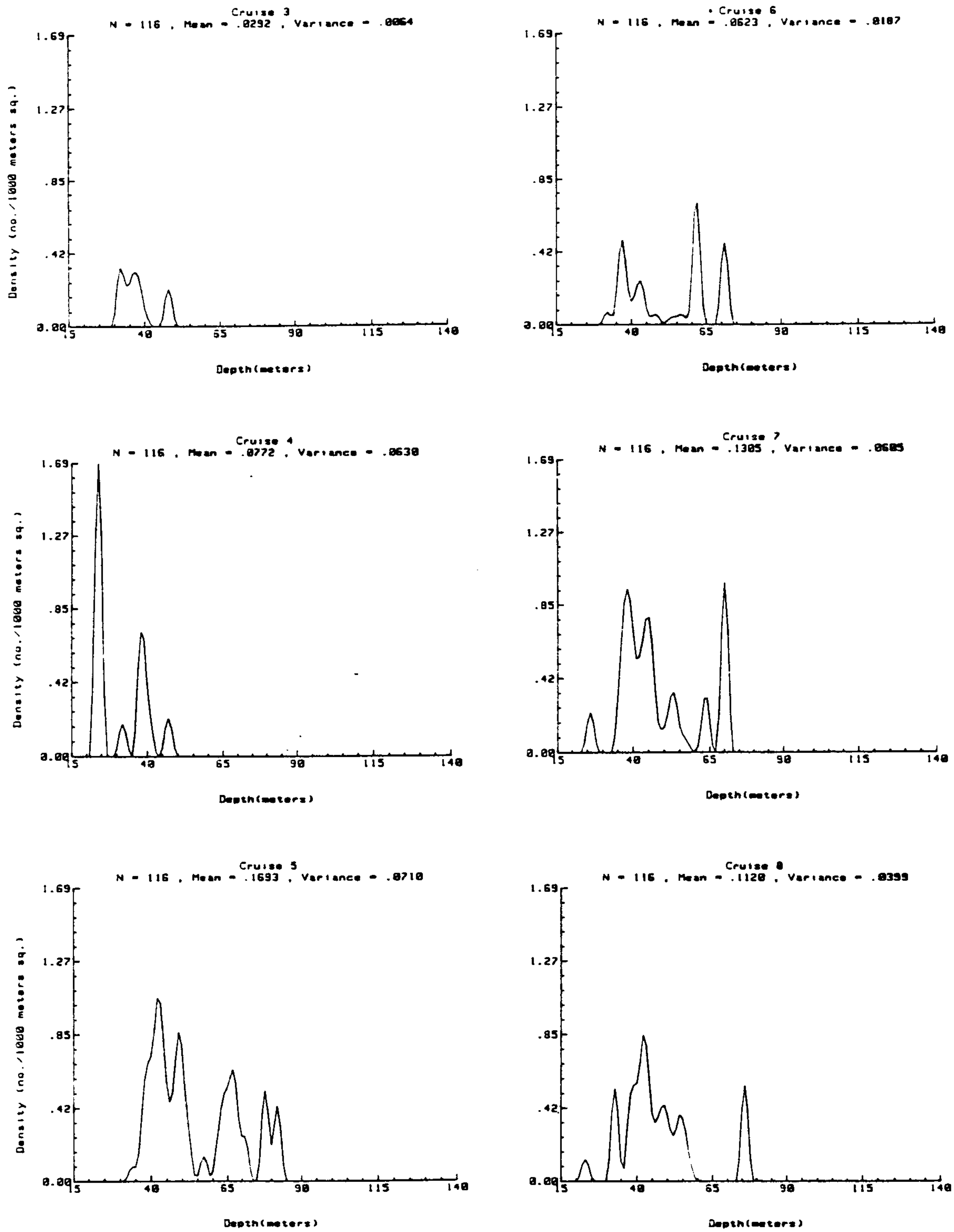

Fig. 6-70. Raw density by depth for Calamus nodosus, knobbed porgy. Cruises 3-8 East Flower Garden Bank.

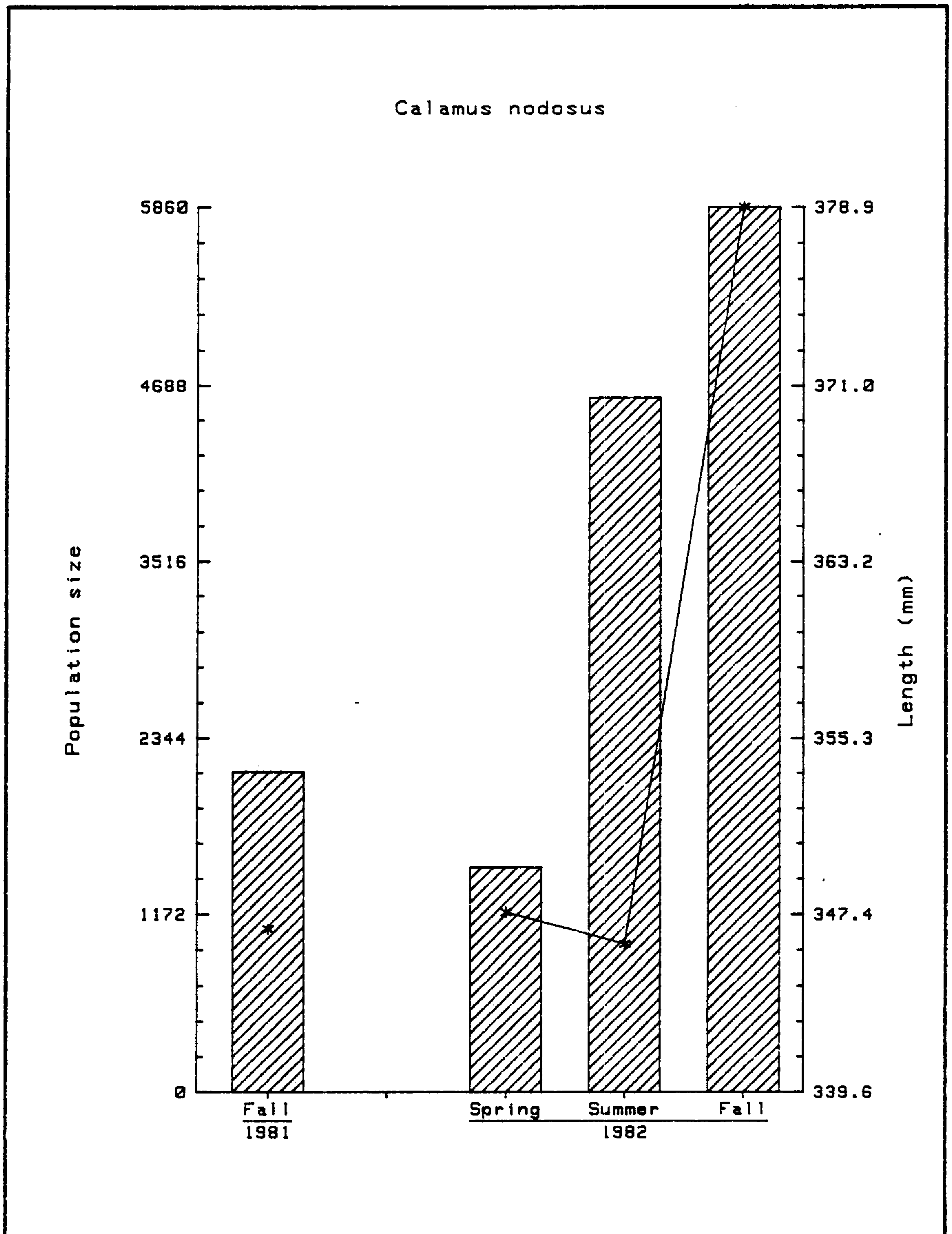

Fig. 6-71. Standing stock and mean length* estimates for knobbed porgy, Calamus nodosus, East Flower Garden Bank.

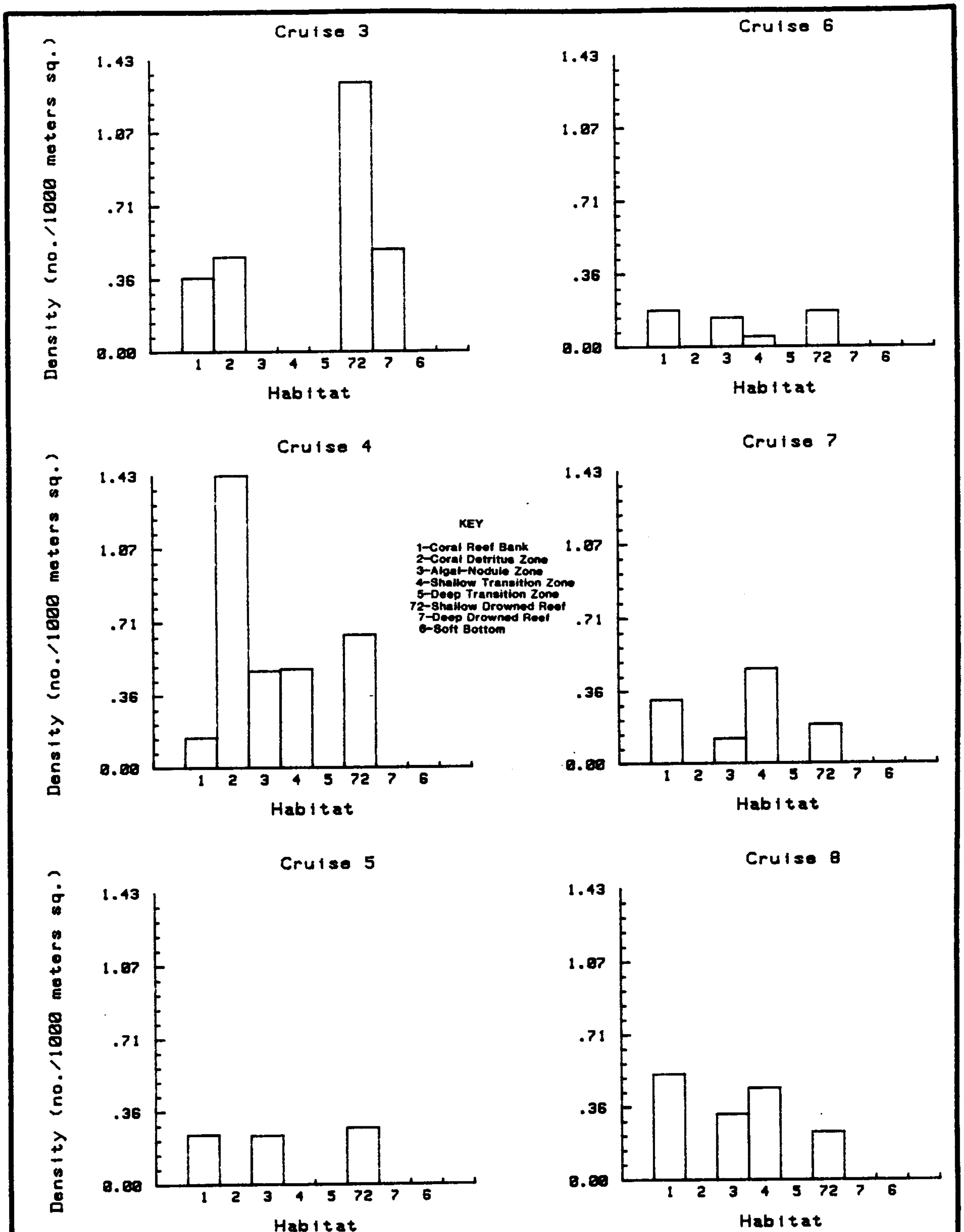

Fig. 6-72. Raw density by habitat for Pomacanthus paru, French angelfish. Cruises 3-8 East Flower Garden Bank.

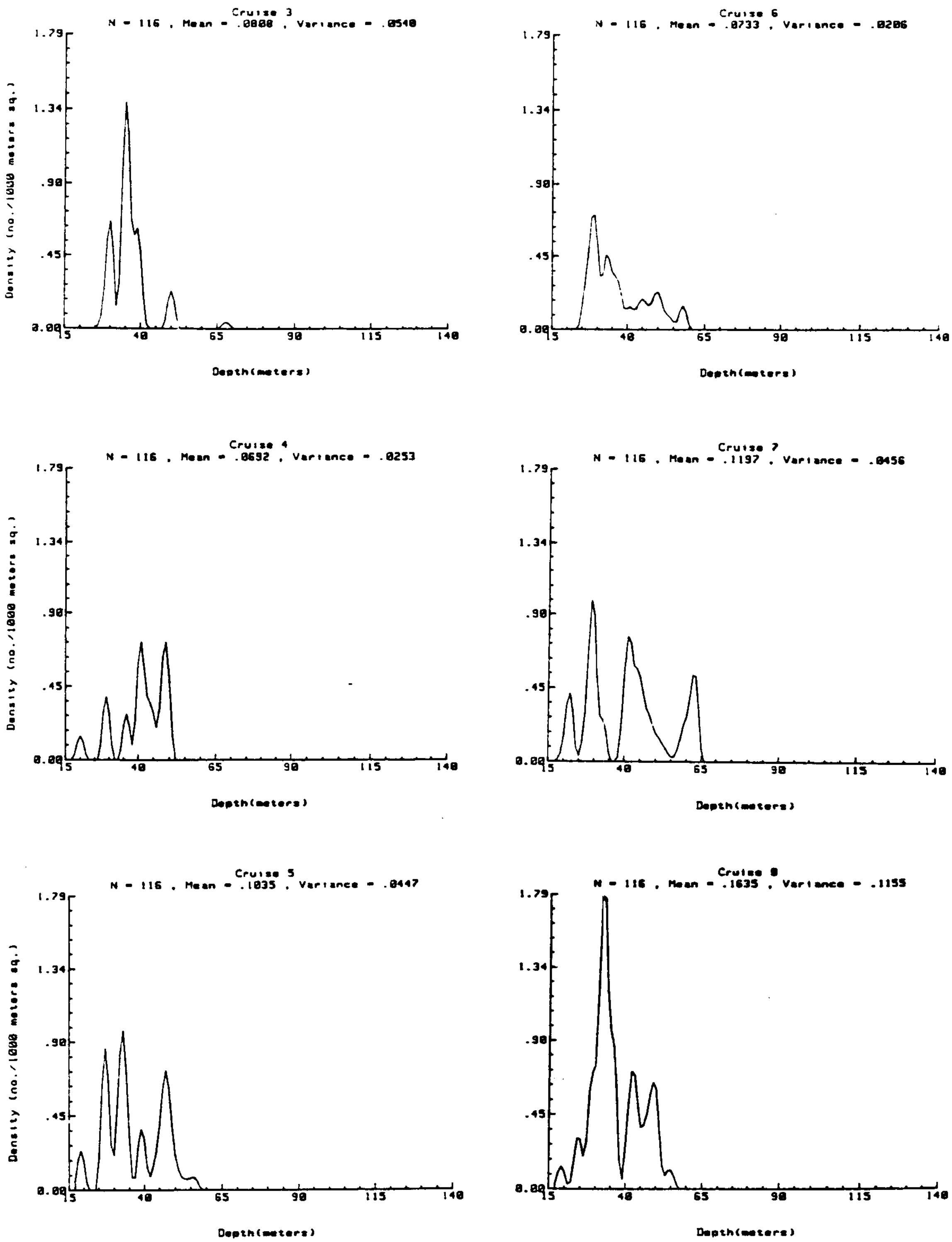

Fig. 6-73 Raw density by depth for Pomacanthus paru, French angelfish. Cruises 3-8 East Flower Garden Bank.

Though not common, this species was also seen as shallow as 17 m on the top of the bank. The maximum density for a given depth was about 1.8 individuals/1000 m^2 which was seen at 33 m during Cruise 8.

Standing stock levels of French angelfish on the East Flower Garden Bank were estimated to have been as high as 17,873 individuals (Fig. 6-74; also see Appendix 6-8). The estimates for Cruises 5-8 resulted in the same pattern as has been shown for several other species. Population levels increased over the spring to fall period of 1982, with the fall 1982 level being markedly higher than the level observed during fall of 1981 (not significant at α = 0.05).

Squirrelfish Group (*Holocentrus* spp.)

Two species were represented in this group. *Holocentrus ascensionis* (Osbeck), the longjaw squirrelfish, and the squirrelfish, *H. rufus* (Walbaum). The major visual distinction between the two is the presence of triangular white marks behind the ends of each dorsal fin spine of *H. rufus*. This distinction could not be reliably made from the videotapes. However, the great majority of records were probably the longjaw squirrelfish based upon results from hook-and-line captures.

Holocenthrus ascensionis occurs from New York through the Caribbean to Brazil, including the Gulf of Mexico, also on islands off the tropical middle and eastern Atlantic. *Holocentrus rufus* is known from offshore reefs and the Caribbean. Also it is recorded from Bermuda and the Carolinas.

Young squirrelfishes are planktonic. Adults assume a bottom-dwelling existence closely associated with reefs or other outcrops. These habitats are used for cover during daylight hours. Individuals have been known to utilize the same shelter for as long as a month (Thresher 1980).

All holocentrids are predators. These two species feed on a variety of benthic crustaceans, molluscs and an occasional fish (Thresher 1980). Hoese and Moore (1977) reported a maximum length of 61 cm for longjaw squirrelfish and 31 cm for the squirrelfish.

Squirrelfish were particularly associated with Shallow Drowned Reef Habitats although they were also commonly seen in the Upper Coral Reef Zone (Fig. 6-75). They were seen at depths from 20 to 93 m, but were

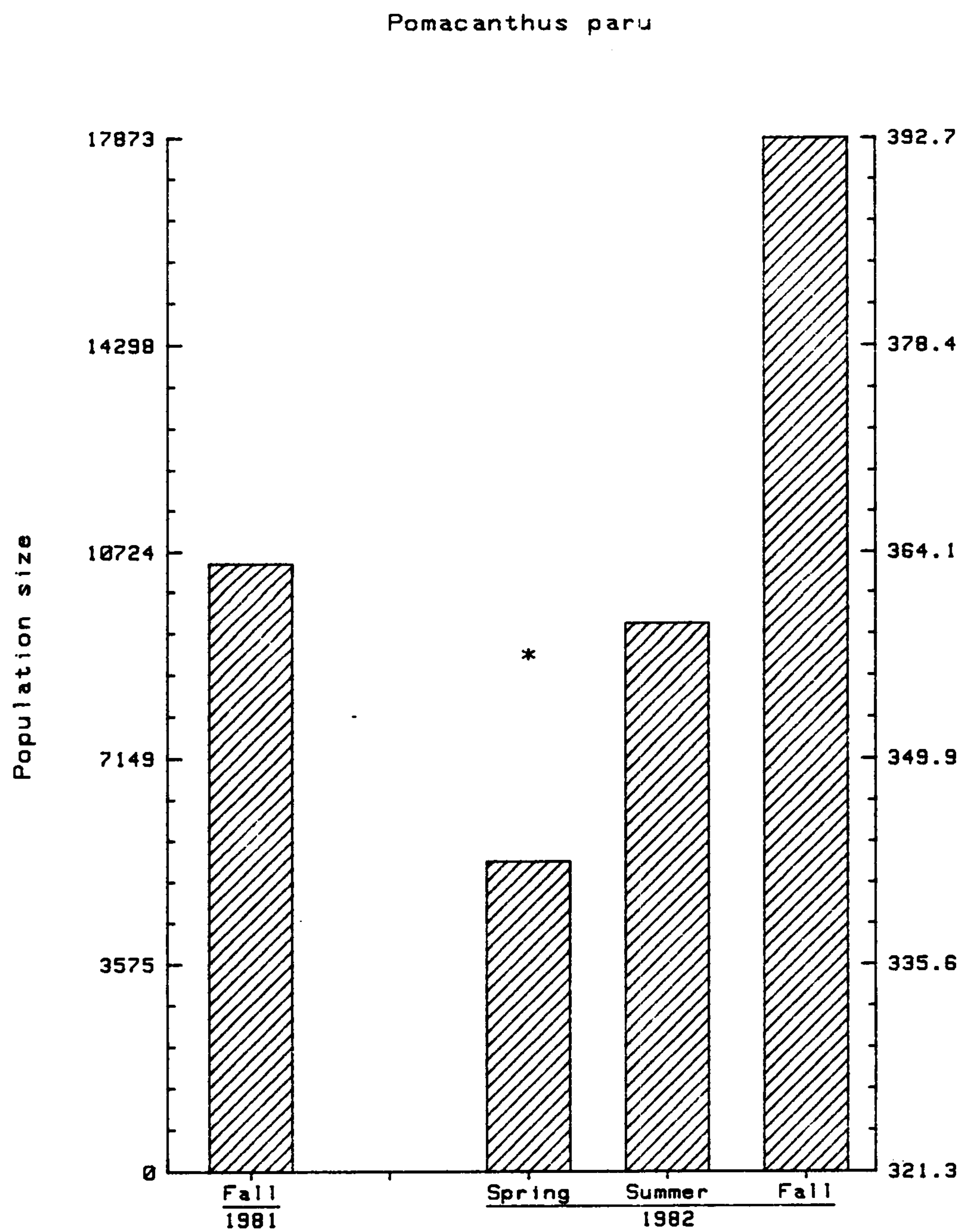

Fig. 6-74. Standing stock and mean length* estimates for French angelfish, Pomacanthus paru, East Flower Garden Bank.

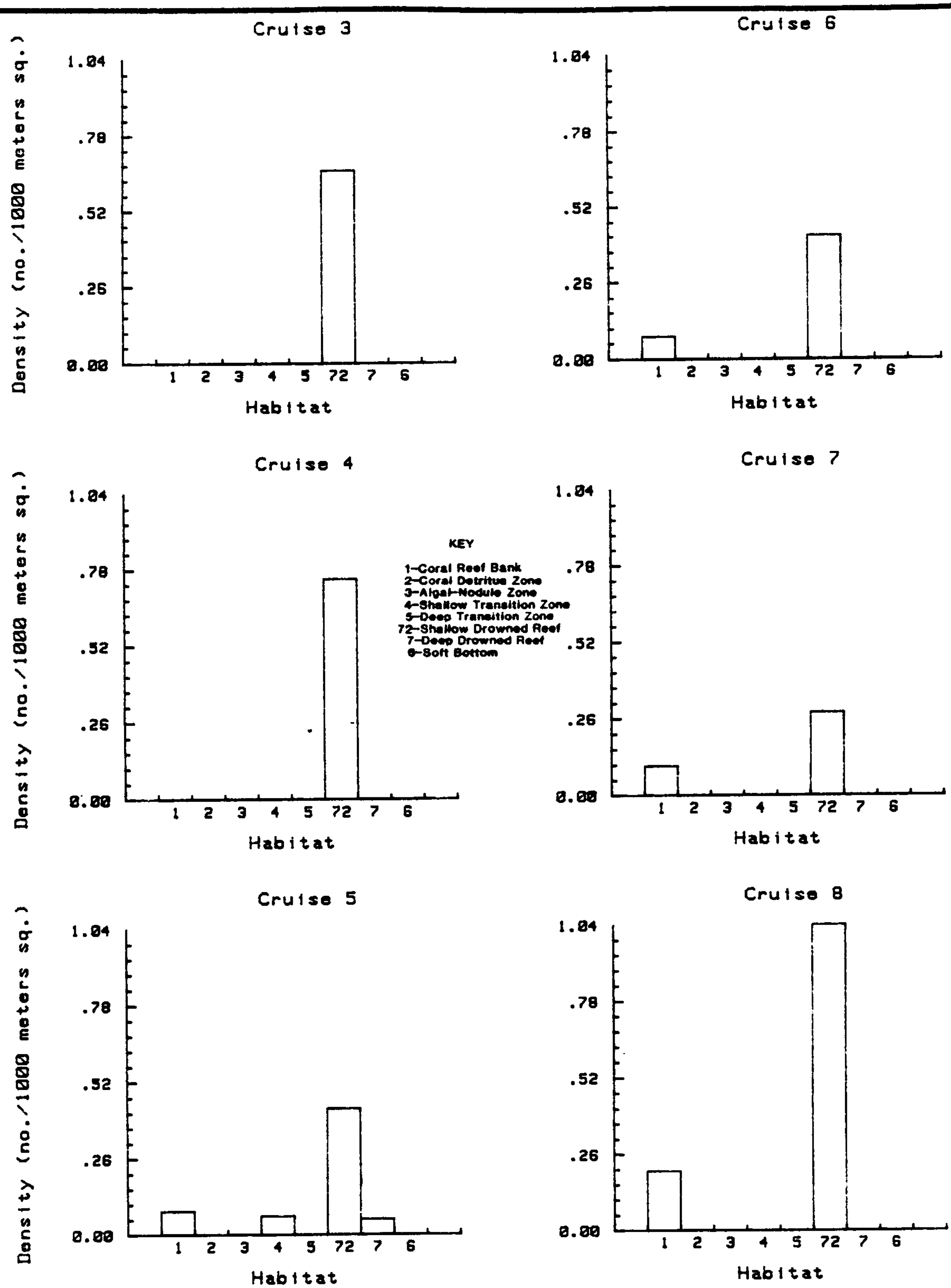

Fig. 6-75. Raw density by habitat for Holocentrus spp., squirrelfish. Cruises 3-8 East Flower Garden Bank.

usually most abundant at depths between 40 to 65 m (Fig. 6-76). The highest standing stock was estimated to have been 7170 individuals present in fall of 1982. The marked decrease in mean length between summer and fall of 1982, coupled with the population increase, suggests recruitment (Fig. 6-77; also see Appendix 6-8). Little variation in standing stocks was evident during other seasons.

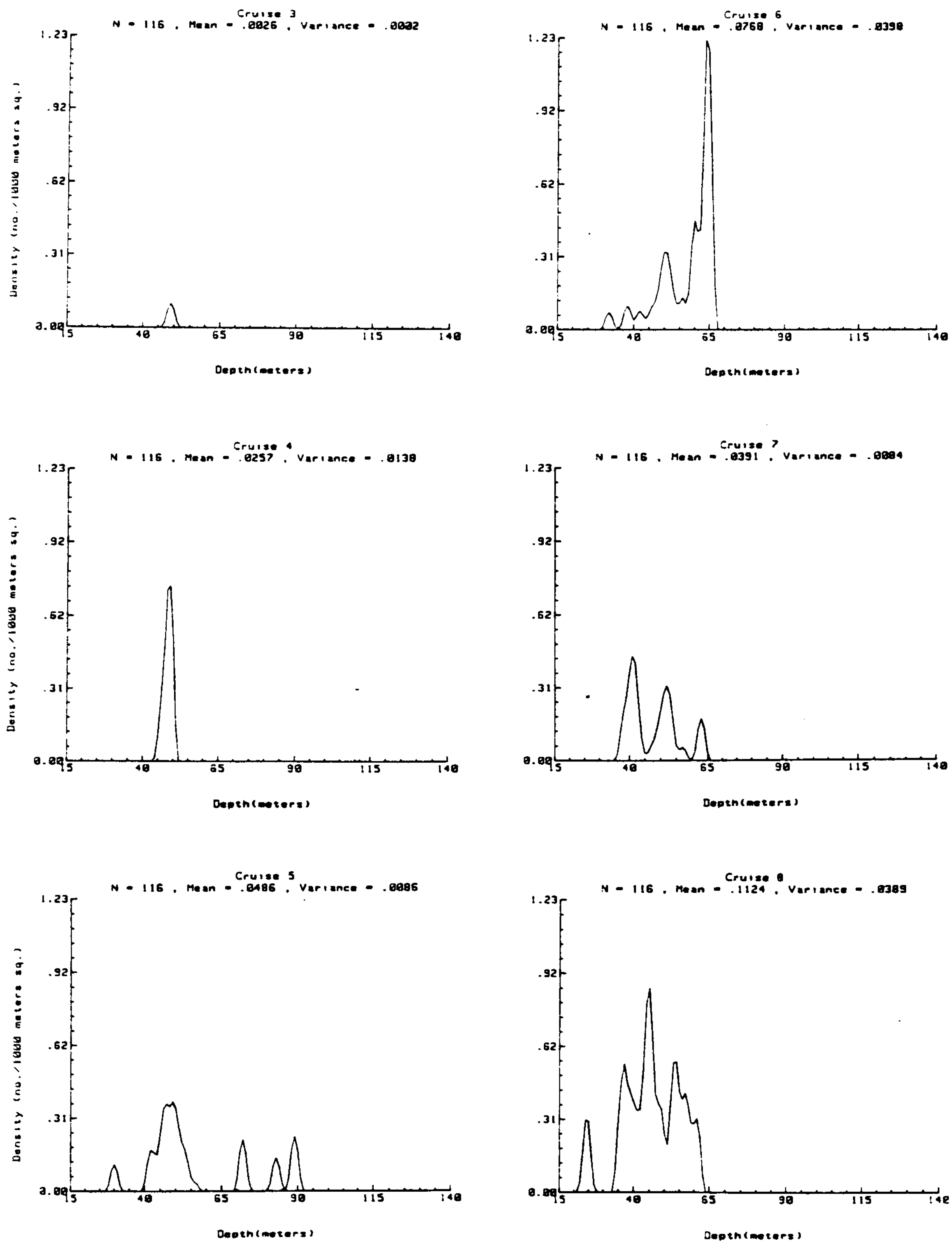

Fig. 6-76. Raw density by depth for Holocentrus spp., squirrelfish. Cruises 3-8 East Flower Garden Bank.

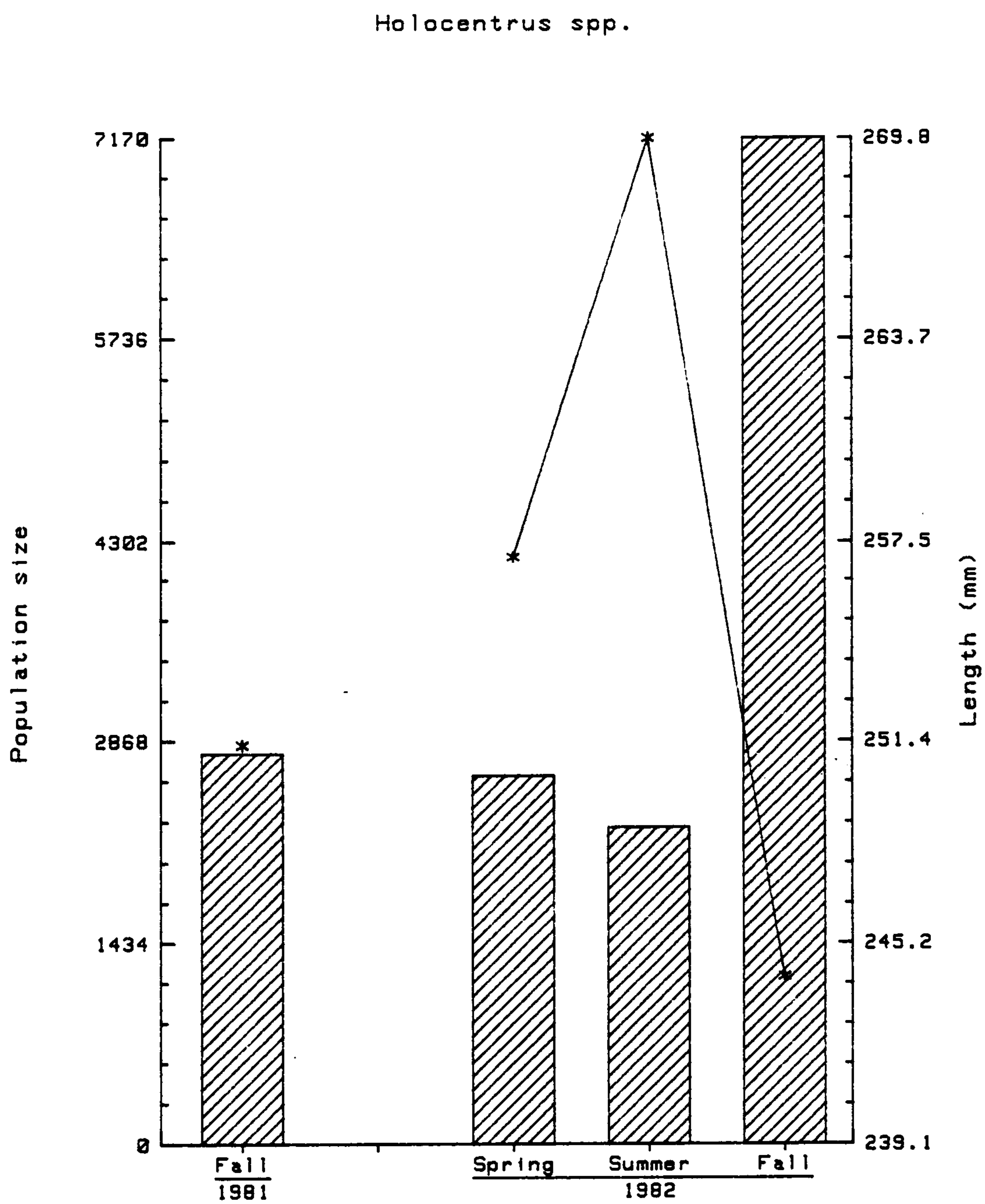

Fig. 6-77. Standing stock and mean length* estimates for squirrelfish, Holocentrus spp., East Flower Garden Bank.

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APPENDICES

APPENDIX 1-1. A BIBLIOGRAPHY ON THE EAST AND WEST FLOWER GARDEN BANKS

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Appendix 3-1. Final habitat type codes, December 1982, Form 804, Project US80, Work Unit B5.

I. Coral Reef Bank	
Predominantly Living Coral	
Greater than 50% hard substrate (outcrop) = A	10.1
Less than 50% hard substrate (outcrop) = B	10.3
Predominantly Dead Coral Rock	
Greater than 50% hard substrate (outcrop) = A	10.5
Less than 50% hard substrate (outcrop) = B	10.7
Finger Coral/Coralline Algal Ridges - with intermittent outcops of hermatypic coral	15.1
- without hermatypic coral outcrops	15.3
II. Coral Detritus Zone	
Coarse carbonate sand with less than 10% rubble or small algal nodules	20.1
Coral rubble (gravel/finger size coral derived from bank)	20.3
Coral rubble with prevalent leafy algae	20.5
III. Algal Nodule Sponge Zone (at least 75% cover of algal nodules)	
- without prevalent leafy algae	30.1
- with prevalent leafy algae	30.3
IV. Transition Mixtures of Coral Detritus and Algal Nodules	
Without prevalent leafy algae	
Up to 25% nodule cover	40.1
25-50% nodule cover	40.3
50-75% nodule cover	40.5
With prevalent leafy algae	
Up to 25% nodule cover	45.1
25-50% nodule cover	45.3
50-75% nodule cover	45.5

V. Transition Zone (<75% cover Algal Nodules/Rubble to Soft Bottom)	
With prevalent leafy algae	50.1
Without prevalent leafy algae	50.3
VI. Soft Bottom - (coral/coralline algae sands grading to sandy/silty clays with depth)	
Without prevalent crinoids	60.1
With prevalent crinoids	65.1
VII. Drowned Reef Zone (Adjacent carbonate rock outcrops occuring within 50 m of each other)	
With surrounding coral/coralline algal sand or fine sediments	
Low relief (less than 1m)	70.1
Moderate relief (1-4m)	70.3
High relief (greater than 4m)	70.5
With surrounding algal nodule or transition zones	
Low relief (less than 1m)	72.1
Moderate relief (1-4m)	72.3
High relief (greater than 4m)	72.5
VIII. Artifical Reef Zones	
Near or within platform legs	80.1
Soft bottom adjacent to platform	80.3
Midwater around platform (within 100m)	80.5

Appendix 3-2. Species code and identification index description.

Species code description

Code numbers were assigned from the American Fisheries Society special Publication No. 6. A list of common and scientific names of fishes from the United States and Canada. Third Edition, 1970.

The five digit code was derived by first numbering all families in order from the beginning of the publication using three digits. Thus the first family, Myxinidae-hagfishes would receive the number 001 and the last family Molidae-molas recieved the code 186. One family was ommitted in the consecutive numbering in this publication, the family Loricariiae-armored catfishes where no species were listed as occurring in North America.

The remaining last two digits of the five digit code was assigned by numerical order of species listing within each family. For example the butterflyfish family, #129 Chaetondontidae, lists the cherubfish first in the list. It would receive the code 12901. The French angelfish is the 12th listing in that family and would be coded 12912.

These codes can only be derived using the 1970 edition of the Names of Fishes. The newer 1980 edition made some changes in species listings within families which would thus change all species codes.

In some cases additional numbers were created beyond the maximum number of species within a family. These additional numbers represented species groups due to problems in accurate identification by visual means only. For example a Mycteroperca spp. grouper is assigned the family number 105 and 99 following it, 10599. As an other example, both Bermuda and Yellow chub occur in the area but cannot be distinguished visually. This group was numbered 12799. A list of all additional species "group" codes is provided in Appendix 6-5.

Identification index

The identification quality index was instituted on a revised form 804 beginning with cruise two (2) data. The need for such an index was due to inherent problems of visual identifications to the species level. Family numbers alone could have been used for unidentified species but in some families the number of possibilities were far greater than the uncertainty of the identification.

Identification index numbers are described as follows:

#5 Highest rating, essentially guaranteed of being the correct species identification

#4 Strong evidence for a particular species but some visual proof lacking.

Appendix 3-2 (cont'd)

#3 Species "group" - Identificaion by taxon above species level, species combinations, families etc. Higher taxon makes identification safe, e.g. similar to #5 in quality but not by species.

#2 Best identification possible with little information available, e.g. depth, habitat and vague body shape of fish.

#1 Best guess - Noted primarily to record the presence of a fish with only an impression of what it may be.

APPENDIX 3-3

LOADING FORMS FOR:

Fish Morphometrics - Tagging (Form 801)
Oceanographic Data (Form 802)
Fish Length Data (Form 803)
Underwater Video Transect Data (Form 804)

Appendix 3-3 (cont'd)

Loading Form For
Fish Morphometrics- Tagging* Form 801, Project US80, Work Unit B.1

Field Name	Position	Length	Format	Use and Meaning
Project	1	2	I2	LGL Project No. - "80" Constant
Card Type	3	1	I1	"1" Constant
Year	4	2	I2	Last two digits of yr.
Month	6	2	I2	Month of the year
Day	8	2	I2	Day of the month (Set Date For Traps)
Site	10	3	A3	Site Location WFG BRG IMP EFG CNA PLA PLB
Station	13	2	I2	Do not use Nos. 1-9 *Start with No. 21
Replicate	15	2	I2	
Latitude	17	7	F7.2	Latitude in 00° 00.00'
Longitude	24	7	F7.2	Longitude in 00° 00.00'
Depth	31	3	I3	Depth in meters
Gear Type	34	1	I1	Method of capture 1=Hook & line 2=Trap 3=Trawl 4=Spear 5=Diver
Number of gear	35	1	I1	No. of pieces of gear in operation during the period
Time	36	4	I4	Time of collection (24-hr. clock) in local time (set time for traps)
Duration	40	4	I4	Total minutes of collection
Species	44	5	I5	5-digit code (from American Fisheries Society, Names of Fishes 1970) (see form 804 description)

.../2

Appendix 3-3 (cont'd)

Form 801

Field Name	Position	Length	Format	Use and Meaning
Length	49	4	I4	Fork length in mm
Weight	53	7	F7.1	Weight in grams to nearest tenth
Release Tag #	60	6	I6	Tag number
Tag Color	66	1	I1	Tag color code 1=White 3=Red 2=Yellow 4=Pink 5=Orange
Recapture Tag #	67	6	I6	Tag number
Tag Color	73	1	I1	Tag color code
Disposition	74	1	I1	Disposition of Fish 1=Floated away 2=Taken by predator 3=Recovered in predator stomach 4=Released recapture 5=Recaptured dead 6=Tag scar or hole 7=Fish for other Work Units 8=Fish for trap or other experiment
Sex	75	1	I1	1=Male 2=Female 3=Undetermined
Gonad Condition	76	1	A1	U=Undeveloped D=Fully developed R=Running ripe S=Spent
Special Gear Codes	77	1	A1	L=Large mesh traps S=Small mesh traps
Special Location Codes	79	1	I1	If Lat & Long not available: 1=Loran C coordinates
Effort/Gear Change	80	1	A1	S=Start time of fishing effort C=Change in gear number E=End time of fishing effort

Loading Form For
Oceanographic Data Form 802, Project US80, Work Unit B.1

Field Name	Position	Length	Format	Use and Meaning
File Type	1	3	I3	LGL Form Number,"802" Constant
Trip	4	2	I2	Cruise Number
Starting Month	6	2	I2	Starting Month of Cruise
Ending Month	8	2	I2	Ending Month of Cruise
Year	10	2	I2	Last digits of the Year
Code	12	3	A3	Site Location WFG PLA IMP EFG BRC PLB CNA
Number	15	2	I2	Station
Cast	17	1	I1	Cast
Bott	18	2	I2	Bottle Number
Addp Dept	20	3	I3	Depth in meters
Temp (c)	24	5	F5.2	Water Temperature (°C)
Pot Temp	30	5	F5.2	Potential Temperature (°C)
Sali	36	6	F6.3	Salinity ppt
Sigma Theta	43	6	F6.3	Water Density
Data Error	49	1	A1	E=Data error probable in Nansen bottle readings
Oxy	50	5	F5.3	Oxygen concentration ml/l
Data Error	55	1	A1	E=Data error probable in Transmissometer readings
Trans	56	5	F5.2	Transmissitivity %
PRES DECI	61	3	I3	Pressure

Loading Form For
Fish Length Data, Form 803, Project US80, Work Unit B.5

Field Name	Position	Length	Format	Use and Meaning
File Type	1	3	I3	LGL Form No., "803" Constant
Cruise	4	1	I1	Cruise Number
Leg	5	1	I1	Cruise Leg Number
Time	6	4	I4	Time of Day (24 hr clock)
Month	10	2	I2	Month of Year
Day	12	2	I2	Day of Month
Year	14	2	I2	Last two digits of year
Tape no.	16	2	I2	Tape Number
Counter No.	18	4	I4	Tape Counter Number
Station Code	22	3	A3	Site Location: WFG PLA EFG BRC CNA PLB
Depth of Observation	25	3	I3	Depth of Observation, measured in m
Bottom Depth	28	3	I3	Bottom Depth measured in m
Species Code	31	5	I5	5 Digit Species Code (see form 804 detail)
Length (mm) from video tape	36	4	I4	Length in mm calculated from television monitor

Appendix 3-3 (cont'd)

Loading Form For
Underwater Video Transect Data, Form 804, Project US80, Work Unit B.5

Field Name	Position	Length	Format	Use and Meaning
File type	1	3	I3	LGL Form Number, "804" Constant
Cruise	4	1	I1	Cruise Number
Leg	5	1	I1	Cruise Leg Number
Time	6	4	I4	Time of Day (24 hr clock)
Month	10	2	I2	Month of Year (1-12)
Day	12	2	I2	Day of Month
Year	14	2	I2	Last two digits of year
Tape number	16	2	I2	Tape number (separate set of every cruise)
Counter No.	18	4	I4	Video cassette recorder counter number
Station Code	22	3	A3	Site Location WFG,EFG,BRC,CNA,PLA,PLB
Starting Latitude	25	6	I6	Starting latitude of transect in a habitat type 00° 00.00'
Starting Longitude	31	6	I6	Starting longitude of transect in a habitat type 00° 00.00'
Ending Latitude	37	6	I6	Ending latitude 00° 00.00'
Ending Longitude	43	6	I6	Ending longitude 00° 00.00'
Transect Length	49	4	I4	Transect Length (m)
Transect Width	53	2	I2	Transect Width (m)
Minimum Depth	55	3	I3	Minimum transect depth (m)
Maximum Depth	58	3	I3	Maximum transect depth (m)

Appendix 3-3 (cont'd)

Form 804

Field Name	Position	Length	Format	Use and Meaning
Temperature (Quadrat No.)	61	3	I3	Temperature in °C - cruises 1-4, Quadrat number - cruises 5-8 (see attached description)
Habitat Type	64	3	I3	Habitat Code (see attached sheets)
Species Code	67	5	I5	5 digit species code (see attached sheets)
Total No. Obs.	72	4	I4	Total number of fish observed
Total No. Obs. Tagged	76	1	I1	Number observed with tags
Depth of Ind. Obs.	77	3	I3	Depth of observation (Beginning cruise 2) (=Bottom depth except at PLA and PLB)
ID Index	80	1	I1	Identification Index (Beginning cruise 2) 1=5 Identification quality 8-start transect segment 9-end transect segment

APPENDIX 3-4. MAXIMUM LIKELIHOOD ESTIMATION

INTRODUCTORY OVERVIEW

Poisson Process

Random Rate Poisson Process

Cluster Poisson Process

DERIVATION OF CONFIDENCE INTERVAL ESTIMATES

Random Rate Poisson Process

Cluster Poisson Process

APPENDIX 3-4

INTRODUCTORY OVERVIEW

The following is an outline of the derivation of the maximum likelihood population estimates and their confidence intervals for the three statistical models. In these discussions, N_1, N_2,....,N_s represents the number of fish and W_1, W_2, ..., W_s the area transected in quadrats 1, 2, ..., s. Further, let W_o represent the total area of the habitat.

Poisson Process

For the Poisson process, the distribution of the number of fish (N), for area of size W is:

$$P(N=n) = \frac{\exp(-\lambda W)\ (\lambda W)^n}{n!} \qquad \lambda > 0 \text{ (density/unit area)}, \quad n = 0,1,2,...$$

where, $E(N) = \lambda W$ and $Var(N) = \lambda W$.

The likelihood function for the data has the following form:

$$L(\lambda; N_1, \ldots, N_s, W_1, \ldots, W_s) = \prod_{j=1}^{s} \frac{\exp(-\lambda W_j)\ (\lambda W_j)^{N_j}}{N_j!}$$

The maximum likelihood estimate is found by maximizing the likelihood with respect to λ. This can be shown to be:

$$\hat{\lambda} = \frac{\Sigma_{j=1}^{s} N_j}{\Sigma_{j=1}^{s} W_j}$$

which is the observed density of fish. Thus the maximum likelihood estimate of the mean number of fish in the entire habitat is:

$$\hat{m} = \hat{\lambda} W_o$$

To obtain a confidence interval for the estimate $\hat{m}$, we use the large sample distribution of $\hat{m}$ which can be shown to be normal with:

$$\text{Mean} = \lambda W_o$$

$$\text{Variance} = \frac{\lambda W_o^2}{\Sigma_{j=1}^{s} W_j}$$

Using the standard technique of replacing the parameters by their estimates in the variance formula, we obtain the following 100 (1-α)% confidence interval for the estimate:

$$\hat{\lambda} W_o \pm Z_{\alpha/2} W_o \sqrt{\frac{\hat{\lambda}}{\Sigma_{j=1}^{s} W_j}}$$

where $Z_{\alpha/2}$ is the (1-α/2) percentile of a standard normal distribution. When the lower confidence bound was negative, it was replaced by the total observed number of fish (this occurred in only a few isolated cases).

Random Rate Poisson Process

Estimation for and description of the random rate Poisson process and the corresponding negative binomial distribution may be found in Bissell (1972). The following is a brief outline of the genesis of the model and a description of the maximum likelihood estimates for its parameters.

First assume, given the value of the rate parameter, the distribution of the number of fish N in an area of size W is Poisson, i.e.

$$P(N=n|\lambda) = \frac{\exp(-\lambda W)\ (\lambda W)^n}{n!} \qquad \lambda>0, \quad n = 0,1,2,\ldots$$

In addition, assume the rate parameter is a random variable and is distributed according to a gamma probability density function, i.e.

$$f(\lambda) = \frac{c^k \exp(-\lambda c)\lambda^{k-1}}{\Gamma(k)} \qquad k>0, \lambda>0, \quad c>0$$

Now, using the process of mixing, the conditional distribution of N over the distribution of λ, we find under reparameterization the distribution of the number of fish N in an area of size W to be a negative binomial:

$$P(N=n) = \frac{\Gamma(k+n)}{\Gamma(k)\Gamma(n+1)}\left(\frac{k}{mW+k}\right)^k\left(\frac{mW}{mW+k}\right)^n \qquad \begin{array}{l} k>0, m>0 \\ n = 0,1,2,\ldots \end{array}$$

where, $m = k/c$, $E(N) = mW$ and $Var(N) = \frac{m^2W^2}{k} + mW$

The likelihood function under random sampling of quadrats is:

$$L(m,k;\ N_1,\ldots,N_s,W_1,\ldots,W_s) = \Pi_{j=1}^{s} \frac{\Gamma(k+N_j)}{\Gamma(k)\Gamma(N_j+1)}\left(\frac{k}{mW_j+k}\right)^k\left(\frac{mW_j}{mW_j+k}\right)^{N_j}$$

To find the maximum likelihood estimates of (m,k) we would like to maximize L(.) as a function of m and k. Unlike the Poisson case, this cannot be done in closed form (i.e. taking derivatives and setting equal to zero and solving). Thus a numerical procedure for maximization is needed. To this end, a modified Newton-Raphson procedure was used to maximize the likelihood. The interative maximization procedure needs initial estimates for the parameters. Bissell (1972) provides suitable method of moment estimators of m and k. They are in modified form:

$$\hat{m}_I = \frac{\Sigma_{j=1}^{s} N_j}{\Sigma_{j=1}^{s} W_j}, \qquad \hat{k}_I = \frac{\hat{m}_I^2}{\dfrac{\Sigma_{j=1}^{s}[W_j(N_j/W_j - \hat{m}_I)^2]}{\Sigma_{j=1}^{s} W_j}}.$$

Using the results of the numerical maximization, the maximum likelihood estimate of the mean number of fish in the entire habitat is therefore,

$$\hat{m}_H = \hat{m}W_o .$$

To find confidence intervals for this estimate, we again will use the large sample distribution of the estimates. Under suitable regularity assumptions (e.g. stability of quadrat size) the maximum likelihood estimates can be shown to have, for large sample size (Serfling 1980), a normal distribution. To obtain an estimate of the variance-covariance structure of this normal distribution, the usual technique of taking the inverse of the Hessian matrix (second derivative matrix of log likelihood) and dividing by sample size was used. Details of this operation are provided below.

Cluster Poisson Process

Similar to the random rate Poisson process, the cluster Poisson process has a negative binomial distribution for abundance. However the parameterization and derivation of the model are completely different.

For the derivation of the distribution of number of fish in an area of size W, we start with an assumption concerning the distribution of the number of fish in a cluster. Let the cluster size (call it X) have a log series distribution, i.e.

$$P(X=x) = \frac{\alpha(1-\exp(-1/\alpha))^x}{x} \qquad x = 1,2,3,\ldots \quad \alpha>0$$

Assume that the clusters appear according to a Poisson process. Thus, letting N_o be the number of clusters in an area of size W, the distribution of the number of clusters is a Poisson:

$$P(N_o=n_o) = \frac{\exp(-\lambda W)\ (\lambda W)^{n_o}}{n_o!} \qquad \lambda>0 \quad n_o = 0,1,2,\ldots$$

To determine the distribution of the number of fish in an area of size W we note the number of fish (N) may be written

$$N = X_1+X_2+X_3+\ \ldots\ +X_{N_o} = \Sigma_{j=1}^{N_o} X_j$$

with X_j having a log series distribution and N_o a Poisson distribution. To determine the distribution of N the technique of compounding the distributions of X and N_o was used following Pielou (1977) which yields a Negative binomial distribution for N with the form:

$$P(N = n) = \binom{\alpha\lambda W+n-1}{\alpha\lambda W-1} (1-\exp(-1/\alpha))^n \exp(-\lambda W) \qquad \alpha>0,\ \lambda>0 \quad n = 0,1,2,\ldots$$

where, $E(N) = \alpha\lambda W(\exp(1/\alpha)-1)$ and $Var(N) = \alpha\lambda W\exp(1/\alpha)(\exp(1/\alpha)-1$.

The likelihood function under random sampling of quadrats is:

$$L(\alpha,\lambda;N_1,\ldots,N_s,W_1,\ldots,W_s) =$$

$$\Pi_{j=1}^{s} \binom{\alpha\lambda W_j+N_j-1}{\alpha\lambda W_j-1} 1-\exp(-1/\alpha))^{N_j} \exp(-\lambda W_j) \quad .$$

As in the case above, the maximum likelihood estimators of (α,λ) may only be found by numerical maximization of the likelihood function. See below for details. The following modified method of moment estimators were used as initial estimates:

$$\hat{\alpha} = 1/\mathrm{Log}(S_W^2/\bar{X}_W) \quad , \qquad \hat{\lambda} = \frac{\bar{X}_W \mathrm{Log}(S_W^2/\bar{X}_W)}{\frac{S_W^2}{\bar{X}_W} - 1}$$

where

$$\bar{X}_W = \frac{\Sigma_{j=1}^{s} N_j}{\Sigma_{j=1}^{s} W_j} \quad , \qquad S_W^2 = \frac{\Sigma_{j=1}^{s} W_j (N_j/W_j - \bar{X}_W)^2}{s} \quad .$$

To obtain the maximum likelihood estimate of the mean number of fish in a habitat of size W_o, we use the results of the numerical maximization of L(.) to obtain $(\hat{\alpha},\hat{\lambda})$, and estimate m with

$$\hat{m}_H = \hat{\alpha}\hat{\lambda} W_o (\exp(1/\hat{\alpha})-1)$$

Under suitable regularity conditions the confidence interval for $\hat{m}_H$ may be found using the large sample distribution of $(\hat{\alpha},\hat{\lambda})$ as shown by the derivation provided below. We note that the large sample variance of $\hat{m}_H$

turns out to be a function of the inverse of the Hessian of the likelihood function evaluated at the estimates $(\hat{\alpha},\hat{\lambda})$.

DERIVATION OF CONFIDENCE INTERVALS

The computation of the confidence intervals depend to an extent on the results of the numerical maximization of the likelihood. Thus a brief outline of the procedure used follows.

In general, to stabilize a maximization procedure a log of the objective function is maximized. It can be shown that this yields identical results to the untransformed case. Thus let $\log(L(\theta;N))$ be the log likelihood of the data where θ is the vector of parameters to be estimated and N the data. The Newton-Raphson procedure for maximizing a likelihood for the i'th iteration is:

$$\hat{\theta}_{i+1} = \hat{\theta}_i - H^{-1}_{\hat{\theta}_i} g_{\hat{\theta}_i}$$

where

$$g = \left\{\frac{\partial \log(L(\theta,N))}{\partial \theta_j}\right\}$$

and

$$H = \left\{\frac{\partial^2 \log(L(\theta,N))}{\partial \theta_j \partial \theta_k}\right\}$$

with j and k referencing the elements of the vector θ. Note when either g or H is subscripted by θ it refers to the evaluation of the gradient or the Hessian at the current estimate of θ.

The iterative scheme is started by letting θ_o be the initial estimates. To determine a final estimate from an iterative scheme a stopping rule must be given. See Bard (1974) for discussion and details.

Appendix 3-4 (cont'd)

Random Rate Poisson Process

Let $\hat{\theta} = (\hat{m},\hat{k})$ be the maximum likelihood estimates of $\theta = (m,k)$ found by numerical maximization of the likelihood for the random rate Poisson process given above. Under suitable regularity conditions it can be shown that $\hat{\theta}$, for large sample size, has a normal distribution with mean θ and variance covariance $(1/n)I_\theta$. Where I is the Fisher information matrix of the negative binomial distribution corresponding to the random rate Poission process, and n is the sample size. This is stated in a simpler manner with the notation:

$$\hat{\theta} \sim N(\theta,(1/n)I_\theta)$$

In this case, the derivation of I_θ is quite complex (see Serfling, 1980) and does not result in a manageable form. Therefore an estimate of I_θ was used. It can be shown that a consistent estimate of I_θ is given by $(-(1/n)H_{\hat{\theta}})$ where H is the Hessian of the log likelihood as defined above. Thus to obtain confidence intervals we use the following distributional result:

$$\hat{\theta} \sim N(\theta,(1/n)\ (H_{\hat{\theta}}^{-1}/n))\ .$$

This yields the 100(1-α)% confidence interval for the mean population size in a habitat of area W_o, i.e.

$$\hat{m}W_o \pm Z_{\alpha/2}W_o\sqrt{(-H_{\hat{\theta}})^{-1}_{(1,1)}}$$

Cluster Poisson Process

Let $\hat{\theta} = (\hat{\alpha},\hat{\lambda})$ be the maximum likelihood estimates of (α,λ). As in the case above $\hat{\theta}$ can be shown to have a normal distribution for large sample size. Again we use the inverse of the Hessian as an estimate of the variance-covariance matrix of $\hat{\theta}$. To obtain a confidence interval for the mean number of fish in a habitat of area W_o the large sample distribution or of $\hat{m}_H$ is needed. As stated above:

Appendix 3-4 (cont'd)

$$\hat{m}_H = \hat{\alpha}\hat{\lambda}W_o\ (\exp(1/\hat{\alpha})-1)\ .$$

To derive the distribution of $\hat{m}_H$ the delta method was used (see Serfling, 1980 for the multivariate version used here). it can be shown that for large sample size,

$$\hat{m}_H \sim N(m_H, W_o^2 d'_{\hat{\theta}}(-H_{\hat{\theta}})^{-1} d_{\hat{\theta}})$$

with

$$d_\theta = \begin{bmatrix} \lambda(\exp(1/\alpha)-1) - (\lambda/\alpha)\exp(1/\alpha) \\ \alpha(\exp(1/\alpha)-1) \end{bmatrix}.$$

Thus a 100(1-α)% confidence interval for $\hat{m}_H$ is given by

$$\hat{m}_H \pm Z_{\alpha/2}\ W_o \sqrt{d'_{\hat{\theta}}(-H_{\hat{\theta}})^{-1} d_{\hat{\theta}}}$$

Appendix 5-1. Summary of all fish collected over all cruises and by all gear types, (excluding trawls).

TOTALS BY SPECIES OVER ALL CRUISES COMBINED

SPECIES	COMMON NAME	SCIENTIFIC NAME	SUM
1204	SILKY SHARK	CARCHARHINUS FALCIFORMIS	5
1218	SMOOTH DOGFISH	MUSTELUS CANIS	1
1298	SMOOTHHOUND SHARK	MUSTELUS SPP.	1
3306	SPOTTED MORAY	GYMNOTHORAX MORINGA	38
3307	BLACKEDGE MORAY	GYMNOTHORAX NIGROMARGINATUS	7
3698	GIANT SNAKE EEL	OPHICHTHUS REX	5
4015	ROUND HERRING	ETRUMEUS TERES	1
7823	SOUTHERN HAKE	UROPHYCIS FLORIDANUS	17
7902	BEARDED BROTULA	BROTULA BARBATA	1
9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	202
9006	SQUIRRELFISH	HOLOCENTRUS RUFUS	16
9901	TRUMPETFISH	AULOSTOMUS MACULATUS	1
10508	MARBLED GROUPER	DERMATOLEPIS INERMIS	3
10511	ROCK HIND	EPINEPHELUS ADSCENSIONIS	52
10514	YELLOWEDGE GROUPER	EPINEPHELUS FLAVOLIMBATUS	10
10515	RED HIND	EPINEPHELUS GUTTATUS	38
10519	WARSAW GROUPER	EPINEPHELUS NIGRITUS	1
10520	SNOWY GROUPER	EPINEPHELUS NIVEATUS	4
10538	YELLOWMOUTH GROUPER	MYCTEROPERCA INTERSTITIALIS	53
10540	GAG	MYCTEROPERCA MICROLEPIS	7
10541	SCAMP	MYCTEROPERCA PHENAX	57
10542	TIGER GROUPER	MYCTEROPERCA TIGRIS	2
10549	CREOLE-FISH	PARANTHIAS FURCIFER	399
10550	GRAYSBY	PETROMETOPON CRUENTATUM	5
10902	BIGEYE	PRIACANTHUS ARENATUS	8
11101	BLACKLINE TILEFISH	CAULOLATILUS CYANOPS	2
11104	SAND TILEFISH	MALACANTHUS PLUMIERI	10
11502	YELLOWJACK	CARANX BARTHOLOMAEI	1
11504	BLUE RUNNER	CARANX CRYSOS	275
11505	CREVALLE JACK	CARANX HIPPOS	1
11506	HORSE-EYE JACK	CARANX LATUS	29
11515	RAINBOW RUNNER	ELAGATIS BIPINNULATA	2
11524	GREATER AMBERJACK	SERIOLA DUMERILI	66
11526	ALMACO JACK	SERIOLA RIVOLIANA	18
11533	ROUGH SCAD	TRACHURUS LATHAMI	1
11905	BLACKFIN SNAPPER	LUTJANUS BUCCANELLA	32
11906	RED SNAPPER	LUTJANUS CAMPECHANUS	530
11908	GREY SNAPPER	LUTJANUS GRISEUS	2
11912	SILK SNAPPER	LUTJANUS VIVANUS	3
11914	WENCHMAN	PRISTIPOMOIDES AQUILONARIS	3
11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	1914
12206	TOMTATE	HAEMULON AUROLINEATUM	3
12212	COTTONWICK	HAEMULON MELANURUM	2607
12216	STRIPED GRUNT	HAEMULON STRIATUM	1
12307	WHITEBONE PORGY	CALAMUS LEUCOSTEUS	2
12308	KNOBBED PORGY	CALAMUS NODOSUS	152
12314	RED PORGY	PAGRUS SEDECIM	206
12315	LONGSPINE PORGY	STENOTOMUS CAPRINUS	1
12417	CUBBYU	EQUETUS UMBROSUS	4
12703	YELLOW CHUB	KYPHOSUS INCISOR	28
12704	BERMUDA CHUB	KYPHOSUS SECTATRIX	2
12906	REEF BUTTERFLYFISH	CHAETODON SEDENTARIUS	14
12908	BLUE ANGELFISH	HOLACANTHUS BERMUDENSIS	1
13306	BROWN CHROMIS	CHROMIS MULTILINEATUS	2
13311	DUSKY DAMSELFISH	POMACENTRUS FUSCUS	1
13503	CREOLE WRASSE	CLEPTICUS PARRAI	4
13514	PUDDINGWIFE	HALICHOERES RADIATUS	2
16002	DOCTORFISH	ACANTHURUS CHIRURGUS	1
16314	KING MACKEREL	SCOMBEROMORUS CAVALLA	1
16918	SPOTTED SCORPIONFISH	SCORPAENA PLUMIERI	1
18205	GREY TRIGGERFISH	BALISTES CAPRISCUS	137
18207	QUEEN TRIGGERFISH	BALISTES VETULA	4
18209	ORANGESPOTTED FILEFISH	CANTHERHINES PULLUS	1
18210	ROUGH TRIGGERFISH	CANTHIDERMIS MACULATUS	1
18211	OCEAN TRIGGERFISH	CANTHIDERMIS SUFFLAMEN	1
18303	SCRAWLED COWFISH	LACTOPHRYS QUADRICORNIS	7
		GRAND TOTAL	7,006

Appendix 5-2. Summary of all fish collect by hook-and-line by cruise and station.

GEAR=1, HOOK AND LINE

CRUISE	SITE	GEAR	SPECIES	COMMON NAME	SCIENTIFIC NAME	SUM	RANK
1	EFG	1	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	2	6.0
1	EFG	1	9006	SQUIRRELFISH	HOLOCENTRUS RUFUS	1	3.0
1	EFG	1	10508	MARBLED GROUPER	DERMATOLEPIS INERMIS	1	3.0
1	EFG	1	10511	ROCK HIND	EPINEPHELUS ADSCENSIONIS	8	10.0
1	EFG	1	10515	RED HIND	EPINEPHELUS GUTTATUS	4	7.0
1	EFG	1	10538	YELLOWMOUTH GROUPER	MYCTEROPERCA INTERSTITIALIS	1	3.0
1	EFG	1	10541	SCAMP	MYCTEROPERCA PHENAX	6	9.0
1	EFG	1	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	14	11.0
1	EFG	1	11912	SILK SNAPPER	LUTJANUS VIVANUS	1	3.0
1	EFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	66	12.0
1	EFG	1	12212	COTTONWICK	HAEMULON MELANURUM	81	13.0
1	EFG	1	12308	KNOBBED PORGY	CALAMUS NODOSUS	5	8.0
1	EFG	1	12314	RED PORGY	PAGRUS SEDECIM	1	3.0
1	PLA	1	11533	ROUGH SCAD	TRACHURUS LATHAMI	1	1.0
1	PLA	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	6	2.0
1	WFG	1	1204	SILKY SHARK	CARCHARHINUS FALCIFORMIS	2	3.5
1	WFG	1	3306	SPOTTED MORAY	GYMNOTHORAX MORINGA	3	5.5
1	WFG	1	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	18	13.0
1	WFG	1	9006	SQUIRRELFISH	HOLOCENTRUS RUFUS	4	7.5
1	WFG	1	10511	ROCK HIND	EPINEPHELUS ADSCENSIONIS	4	7.5
1	WFG	1	10515	RED HIND	EPINEPHELUS GUTTATUS	7	10.0
1	WFG	1	10902	BIGEYE	PRIACANTHUS ARENATUS	2	3.5
1	WFG	1	11504	BLUE RUNNER	CARANX CRYSOS	56	15.0
1	WFG	1	11506	HORSE-EYE JACK	CARANX LATUS	6	9.0
1	WFG	1	11515	RAINBOW RUNNER	ELAGATIS BIPINNULATA	1	1.5
1	WFG	1	11524	GREATER AMBERJACK	SERIOLA DUMERILI	3	5.5
1	WFG	1	11906	RED'SNAPPER	LUTJANUS CAMPECHANUS	53	14.0
1	WFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	136	16.0
1	WFG	1	12212	COTTONWICK	HAEMULON MELANURUM	571	17.0
1	WFG	1	12308	KNOBBED PORGY	CALAMUS NODOSUS	13	12.0
1	WFG	1	12314	RED PORGY	PAGRUS SEDECIM	8	11.0
1	WFG	1	12703	YELLOW CHUB	KYPHOSUS INCISOR	1	1.5
					CRUISE TOTAL		1086
2	WFG	1	3306	SPOTTED MORAY	GYMNOTHORAX MORINGA	1	4.5
2	WFG	1	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	16	15.0
2	WFG	1	9006	SQUIRRELFISH	HOLOCENTRUS RUFUS	1	4.5
2	WFG	1	10515	RED HIND	EPINEPHELUS GUTTATUS	1	4.5
2	WFG	1	10538	YELLOWMOUTH GROUPER	MYCTEROPERCA INTERSTITIALIS	1	4.5
2	WFG	1	10541	SCAMP	MYCTEROPERCA PHENAX	1	4.5
2	WFG	1	11504	BLUE RUNNER	CARANX CRYSOS	12	14.0
2	WFG	1	11506	HORSE-EYE JACK	CARANX LATUS	1	4.5
2	WFG	1	11524	GREATER AMBERJACK	SERIOLA DUMERILI	5	11.5
2	WFG	1	11526	ALMACO JACK	SERIOLA RIVOLIANA	1	4.5
2	WFG	1	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	58	16.0
2	WFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	90	17.0
2	WFG	1	12212	COTTONWICK	HAEMULON MELANURUM	3	9.5
2	WFG	1	12212	COTTONWICK	HAEMULON MELANURUM	252	18.0
2	WFG	1	12308	KNOBBED PORGY	CALAMUS NODOSUS	5	11.5
2	WFG	1	12314	RED PORGY	PAGRUS SEDECIM	6	13.0
2	WFG	1	12703	YELLOW CHUB	KYPHOSUS INCISOR	3	9.5
2	WFG	1	18205	GREY TRIGGERFISH	BALISTES CAPRISCUS	1	4.5
					CRUISE TOTAL		458

Appendix 5-2 (cont'd)

GEAR-1, HOOK AND LINE (cont'd)

CRUISE	SITE	GEAR	SPECIES	COMMON NAME	SCIENTIFIC NAME	SUM	RANK
3	EFG	1	3306	SPOTTED MORAY	GYMNOTHORAX MORINGA	1	2.0
3	EFG	1	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	3	5.0
3	EFG	1	10515	RED HIND	EPINEPHELUS GUTTATUS	1	2.0
3	EFG	1	10538	YELLOWMOUTH GROUPER	MYCTEROPERCA INTERSTITIALIS	4	6.0
3	EFG	1	11905	BLACKFIN SNAPPER	LUTJANUS BUCCANELLA	1	2.0
3	EFG	1	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	2	4.0
3	EFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	18	8.0
3	EFG	1	12212	COTTONWICK	HAEMULON MELANURUM	31	9.0
3	EFG	1	12308	KNOBBED PORGY	CALAMUS NODOSUS	6	7.0
3	EFG	1	12314	RED PORGY	PAGRUS SEDECIM	44	10.0
3	PLA	1	3307	BLACKEDGE MORAY	GYMNOTHORAX NIGROMARGINATUS	5	6.0
3	PLA	1	10514	YELLOWEDGE GROUPER	EPINEPHELUS FLAVOLIMBATUS	6	7.0
3	PLA	1	10520	SNOWY GROUPER	EPINEPHELUS NIVEATUS	4	4.5
3	PLA	1	11515	RAINBOW RUNNER	ELAGATIS BIPINNULATA	1	2.0
3	PLA	1	11526	ALMACO JACK	SERIOLA RIVOLIANA	4	4.5
3	PLA	1	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	1	2.0
3	PLA	1	12703	YELLOW CHUB	KYPHOSUS INCISOR	1	2.0
3	WFG	1	3306	SPOTTED MORAY	GYMNOTHORAX MORINGA	1	5.5
3	WFG	1	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	11	18.0
3	WFG	1	9006	SQUIRRELFISH	HOLOCENTRUS RUFUS	1	5.5
3	WFG	1	10511	ROCK HIND	EPINEPHELUS ADSCENSIONIS	1	5.5
3	WFG	1	10515	RED HIND	EPINEPHELUS GUTTATUS	1	5.5
3	WFG	1	10541	SCAMP	MYCTEROPERCA PHENAX	1	5.5
3	WFG	1	10549	CREOLE-FISH	PARANTHIAS FURCIFER	2	12.5
3	WFG	1	10550	GRAYSBY	PETROMETOPON CRUENTATUM	2	12.5
3	WFG	1	11104	SAND TILEFISH	MALACANTHUS PLUMIERI	1	5.5
3	WFG	1	11505	CREVALLE JACK	CARANX HIPPOS	1	5.5
3	WFG	1	11524	GREATER AMBERJACK	SERIOLA DUMERILI	1	5.5
3	WFG	1	11526	ALMACO JACK	SERIOLA RIVOLIANA	1	5.5
3	WFG	1	11905	BLACKFIN SNAPPER	LUTJANUS BUCCANELLA	4	16.5
3	WFG	1	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	18	20.0
3	WFG	1	11912	SILK SNAPPER	LUTJANUS VIVANUS	1	5.5
3	WFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	190	23.0
3	WFG	1	12212	COTTONWICK	HAEMULON MELANURUM	99	22.0
3	WFG	1	12308	KNOBBED PORGY	CALAMUS NODOSUS	17	19.0
3	WFG	1	12314	RED PORGY	PAGRUS SEDECIM	24	21.0
3	WFG	1	12703	YELLOW CHUB	KYPHOSUS INCISOR	2	12.5
3	WFG	1	13514	PUDDINGWIFE	HALICHOERES RADIATUS	2	12.5
3	WFG	1	18205	GREY TRIGGERFISH	BALISTES CAPRISCUS	4	16.5
3	WFG	1	18207	QUEEN TRIGGERFISH	BALISTES VETULA	3	15.0
					CRUISE TOTAL	521	

Appendix 5-2 (cont'd)

GEAR-1, HOOK AND LINE (cont'd)

CRUISE	SITE	GEAR	SPECIES	COMMON NAME	SCIENTIFIC NAME	SUM	RANK
4	EFG	1	3306	SPOTTED MORAY	GYMNOTHORAX MORINGA	1	3.5
4	EFG	1	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	14	15.5
4	EFG	1	10511	ROCK HIND	EPINEPHELUS ADSCENSIONIS	4	10.5
4	EFG	1	10515	RED HIND	EPINEPHELUS GUTTATUS	2	8.0
4	EFG	1	10538	YELLOWMOUTH GROUPER	MYCTEROPERCA INTERSTITIALIS	5	12.5
4	EFG	1	10540	GAG	MYCTEROPERCA MICROLEPIS	4	10.5
4	EFG	1	10902	BIGEYE	PRIACANTHUS ARENATUS	1	3.5
4	EFG	1	11104	SAND TILEFISH	MALACANTHUS PLUMIERI	1	3.5
4	PLA	1	11504	BLUE RUNNER	CARANX CRYSOS	2	4.0
4	PLA	1	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	1	2.0
4	PLA	1	12417	CUBBYU	EQUETUS UMBROSUS	4	6.0
4	WFG	1	1204	SILKY SHARK	CARCHARHINUS FALCIFORMIS	3	9.5
4	WFG	1	3306	SPOTTED MORAY	GYMNOTHORAX MORINGA	1	3.5
4	WFG	1	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	14	15.0
4	WFG	1	9006	SQUIRRELFISH	HOLOCENTRUS RUFUS	1	3.5
4	WFG	1	10511	ROCK HIND	EPINEPHELUS ADSCENSIONIS	1	3.5
4	WFG	1	10538	YELLOWMOUTH GROUPER	MYCTEROPERCA INTERSTITIALIS	1	3.5
4	WFG	1	10540	GAG	MYCTEROPERCA MICROLEPIS	1	3.5
4	WFG	1	10902	BIGEYE	PRIACANTHUS ARENATUS	3	9.5
4	WFG	1	11101	BLACKLINE TILEFISH	CAULOLATILUS CYANOPS	2	7.5
4	WFG	1	11504	BLUE RUNNER	CARANX CRYSOS	4	11.0
4	WFG	1	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	13	14.0
4	WFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	421	17.0
4	WFG	1	12212	COTTONWICK	HAEMULON MELANURUM	59	16.0
4	WFG	1	12308	KNOBBED PORGY	CALAMUS NODOSUS	7	12.0
4	WFG	1	12314	RED PORGY	PAGRUS SEDECIM	9	13.0
4	WFG	1	18205	GREY TRIGGERFISH	BALISTES CAPRISCUS	2	7.5
4	WFG	1	18207	QUEEN TRIGGERFISH	BALISTES VETULA	1	3.5
					CRUISE TOTAL	757	
5	EFG	1	3306	SPOTTED MORAY	GYMNOTHORAX MORINGA	3	7.0
5	EFG	1	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	23	15.0
5	EFG	1	10511	ROCK HIND	EPINEPHELUS ADSCENSIONIS	9	13.0
5	EFG	1	10515	RED HIND	EPINEPHELUS GUTTATUS	4	8.5
5	EFG	1	10538	YELLOWMOUTH GROUPER	MYCTEROPERCA INTERSTITIALIS	2	6.0
5	EFG	1	10540	GAG	MYCTEROPERCA MICROLEPIS	1	3.0
5	EFG	1	10549	CREOLE-FISH	PARANTHIAS FURCIFER	1	3.0
5	EFG	1	11104	SAND TILEFISH	MALACANTHUS PLUMIERI	6	11.0
5	EFG	1	11504	BLUE RUNNER	CARANX CRYSOS	122	19.0
5	EFG	1	11506	HORSE-EYE JACK	CARANX LATUS	4	8.5
5	EFG	1	11524	GREATER AMBERJACK	SERIOLA DUMERILI	1	3.0
5	EFG	1	11526	ALMACO JACK	SERIOLA RIVOLIANA	1	3.0
5	EFG	1	11905	BLACKFIN SNAPPER	LUTJANUS BUCCANELLA	5	10.0
5	EFG	1	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	27	17.0
5	EFG	1	11908	GREY SNAPPER	LUTJANUS GRISEUS	1	3.0
5	EFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	80	18.0
5	EFG	1	12212	COTTONWICK	HAEMULON MELANURUM	239	20.0
5	EFG	1	12308	KNOBBED PORGY	CALAMUS NODOSUS	25	16.0
5	EFG	1	12314	RED PORGY	PAGRUS SEDECIM	7	12.0
5	EFG	1	18205	GREY TRIGGERFISH	BALISTES CAPRISCUS	13	14.0
5	WFG	1	3306	SPOTTED MORAY	GYMNOTHORAX MORINGA	1	2.5
5	WFG	1	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	1	2.5
5	WFG	1	9006	SQUIRRELFISH	HOLOCENTRUS RUFUS	1	2.5
5	WFG	1	10515	RED HIND	EPINEPHELUS GUTTATUS	1	2.5
5	WFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	11	5.0
5	WFG	1	12212	COTTONWICK	HAEMULON MELANURUM	14	6.0
					CRUISE TOTAL	603	

GEAR-1, HOOK AND LINE (cont'd)

CRUISE	SITE	GEAR	SPECIES	COMMON NAME	SCIENTIFIC NAME	SUM	RANK
6	EFG	1	1298	SMOOTHHOUND SHARK	MUSTELUS SPP.	1	3.5
6	EFG	1	3306	SPOTTED MORAY	GYMNOTHORAX MORINGA	8	12.0
6	EFG	1	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	30	15.0
6	EFG	1	9006	SQUIRRELFISH	HOLOCENTRUS RUFUS	2	8.0
6	EFG	1	10511	ROCK HIND	EPINEPHELUS ADSCENSIONIS	7	11.0
6	EFG	1	10515	RED HIND	EPINEPHELUS GUTTATUS	1	3.5
6	EFG	1	10538	YELLOWMOUTH GROUPER	MYCTEROPERCA INTERSTITIALIS	2	8.0
6	EFG	1	10541	SCAMP	MYCTEROPERCA PHENAX	2	8.0
6	EFG	1	10550	GRAYSBY	PETROMETOPON CRUENTATUM	1	3.5
6	EFG	1	11104	SAND TILEFISH	MALACANTHUS PLUMIERI	1	3.5
6	EFG	1	11504	BLUE RUNNER	CARANX CRYSOS	1	3.5
6	EFG	1	11526	ALMACO JACK	SERIOLA RIVOLIANA	1	3.5
6	EFG	1	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	72	16.0
6	EFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	79	17.0
6	EFG	1	12212	COTTONWICK	HAEMULON MELANURUM	211	18.0
6	EFG	1	12308	KNOBBED PORGY	CALAMUS NODOSUS	24	13.0
6	EFG	1	12314	RED PORGY	PAGRUS SEDECIM	27	14.0
6	EFG	1	18205	GREY TRIGGERFISH	BALISTES CAPRISCUS	4	10.0
6	WFG	1	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	2	1.5
6	WFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	50	4.0
6	WFG	1	12212	COTTONWICK	HAEMULON MELANURUM	5	3.0
6	WFG	1	18205	GREY TRIGGERFISH	BALISTES CAPRISCUS	2	1.5
					CRUISE TOTAL		533
7	EFG	1	1218	SMOOTH DOGFISH	MUSTELUS CANIS	1	2.5
7	EFG	1	3306	SPOTTED MORAY	GYMNOTHORAX MORINGA	10	14.0
7	EFG	1	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	17	17.0
7	EFG	1	9006	SQUIRRELFISH	HOLOCENTRUS RUFUS	3	7.0
7	EFG	1	10508	MARBLED GROUPER	DERMATOLEPIS INERMIS	1	2.5
7	EFG	1	10511	ROCK HIND	EPINEPHELUS ADSCENSIONIS	9	12.5
7	EFG	1	10515	RED HIND	EPINEPHELUS GUTTATUS	7	10.5
7	EFG	1	10538	YELLOWMOUTH GROUPER	MYCTEROPERCA INTERSTITIALIS	25	19.0
7	EFG	1	10541	SCAMP	MYCTEROPERCA PHENAX	31	20.0
7	EFG	1	10549	CREOLE-FISH	PARANTHIAS FURCIFER	4	8.5
7	EFG	1	10550	GRAYSBY	PETROMETOPON CRUENTATUM	2	5.5
7	EFG	1	10902	BIGEYE	PRIACANTHUS ARENATUS	2	5.5
7	EFG	1	11504	BLUE RUNNER	CARANX CRYSOS	9	12.5
7	EFG	1	11506	HORSE-EYE JACK	CARANX LATUS	14	16.0
7	EFG	1	11524	GREATER AMBERJACK	SERIOLA DUMERILI	33	21.0
7	EFG	1	11526	ALMACO JACK	SERIOLA RIVOLIANA	7	10.5
7	EFG	1	11905	BLACKFIN SNAPPER	LUTJANUS BUCCANELLA	11	15.0
7	EFG	1	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	135	23.0
7	EFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	265	24.0
7	EFG	1	12212	COTTONWICK	HAEMULON MELANURUM	1	2.5
7	EFG	1	12212	COTTONWICK	HAEMULON MELANURUM	517	25.0
7	EFG	1	12216	STRIPED GRUNT	HAEMULON STRIATUM	1	2.5
7	EFG	1	12308	KNOBBED PORGY	CALAMUS NODOSUS	24	18.0
7	EFG	1	12314	RED PORGY	PAGRUS SEDECIM	36	22.0
7	EFG	1	12703	YELLOW CHUB	KYPHOSUS INCISOR	4	8.5
7	WFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	59	4.0
7	WFG	1	12212	COTTONWICK	HAEMULON MELANURUM	1	1.0
7	WFG	1	12314	RED PORGY	PAGRUS SEDECIM	4	2.5
7	WFG	1	18205	GREY TRIGGERFISH	BALISTES CAPRISCUS	4	2.5
					CRUISE TOTAL		1237

Appendix 5-2 (cont'd)

GEAR-1, HOOK AND LINE (cont'd)

CRUISE	SITE	GEAR	SPECIES	COMMON NAME	SCIENTIFIC NAME	SUM	RANK
8	EFG	1	3306	SPOTTED MORAY	GYMNOTHORAX MORINGA	3	4.5
8	EFG	1	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	18	10.0
8	EFG	1	10511	ROCK HIND	EPINEPHELUS ADSCENSIONIS	4	6.5
8	EFG	1	10515	RED HIND	EPINEPHELUS GUTTATUS	2	2.5
8	EFG	1	10541	SCAMP	MYCTEROPERCA PHENAX	4	6.5
8	EFG	1	11504	BLUE RUNNER	CARANX CRYSOS	56	13.0
8	EFG	1	11506	HORSE-EYE JACK	CARANX LATUS	3	4.5
8	EFG	1	11524	GREATER AMBERJACK	SERIOLA DUMERILI	2	2.5
8	EFG	1	11905	BLACKFIN SNAPPER	LUTJANUS BUCCANELLA	8	8.5
8	EFG	1	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	42	12.0
8	EFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	204	15.0
8	EFG	1	12212	COTTONWICK	HAEMULON MELANURUM	91	14.0
8	EFG	1	12308	KNOBBED PORGY	CALAMUS NODOSUS	8	8.5
8	EFG	1	12314	RED PORGY	PAGRUS SEDECIM	1	1.0
8	EFG	1	18205	GREY TRIGGERFISH	BALISTES CAPRISCUS	20	11.0
8	WFG	1	11504	BLUE RUNNER	CARANX CRYSOS	8	4.0
8	WFG	1	11506	HORSE-EYE JACK	CARANX LATUS	1	1.5
8	WFG	1	11524	GREATER AMBERJACK	SERIOLA DUMERILI	18	6.0
8	WFG	1	11905	BLACKFIN SNAPPER	LUTJANUS BUCCANELLA	1	1.5
8	WFG	1	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	9	5.0
8	WFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	78	7.0
8	WFG	1	12212	COTTONWICK	HAEMULON MELANURUM	7	3.0
					CRUISE TOTAL	588	

Appendix 5-3. Summary of all fish collected by trap, by cruise and station.

GEAR=2, TRAP

CRUISE	SITE	GEAR	SPECIES	COMMON NAME	SCIENTIFIC NAME	SUM	RANK
1	CNA	2	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	2	1.0
1	EFG	2	9901	TRUMPETFISH	AULOSTOMUS MACULATUS	1	2.0
1	EFG	2	10511	ROCK HIND	EPINEPHELUS ADSCENSIONIS	1	2.0
1	EFG	2	10515	RED HIND	EPINEPHELUS GUTTATUS	1	2.0
1	EFG	2	10538	YELLOWMOUTH GROUPER	MYCTEROPERCA INTERSTITIALIS	2	5.0
1	EFG	2	10541	SCAMP	MYCTEROPERCA PHENAX	2	5.0
1	EFG	2	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	5	8.0
1	EFG	2	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	9	10.0
1	EFG	2	12206	TOMTATE	HAEMULON AUROLINEATUM	3	7.0
1	EFG	2	12212	COTTONWICK	HAEMULON MELANURUM	30	11.0
1	EFG	2	12314	RED PORGY	PAGRUS SEDECIM	2	5.0
1	EFG	2	18205	GREY TRIGGERFISH	BALISTES CAPRISCUS	7	9.0
1	WFG	2	3306	SPOTTED MORAY	GYMNOTHORAX MORINGA	3	6.5
1	WFG	2	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	8	11.0
1	WFG	2	9006	SQUIRRELFISH	HOLOCENTRUS RUFUS	2	4.5
1	WFG	2	10511	ROCK HIND	EPINEPHELUS ADSCENSIONIS	3	6.5
1	WFG	2	10515	RED HIND	EPINEPHELUS GUTTATUS	2	4.5
1	WFG	2	10540	GAG	MYCTEROPERCA MICROLEPIS	1	2.0
1	WFG	2	10541	SCAMP	MYCTEROPERCA PHENAX	5	9.5
1	WFG	2	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	13	13.5
1	WFG	2	11912	SILK SNAPPER	LUTJANUS VIVANUS	1	2.0
1	WFG	2	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	56	16.0
1	WFG	2	12212	COTTONWICK	HAEMULON MELANURUM	52	15.0
1	WFG	2	12308	KNOBBED PORGY	CALAMUS NODOSUS	1	2.0
1	WFG	2	12314	RED PORGY	PAGRUS SEDECIM	12	12.0
1	WFG	2	12703	YELLOW CHUB	KYPHOSUS INCISOR	5	9.5
1	WFG	2	12906	REEF BUTTERFLYFISH	CHAETODON SEDENTARIUS	13	13.5
1	WFG	2	18205	GREY TRIGGERFISH	BALISTES CAPRISCUS	4	8.0
					CRUISE TOTAL		246
2	PLA	2	3307	BLACKEDGE MORAY	GYMNOTHORAX NIGROMARGINATUS	2	1.0
2	WFG	2	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	3	4.5
2	WFG	2	10541	SCAMP	MYCTEROPERCA PHENAX	1	1.5
2	WFG	2	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	9	6.0
2	WFG	2	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	3	4.5
2	WFG	2	12212	COTTONWICK	HAEMULON MELANURUM	88	7.0
2	WFG	2	12308	KNOBBED PORGY	CALAMUS NODOSUS	1	1.5
2	WFG	2	12703	YELLOW CHUB	KYPHOSUS INCISOR	2	3.0
					CRUISE TOTAL		109

Appendix 5-3 (cont'd)

GEAR=2, TRAP (cont'd)

CRUISE	SITE	GEAR	SPECIES	COMMON NAME	SCIENTIFIC NAME	SUM	RANK
3	EFG	2	3306	SPOTTED MORAY	GYMNOTHORAX MORINGA	2	7.0
3	EFG	2	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	3	9.0
3	EFG	2	10511	ROCK HIND	EPINEPHELUS ADSCENSIONIS	1	3.0
3	EFG	2	10515	RED HIND	EPINEPHELUS GUTTATUS	1	3.0
3	EFG	2	11104	SAND TILEFISH	MALACANTHUS PLUMIERI	1	3.0
3	EFG	2	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	16	12.0
3	EFG	2	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	13	11.0
3	EFG	2	12212	COTTONWICK	HAEMULON MELANURUM	32	13.0
3	EFG	2	12308	KNOBBED PORGY	CALAMUS NODOSUS	2	7.0
3	EFG	2	12314	RED PORGY	PAGRUS SEDECIM	5	10.0
3	EFG	2	12908	BLUE ANGELFISH	HOLACANTHUS BERMUDENSIS	1	3.0
3	EFG	2	16918	SPOTTED SCORPIONFISH	SCORPAENA PLUMIERI	1	3.0
3	EFG	2	18205	GREY TRIGGERFISH	BALISTES CAPRISCUS	2	7.0
3	PLA	2	3698	GIANT SNAKE EEL	OPHICHTHUS REX	4	2.0
3	PLA	2	7823	SOUTHERN HAKE	UROPHYCIS FLORIDANUS	10	3.0
3	PLA	2	7902	BEARDED BROTULA	BROTULA BARBATA	1	1.0
3	WFG	2	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	16	11.0
3	WFG	2	10515	RED HIND	EPINEPHELUS GUTTATUS	2	5.0
3	WFG	2	10519	WARSAW GROUPER	EPINEPHELUS NIGRITUS	1	1.5
3	WFG	2	10541	SCAMP	MYCTEROPERCA PHENAX	2	5.0
3	WFG	2	11524	GREATER AMBERJACK	SERIOLA DUMERILI	2	5.0
3	WFG	2	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	4	8.0
3	WFG	2	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	30	12.0
3	WFG	2	12212	COTTONWICK	HAEMULON MELANURUM	101	13.0
3	WFG	2	12314	RED PORGY	PAGRUS SEDECIM	5	9.0
3	WFG	2	12703	YELLOW CHUB	KYPHOSUS INCISOR	2	5.0
3	WFG	2	12906	REEF BUTTERFLYFISH	CHAETODON SEDENTARIUS	1	1.5
3	WFG	2	18205	GREY TRIGGERFISH	BALISTES CAPRISCUS	2	5.0
3	WFG	2	18303	SCRAWLED COWFISH	LACTOPHRYS QUADRICORNIS	6	10.0
					CRUISE TOTAL		269

Appendix 5-3 (cont'd)

GEAR=2, TRAP (cont'd)

CRUISE	SITE	GEAR	SPECIES	COMMON NAME	SCIENTIFIC NAME	SUM	RANK
4	CNA	2	10514	YELLOEDGE GROUPER	EPINEPHELUS FLAVOLIMBATUS	1	2.0
4	CNA	2	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	1	2.0
4	CNA	2	11914	WENCHMAN	PRISTIPOMOIDES AQUILONARIS	3	4.0
4	CNA	2	12315	LONGSPINE PORGY	STENOTOMUS CAPRINUS	1	2.0
4	EFG	2	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	1	2.5
4	EFG	2	10515	RED HIND	EPINEPHELUS GUTTATUS	1	2.5
4	EFG	2	10538	YELLOWMOUTH GROUPER	MYCTEROPERCA INTERSTITIALIS	4	6.0
4	EFG	2	10541	SCAMP	MYCTEROPERCA PHENAX	1	2.5
4	EFG	2	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	9	9.0
4	EFG	2	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	3	5.0
4	EFG	2	12307	WHITEBONE PORGY	CALAMUS LEUCOSTEUS	1	2.5
4	EFG	2	12314	RED PORGY	PAGRUS SEDECIM	6	8.0
4	EFG	2	18205	GREY TRIGGERFISH	BALISTES CAPRISCUS	5	7.0
4	WFG	2	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	4	7.0
4	WFG	2	10538	YELLOWMOUTH GROUPER	MYCTEROPERCA INTERSTITIALIS	3	5.5
4	WFG	2	10541	SCAMP	MYCTEROPERCA PHENAX	1	2.0
4	WFG	2	11905	BLACKFIN SNAPPER	LUTJANUS BUCCANELLA	2	4.0
4	WFG	2	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	7	8.0
4	WFG	2	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	15	9.0
4	WFG	2	12212	COTTONWICK	HAEMULON MELANURUM	27	10.0
4	WFG	2	12307	WHITEBONE PORGY	CALAMUS LEUCOSTEUS	1	2.0
4	WFG	2	12314	RED PORGY	PAGRUS SEDECIM	3	5.5
4	WFG	2	18303	SCRAWLED COWFISH	LACTOPHRYS QUADRICORNIS	1	2.0
					CRUISE TOTAL		101
6	EFG	2	12212	COTTONWICK	HAEMULON MELANURUM	1	1.0
					CRUISE TOTAL		1
7	EFG	2	10538	YELLOWMOUTH GROUPER	MYCTEROPERCA INTERSTITIALIS	1	1.5
7	EFG	2	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	1	1.5
7	EFG	2	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	4	3.5
7	EFG	2	12212	COTTONWICK	HAEMULON MELANURUM	4	3.5
							10

Appendix 5-4. Summary of all fish collected by divers by cruise and station.

GEAR=4, DIVER AND SPEAR

CRUISE	SITE	GEAR	SPECIES	COMMON NAME	SCIENTIFIC NAME	SUM	RANK
3	PLA	4	11526	ALMACO JACK	SERIOLA RIVOLIANA	1	2.5
3	PLA	4	12703	YELLOW CHUB	KYPHOSUS INCISOR	7	6.0
3	PLA	4	12704	BERMUDA CHUB	KYPHOSUS SECTATRIX	2	5.0
3	PLA	4	16002	DOCTORFISH	ACANTHURUS CHIRURGUS	1	2.5
3	PLA	4	18205	GREY TRIGGERFISH	BALISTES CAPRISCUS	13	7.0
3	PLA	4	18209	ORANGESPOTTED FILEFISH	CANTHERHINES PULLUS	1	2.5
3	PLA	4	18210	ROUGH TRIGGERFISH	CANTHIDERMIS MACULATUS	1	2.5
					CRUISE TOTAL	26	
4	EFG	4	10508	MARBLED GROUPER	DERMATOLEPIS INERMIS	1	2.5
4	EFG	4	10538	YELLOWMOUTH GROUPER	MYCTEROPERCA INTERSTITIALIS	2	5.5
4	EFG	4	10542	TIGER GROUPER	MYCTEROPERCA TIGRIS	2	5.5
4	EFG	4	10549	CREOLE-FISH	PARANTHIAS FURCIFER	31	8.0
4	EFG	4	11908	GREY SNAPPER	LUTJANUS GRISEUS	1	2.5
4	EFG	4	13306	BROWN CHROMIS	CHROMIS MULTILINEATUS	1	2.5
4	EFG	4	13311	DUSKY DAMSELFISH	POMACENTRUS FUSCUS	1	2.5
4	EFG	4	13503	CREOLE WRASSE	CLEPTICUS PARRAI	3	7.0
4	PLA	4	18205	GREY TRIGGERFISH	BALISTES CAPRISCUS	4	1.0
4	WFG	4	10549	CREOLE-FISH	PARANTHIAS FURCIFER	39	2.0
4	WFG	4	13503	CREOLE WRASSE	CLEPTICUS PARRAI	1	1.0
					CRUISE TOTAL	86	
5	EFG	4	10549	CREOLE-FISH	PARANTHIAS FURCIFER	77	2.0
5	EFG	4	12212	COTTONWICK	HAEMULON MELANURUM	2	1.0
5	WFG	4	10549	CREOLE-FISH	PARANTHIAS FURCIFER	10	1.0
					CRUISE TOTAL	89	
6	EFG	4	10549	CREOLE-FISH	PARANTHIAS FURCIFER	25	1.0
6	PLB	4	10549	CREOLE-FISH	PARANTHIAS FURCIFER	4	2.0
6	PLB	4	12703	YELLOW CHUB	KYPHOSUS INCISOR	1	1.0
6	PLB	4	18205	GREY TRIGGERFISH	BALISTES CAPRISCUS	11	3.0
6	WFG	4	10549	CREOLE-FISH	PARANTHIAS FURCIFER	16	3.0
6	WFG	4	11502	YELLOWJACK	CARANX BARTHOLOMAEI	1	1.5
6	WFG	4	13306	BROWN CHROMIS	CHROMIS MULTILINEATUS	1	1.5
					CRUISE TOTAL	59	
7	EFG	4	10549	CREOLE-FISH	PARANTHIAS FURCIFER	29	1.0
7	PLB	4	10549	CREOLE-FISH	PARANTHIAS FURCIFER	41	2.0
7	PLB	4	18205	GREY TRIGGERFISH	BALISTES CAPRISCUS	29	1.0
7	WFG	4	10549	CREOLE-FISH	PARANTHIAS FURCIFER	31	1.0
					CRUISE TOTAL	130	
8	EFG	4	10549	CREOLE-FISH	PARANTHIAS FURCIFER	30	1.0
8	PLB	4	10549	CREOLE-FISH	PARANTHIAS FURCIFER	24	2.0
8	PLB	4	18205	GREY TRIGGERFISH	BALISTES CAPRISCUS	8	1.0
8	WFG	4	10549	CREOLE-FISH	PARANTHIAS FURCIFER	35	1.0
					CRUISE TOTAL	97	

Appendix 5-5. Numbers of fish tagged and released, Cruises 1-8. (Gear #1=hook-and-line; #2=trap)

CRUISE= 1

CRUISE	SITE	GEAR	SPECIES	COMMON NAME	SCIENTIFIC NAME	NUMBER TAGGED
1	EFG	1	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	1
1	EFG	1	10541	SCAMP	MYCTEROPERCA PHENAX	2
1	EFG	1	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	2
1	EFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	8
1	EFG	1	12212	COTTONWICK	HAEMULON MELANURUM	13
1	EFG	1	12314	RED PORGY	PAGRUS SEDECIM	1
1	PLA	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	2
1	WFG	1	1204	SILKY SHARK	CARCHARHINUS FALCIFORMIS	2
1	WFG	1	3306	SPOTTED MORAY	GYMNOTHORAX MORINGA	2
1	WFG	1	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	17
1	WFG	1	9006	SQUIRRELFISH	HOLOCENTRUS RUFUS	4
1	WFG	1	10511	ROCK HIND	EPINEPHELUS ADSCENSIONIS	1
1	WFG	1	10515	RED HIND	EPINEPHELUS GUTTATUS	1
1	WFG	1	10902	BIGEYE	PRIACANTHUS ARENATUS	2
1	WFG	1	11504	BLUE RUNNER	CARANX CRYSOS	53
1	WFG	1	11506	HORSE-EYE JACK	CARANX LATUS	5
1	WFG	1	11515	RAINBOW RUNNER	ELAGATIS BIPINNULATA	1
1	WFG	1	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	43
1	WFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	81
1	WFG	1	12212	COTTONWICK	HAEMULON MELANURUM	536
1	WFG	1	12308	KNOBBED PORGY	CALAMUS NODOSUS	11
1	WFG	1	12314	RED PORGY	PAGRUS SEDECIM	3
1	WFG	1	12703	YELLOW CHUB	KYPHOSUS INCISOR	1
1	WFG	2	3306	SPOTTED MORAY	GYMNOTHORAX MORINGA	1
1	WFG	2	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	8
1	WFG	2	9006	SQUIRRELFISH	HOLOCENTRUS RUFUS	1
1	WFG	2	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	20
1	WFG	2	12212	COTTONWICK	HAEMULON MELANURUM	39
1	WFG	2	12703	YELLOW CHUB	KYPHOSUS INCISOR	1
1	WFG	2	12906	REEF BUTTERFLYFISH	CHAETODON SEDENTARIUS	2
1	WFG	2	18205	GREY TRIGGERFISH	BALISTES CAPRISCUS	2

					CRUISE TOTAL	866

CRUISE= 2

CRUISE	SITE	GEAR	SPECIES	COMMON NAME	SCIENTIFIC NAME	NUMBER TAGGED
2	PLA	2	3307	BLACKEDGE MORAY	GYMNOTHORAX NIGROMARGINATUS	2
2	WFG	1	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	16
2	WFG	1	9006	SQUIRRELFISH	HOLOCENTRUS RUFUS	1
2	WFG	1	12212	COTTONWICK	HAEMULON MELANURUM	3
2	WFG	1	11504	BLUE RUNNER	CARANX CRYSOS	11
2	WFG	1	11506	HORSE-EYE JACK	CARANX LATUS	1
2	WFG	1	11524	GREATER AMBERJACK	SERIOLA DUMERILI	5
2	WFG	1	11526	ALMACO JACK	SERIOLA RIVOLIANA	1
2	WFG	1	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	12
2	WFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	53
2	WFG	1	12212	COTTONWICK	HAEMULON MELANURUM	213
2	WFG	1	12308	KNOBBED PORGY	CALAMUS NODOSUS	2
2	WFG	1	12703	YELLOW CHUB	KYPHOSUS INCISOR	3
2	WFG	2	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	3
2	WFG	2	12212	COTTONWICK	HAEMULON MELANURUM	11

					CRUISE TOTAL	337

Appendix 5-5 (cont'd)

CRUISE= 3

CRUISE	SITE	GEAR	SPECIES	COMMON NAME	SCIENTIFIC NAME	NUMBER TAGGED
3	EFG	1	3306	SPOTTED MORAY	GYMNOTHORAX MORINGA	1
3	EFG	1	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	3
3	EFG	1	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	2
3	EFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	6
3	EFG	1	12308	KNOBBED PORGY	CALAMUS NODOSUS	3
3	EFG	1	12314	RED PORGY	PAGRUS SEDECIM	26
3	EFG	2	3306	SPOTTED MORAY	GYMNOTHORAX MORINGA	1
3	EFG	2	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	3
3	EFG	2	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	9
3	EFG	2	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	12
3	EFG	2	12212	COTTONWICK	HAEMULON MELANURUM	31
3	EFG	2	12308	KNOBBED PORGY	CALAMUS NODOSUS	2
3	EFG	2	12314	RED PORGY	PAGRUS SEDECIM	4
3	PLA	1	3307	BLACKEDGE MORAY	GYMNOTHORAX NIGROMARGINATUS	3
3	PLA	1	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	1
3	PLA	1	12703	YELLOW CHUB	KYPHOSUS INCISOR	1
3	WFG	1	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	9
3	WFG	1	9006	SQUIRRELFISH	HOLOCENTRUS RUFUS	1
3	WFG	1	10511	ROCK HIND	EPINEPHELUS ADSCENSIONIS	1
3	WFG	1	11905	BLACKFIN SNAPPER	LUTJANUS BUCCANELLA	2
3	WFG	1	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	1
3	WFG	1	11912	SILK SNAPPER	LUTJANUS VIVANUS	1
3	WFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	109
3	WFG	1	12212	COTTONWICK	HAEMULON MELANURUM	57
3	WFG	1	12308	KNOBBED PORGY	CALAMUS NODOSUS	12
3	WFG	1	12314	RED PORGY	PAGRUS SEDECIM	10
3	WFG	1	13514	PUDDINGWIFE	HALICHOERES RADIATUS	1
3	WFG	1	18207	QUEEN TRIGGERFISH	BALISTES VETULA	2
3	WFG	2	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	11
3	WFG	2	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	11
3	WFG	2	12212	COTTONWICK	HAEMULON MELANURUM	79
3	WFG	2	12314	RED PORGY	PAGRUS SEDECIM	1
3	WFG	2	18303	SCRAWLED COWFISH	LACTOPHRYS QUADRICORNIS	6
					CRUISE TOTAL	422

Appendix 5-5 (cont'd)

CRUISE= 4

CRUISE	SITE	GEAR	SPECIES	COMMON NAME	SCIENTIFIC NAME	NUMBER TAGGED
4	EFG	1	3306	SPOTTED MORAY	GYMNOTHORAX MORINGA	1
4	EFG	1	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	11
4	EFG	1	10511	ROCK HIND	EPINEPHELUS ADSCENSIONIS	2
4	EFG	1	10515	RED HIND	EPINEPHELUS GUTTATUS	1
4	EFG	1	10538	YELLOWMOUTH GROUPER	MYCTEROPERCA INTERSTITIALIS	1
4	EFG	1	10540	GAG	MYCTEROPERCA MICROLEPIS	3
4	EFG	1	10902	BIGEYE	PRIACANTHUS ARENATUS	1
4	EFG	1	11504	BLUE RUNNER	CARANX CRYSOS	5
4	EFG	1	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	1
4	EFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	9
4	EFG	1	12212	COTTONWICK	HAEMULON MELANURUM	45
4	EFG	1	12308	KNOBBED PORGY	CALAMUS NODOSUS	11
4	EFG	1	18211	OCEAN TRIGGERFISH	CANTHIDERMIS SUFFLAMEN	1
4	EFG	2	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	1
4	EFG	2	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	6
4	EFG	2	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	2
4	EFG	2	12314	RED PORGY	PAGRUS SEDECIM	3
4	EFG	2	18205	GREY TRIGGERFISH	BALISTES CAPRISCUS	1
4	PLA	1	3698	GIANT SNAKE EEL	OPHICHTHUS REX	1
4	PLA	1	7823	SOUTHERN HAKE	UROPHYCIS FLORIDANUS	1
4	PLA	1	11504	BLUE RUNNER	CARANX CRYSOS	1
4	WFG	1	3306	SPOTTED MORAY	GYMNOTHORAX MORINGA	1
4	WFG	1	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	5
4	WFG	1	10511	ROCK HIND	EPINEPHELUS ADSCENSIONIS	1
4	WFG	1	10540	GAG	MYCTEROPERCA MICROLEPIS	1
4	WFG	1	10902	BIGEYE	PRIACANTHUS ARENATUS	2
4	WFG	1	11504	BLUE RUNNER	CARANX CRYSOS	1
4	WFG	1	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	6
4	WFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	297
4	WFG	1	12212	COTTONWICK	HAEMULON MELANURUM	34
4	WFG	1	12308	KNOBBED PORGY	CALAMUS NODOSUS	5
4	WFG	1	12314	RED PORGY	PAGRUS SEDECIM	2
4	WFG	2	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	2
4	WFG	2	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	1
4	WFG	2	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	8
4	WFG	2	12212	COTTONWICK	HAEMULON MELANURUM	10
4	WFG	2	18303	SCRAWLED COWFISH	LACTOPHRYS QUADRICORNIS	1

					CRUISE TOTAL	485

CRUISE= 5

CRUISE	SITE	GEAR	SPECIES	COMMON NAME	SCIENTIFIC NAME	NUMBER TAGGED
5	EFG	1	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	11
5	EFG	1	11504	BLUE RUNNER	CARANX CRYSOS	49
5	EFG	1	11506	HORSE-EYE JACK	CARANX LATUS	3
5	EFG	1	12212	COTTONWICK	HAEMULON MELANURUM	171
5	EFG	1	12308	KNOBBED PORGY	CALAMUS NODOSUS	7

					CRUISE TOTAL	241

Appendix 5-5 (cont'd)

CRUISE= 6

CRUISE	SITE	GEAR	SPECIES	COMMON NAME	SCIENTIFIC NAME	NUMBER TAGGED
6	EFG	1	3306	SPOTTED MORAY	GYMNOTHORAX MORINGA	1
6	EFG	1	12212	COTTONWICK	HAEMULON MELANURUM	144
6	EFG	1	12308	KNOBBED PORGY	CALAMUS NODOSUS	1
6	EFG	2	12212	COTTONWICK	HAEMULON MELANURUM	1

					CRUISE TOTAL	147

CRUISE= 7

CRUISE	SITE	GEAR	SPECIES	COMMON NAME	SCIENTIFIC NAME	NUMBER TAGGED
7	EFG	1	1218	SMOOTH DOGFISH	MUSTELUS CANIS	1
7	EFG	1	3306	SPOTTED MORAY	GYMNOTHORAX MORINGA	4
7	EFG	1	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	16
7	EFG	1	9006	SQUIRRELFISH	HOLOCENTRUS RUFUS	2
7	EFG	1	10511	ROCK HIND	EPINEPHELUS ADSCENSIONIS	1
7	EFG	1	10538	YELLOWMOUTH GROUPER	MYCTEROPERCA INTERSTITIALIS	11
7	EFG	1	10541	SCAMP	MYCTEROPERCA PHENAX	8
7	EFG	1	10549	CREOLE-FISH	PARANTHIAS FURCIFER	3
7	EFG	1	10902	BIGEYE	PRIACANTHUS ARENATUS	2
7	EFG	1	12212	COTTONWICK	HAEMULON MELANURUM	1
7	EFG	1	11504	BLUE RUNNER	CARANX CRYSOS	5
7	EFG	1	11506	HORSE-EYE JACK	CARANX LATUS	9
7	EFG	1	11524	GREATER AMBERJACK	SERIOLA DUMERILI	29
7	EFG	1	11526	ALMACO JACK	SERIOLA RIVOLIANA	6
7	EFG	1	11905	BLACKFIN SNAPPER	LUTJANUS BUCCANELLA	3
7	EFG	1	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	15
7	EFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	134
7	EFG	1	12212	COTTONWICK	HAEMULON MELANURUM	394
7	EFG	1	12308	KNOBBED PORGY	CALAMUS NODOSUS	13
7	EFG	1	12314	RED PORGY	PAGRUS SEDECIM	12
7	EFG	1	12703	YELLOW CHUB	KYPHOSUS INCISOR	2

					CRUISE TOTAL	671

CRUISE= 8

CRUISE	SITE	GEAR	SPECIES	COMMON NAME	SCIENTIFIC NAME	NUMBER TAGGED
8	EFG	1	3306	SPOTTED MORAY	GYMNOTHORAX MORINGA	3
8	EFG	1	9002	LONGJAW SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	17
8	EFG	1	10511	ROCK HIND	EPINEPHELUS ADSCENSIONIS	1
8	EFG	1	10541	SCAMP	MYCTEROPERCA PHENAX	2
8	EFG	1	11504	BLUE RUNNER	CARANX CRYSOS	53
8	EFG	1	11506	HORSE-EYE JACK	CARANX LATUS	3
8	EFG	1	11524	GREATER AMBERJACK	SERIOLA DUMERILI	2
8	EFG	1	11905	BLACKFIN SNAPPER	LUTJANUS BUCCANELLA	4
8	EFG	1	11906	RED SNAPPER	LUTJANUS CAMPECHANUS	5
8	EFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	115
8	EFG	1	12212	COTTONWICK	HAEMULON MELANURUM	86
8	EFG	1	12308	KNOBBED PORGY	CALAMUS NODOSUS	7
8	WFG	1	11504	BLUE RUNNER	CARANX CRYSOS	7
8	WFG	1	11506	HORSE-EYE JACK	CARANX LATUS	1
8	WFG	1	11524	GREATER AMBERJACK	SERIOLA DUMERILI	15
8	WFG	1	11915	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	14

					CRUISE TOTAL	335
					GRAND TOTAL	3504

APPENDIX 5-6

POPULATION DYNAMICS OF THE RED SNAPPER (*Lutjanus campechanus*) IN THE NORTHWESTERN GULF OF MEXICO

by

W.J. Gazey

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May 1980

POPULATION DYNAMICS OF THE RED SNAPPER (*Lutjanus campechanus*) IN THE NORTHWESTERN GULF OF MEXICO

INTRODUCTION

One of the major objectives of the National Marine Fisheries Service's (NMFS) study of the ecological effects of energy development on reef fish and benthic populations of the Flower Garden Banks of the Gulf of Mexico is to describe the biological characteristics, vital statistics and dynamics of populations of red snapper associated with the natural reefs and to compare these data to those for populations found at a nearby drilling platform. The effects of offshore oil and gas activities on reef fishes such as red snapper may be expressed in two major ways. One way is the impact of the contaminant discharges on the health and condition of individuals, whereas the other way, and subject of this paper, concerns the impact of the structures *per se*; i.e. increasing the habitat of a presumably habitat-limited species.

Recently, the Gulf of Mexico Fisheries Management Council (GMFMC, 1980) has published a proposed management plan for red snapper. Included in the management plan are the historical catch-effort data for the red snapper commercial fishery of the Gulf of Mexico for the period 1957-1974. Results of analysis of the catch-effort data for Texas and Louisiana (following Deriso 1980) are presented below. The effects of offshore petroleum structures and the related fisheries on the population dynamics of red snapper are then hypothesized and evaluated in light of the available information.

Red snapper landings in Texas and Louisiana are small in comparison to the landings in the eastern gulf, particularly Florida. However, landings for Texas and Louisiana are considered to be representative of the respective local (or state) stocks, whereas landings for Florida are not considered representative of the local stock. Fish landed in Florida are typically taken at snapper grounds throughout the gulf. The Florida commercial fishery includes several fleets of large vessels which remain at sea for extended periods and fish large geographic areas.

Historically, many Florida vessels would initially fish from Florida to Galveston where the catch would be offloaded and shipped by truck to Florida. The boats would then proceed to fish south Texas, then on to the Campeche banks, and ultimately the vessels would return to Florida. Presently, as much as 50% of the commercial red snapper catch landed in Florida may come from the northwestern gulf, particularly from the offshore area extending from the Mississippi River delta westward to Texas (pers. comm., Percy Thompson, NMFS, April 1981). This geographic area, often referred to as the "oil patch", sustains not only the Louisiana commercial fishery and a large part of the eastern gulf snapper fishery, but also a substantial recreational fishery. The area is the most intensively developed offshore oil and gas area in the world (Fig. 1), and the petroleum platforms and pipelines on the middle and outer part of the shelf provide habitat for subadult (Age 1) and adult (Age 2+) red snapper.

Red snapper apparently prefer, or at least show an attraction to, reef or hard bank habitats at the end of their first year. During the first year, the Age 0 fish occupy the soft bottoms of the brown shrimp (*Penaeus aztecus*) grounds, particularly areas around the Mississippi River delta. Large numbers of small red snapper (and some large specimens) are taken in the by-catch of the shrimp fishery. Once red snapper have taken residence at a reef in the northwestern gulf, there is little evidence that they exhibit any major movement or migratory behavior. It is likely, based upon results of tagging studies (Fable 1979, Gallaway 1980), that the fish remain associated with a specific reef for the entirety of their life, unless environmental conditions become intolerable, forcing movement. As the lower lethal temperature for red snapper is about 13 C, and the optimal activity temperature is 18 C (GMFMC 1980), fish which have initially occupied inshore banks in shallow waters during warm periods (or years) probably move offshore during cold periods and years in direct response to temperature. If suitable habitats are not located offshore, these displaced fish probably again disperse inshore with the advent of warming temperatures. We believe this to be the only major class of movement by red snapper in the northwestern gulf, rejecting the often-stated hypothesis that the fish are characterized by not only

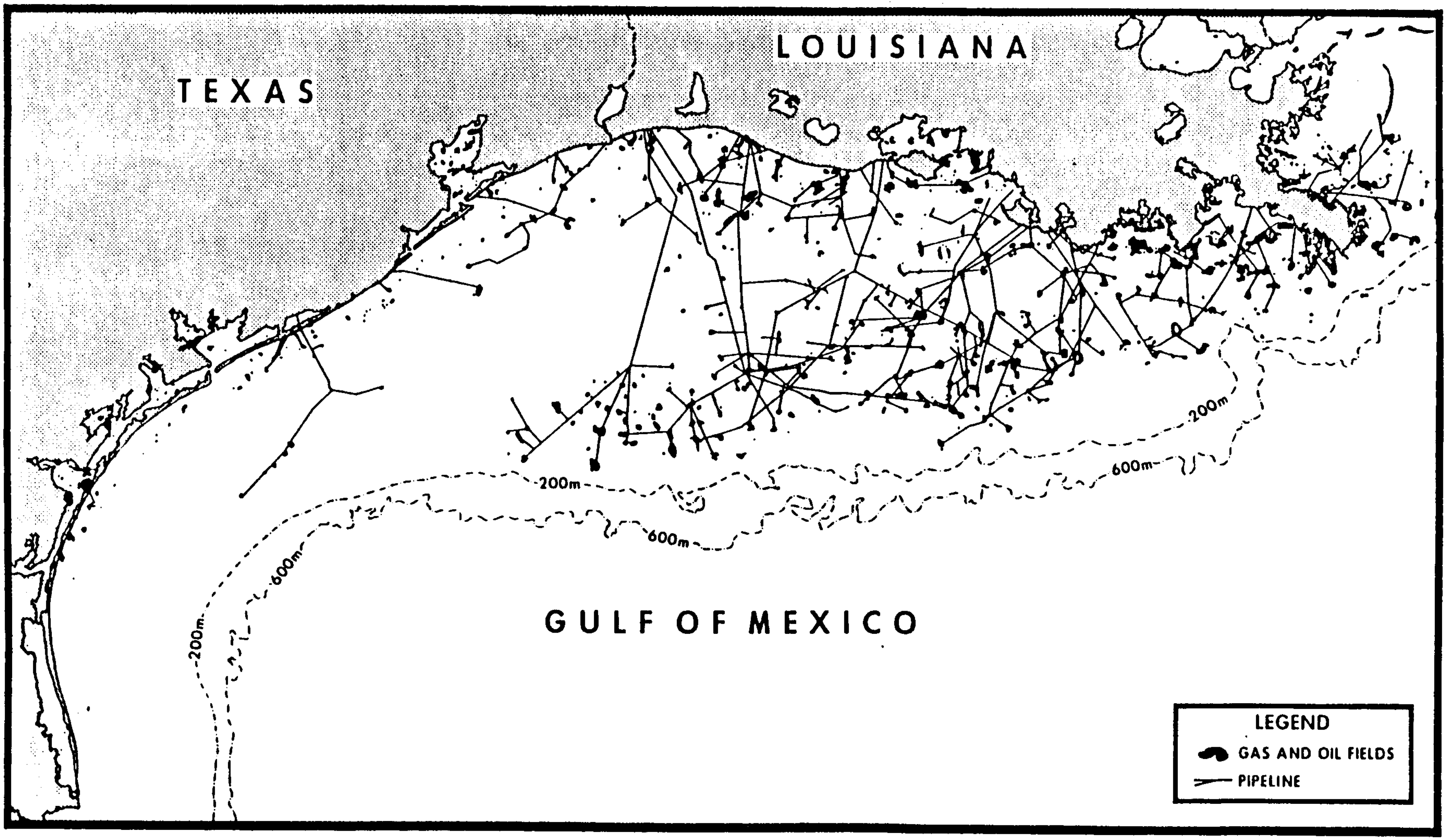

Fig. 1. Distribution of gas and oil fields and pipelines on the Texas-Louisiana continental shelf. Map provided by TRANSCO Companies, Inc. 1979.

seasonal offshore-onshore movements related to temperature, but also by an offshore spawning migration and return during the spawning period.

Red snapper grow rapidly during their first year, attaining fork lengths of about 200 mm and grow at a rate of about 75 mm per year after the first year (Bradley and Bryan 1976). The fish become sexually mature after age two, and spawning occurs from June to October. Maximum age has been estimated at 20 years with a maximum length of 900 mm and a maximum weight of 18 kg. Most specimens which comprise the fishery are apparently two-year-olds (GMFMC 1980).

The red snapper is carnivorous and food habits change with size or age. Juvenile red snapper while over soft bottoms feed on shrimp and other epifaunal benthic invertebrates, and are quite susceptible to mortality from shrimp fishing. Red snapper at reefs remain basically bottom feeders, but they do feed on some pelagic forms from the water column. With increase in size of the red snapper, fish become more prevalent in their diet. Most of the prey species consumed by red snapper, are not reef or rock dwellers, and "therefore the inference can be made that the species feeds away from these areas" (GMFMC 1980).

THE DERISO MODEL

Traditionally, catch and effort statistics have been utilized in stock-production models which are based on the logistic equation or some similar function (e.g. Schaefer 1954; Pella and Tomlinson 1969; Fletcher 1978). Deriso (1978, 1980) has made a major contribution with a delay-difference model which addresses the deficiencies found in stock-production models. As Deriso (1980) says:

> "As a class they [stock-production models] have accumulated a long history of adverse criticism: their equation forms all imply continuous reproduction (as opposed to seasonal breeding), and in applying the models one must suppose that progeny age instantaneously to adulthood. And because of the composite nature of the terms in these models, the model parameters have no direct correspondence to observable phenomena. In consequence, one's estimates of model parameters cannot be corroborated by estimates independent of the model itself."

Although the Deriso model is not free of mathematical complications, it can be conceptually broken into six components which are common to fisheries literature. The purpose of this section is to examine these components for their underlying biological assumptions. The specific algebraic manipulations that are required to formulate the model may be found in Deriso's original papers; a listing of the notations used below are provided as Table 1.

We start by defining catchable population biomass (B_t) during year t as,

$$B_t = \sum_{i=k}^{\infty} W_{i,t} N_{i,t} \qquad (1)$$

where $W_{i,t}$ is the average weight of a catchable adult and $N_{i,t}$ is number of individuals i years old in year t. Note that age indexing starts at k (age of recruitment of individuals to the fishery) and extends to infinity, which is an important mathematical requirement in the formulation of the model. Thus, theoretically, a fish lives forever. However, as we will demonstrate below, only a very few adults will actually attain the maximum, physiologically possible age, and consequently the overestimation of biomass should not be significant.

Equation (1) may be rewritten as,

$$B_{t+1} = \sum_{i=K+1}^{\infty} W_{i,t+1} N_{i,t+1} + W_{k,t+1} N_{k,t+1}$$

with the last term representing the biomass of adults entering the fishery in year t+1 (i.e. recruitment). The usual assumption that recruitment is a function of escapement is made (see Ricker 1975),

$$W_{k,t+1} N_{k,t+1} = R\ (S_{t+1-k}) \qquad (2)$$

where, $S_t = B_t - C_t$ = escapement of catchable adults in year t and
C_t = the total catch (in weight) in year t

The functional form of stock-recruit relationship can take on any shape. For example the Ricker curve is,

$$R\ (S_{t+1-r}) = S_{t+1-r}\ \exp\ \{\alpha(1-S_{t+1-k})/\beta\}$$

Table 1. Summary of notations.

Roman Symbols:

B_t	-	biomass of the catchable population in year t
C_t	-	biomass of catch in year t
c_t	-	catch per unit effort in year t
E_t	-	annual measure of effort for year t, having units suitable to the techniques of the fishery, but standardized for all users of a single fish stock
$\bar{E}$	-	mean effort over time series available
F	-	instantaneous fishing mortality (dimensionless)
k	-	age of recruitment of individuals to the fishery
ℓ	-	annual natural survival fraction for catchable adults
1-m	-	fraction of individuals in ρ_t that become catchable (enter B_t) at the beginning of year t (prior to harvesting in that year)
$N_{i,t}$	-	number of individuals of age i in year t
P_t	-	biomass of uncatchable population in year t
q	-	catchability coefficient with dimensions of $(\text{unit effort})^{-1}$
S_t	-	biomass of escapement of catchable adults in year t
$W_{i,t}$	-	average weight of a catchable adult in year t

Greek Symbols:

α	-	dimensionless parameter controlling shape of Ricker recruitment curve
β	-	biomass of replacement abundance in Ricker recruitment curve
ρ	-	Ford's growth coefficient

where the parameter α controls the shape of the curve and β is the replacement abundance (see Fig. 2). Another common stock recruitment relationship is the Beverton-Holt curve and Deriso (1978) has presented a three parameter generalized stock-recruitment curve.

Now that the first two components of the model have been defined, we may examine the rules controlling weight increment and decline in numbers (mortality) of a cohort over time. Ford (1933) and later Walford (1946) formed a recursive relationship of length increments over time based on the von-Bertalanffy growth equation. The same relationship holds for weight; however, care must be taken that only weight above the inflection point is used. Thus,

$$W_{i+1,t+1} = (1+\rho)\ W_{i,t} = \rho\ W_{i-1,t-1} \qquad (3)$$

where ρ is Ford's growth coefficient and has values between 0 and 1. Deriso mistakingly calls ρ the Brody growth coefficient (the relationship between the two is $\rho = e^{-k}$ where k is the Brody growth coefficient). Note that the age of recruitment must coincide with the onset of maturity. If we reason that an individual's growth deaccelerates because of an energy transfer to reproductive effort then the growth in weight of catchable fish will be to the right of any inflection point (see Fig. 3).

The natural mortality component in the model is generated by assuming that (1) catchable adults experience a common annual mortality, and (2) that natural mortality is minimal (or at least small in comparison to fishing mortality) during the period of harvesting; i.e.,

$$\ell = \left(\frac{N_{t+1}}{N_t}\right)\left(\frac{S_t}{B_t}\right) \qquad (4)$$

where ℓ is the annual natural survival fraction for catchable adults. Compounding ℓ through time will result in very few fish reaching the maximum physiologically possible age.

A partial result can now be generated for knife edge-recruitment, where all fish of a given age become vulnerable to the fishery with their vulnerability remaining constant throughout their lifetimes, by substituting equations (2), (3) and (4) into equation (1) which yields,

$$B_{t+1} = (1+\rho)\ \ell\ S_t - \rho\ \ell^2 \frac{S_t}{B_t} S_{t-1} + R\ (S_{t+1-k})$$

(Deriso's equation 4).

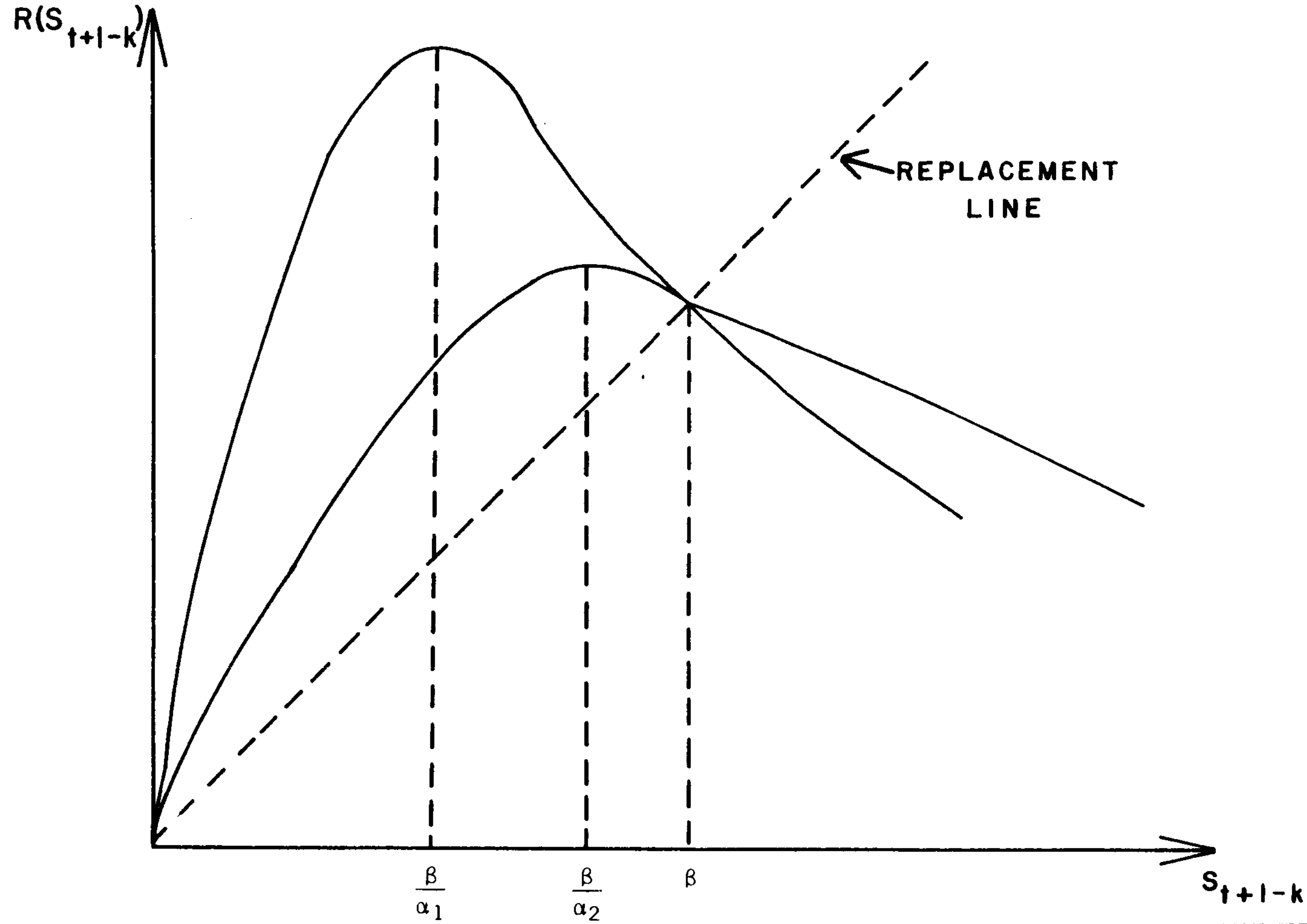

Fig. 2. Ricker stock-recruitment curves. The two curves have same β but different $\alpha_1 > \alpha_2 > 1$.

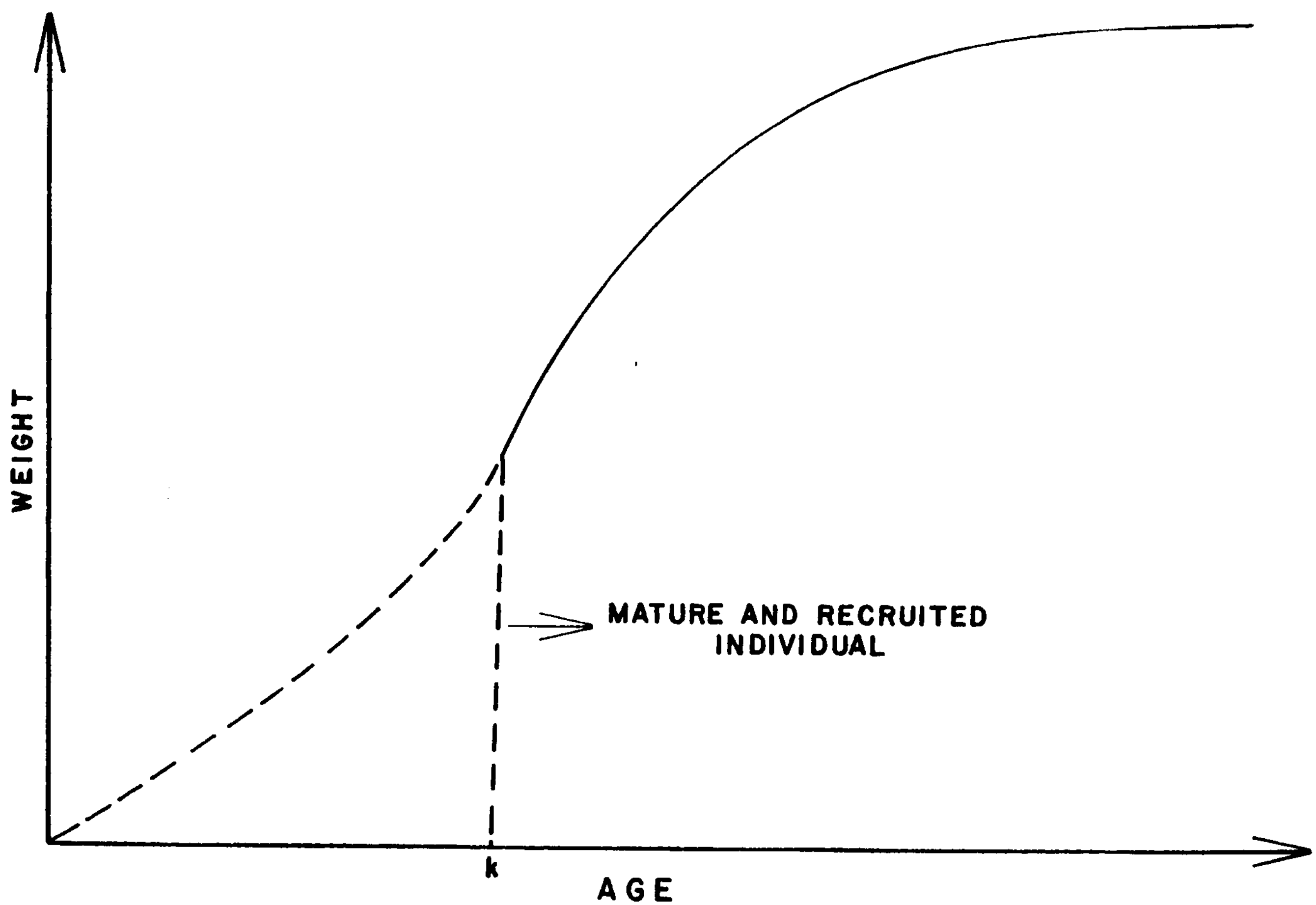

Fig. 3. Growth over time. Individual recruited at age k which coincides with any inflection point.

Two other recruitment patterns can be identified (Ricker 1975). First, platoon recruitment occurs when the vulnerability of a year-class increases gradually with time but where individuals, during any fishing season, are fully catchable or not catchable. Second, continuous recruitment is defined as increasing vulnerability of a year class such that each fish, as it grows larger and older, experiences an increasing likelihood of being caught until a limit of maximum vulnerability is reached. Both of these regimes may be approximated by introducing a population P_t of sexually immature fish (but of age k or older). If it is assumed that a constant fraction (1-m) is recruited annually into the catchable population then the recruited portion is,

$$(1-m)\ P_{t+1} \qquad (5)$$

By the substitution of expression (5) into the "complete recruitment" model and by using the above arguments on a sexually immature population, the "incomplete recruitment" model may be expressed by the set of equations,

$$P_{t+1} = (1+p)\ \ell m\ P_t - p(\ell m)^2 p_{t-1} + R\ (S_{t+1-k})$$

$$B_{t+1} = (1+p)\ \ell\ S_t - p\ \ell^2\ \frac{S_t}{B_t}\ S_{t-1} + (1-m)\ P_{t+1}$$

(Deriso's equation 8).

The relatively simple form of the above model can only be achieved by introducing a single step (year) growth boost to uncatchable adults when they enter the catchable population (Fig. 4). Thus catchable adults in any year-class are larger than the uncatchable adults from the same cohort. Figure 4 graphically represents the population dynamics with incomplete recruitment.

Since biomass cannot be measured directly, the usual index utilized is catch per unit effort, i.e.,

$$c_t = C_t/_{E_t} = q\ B_t \qquad (6)$$

where c_t is the catch per unit effort, E_t is unit effort in year t, and q is the catchability coefficient. Substitution of (6) into the "incomplete

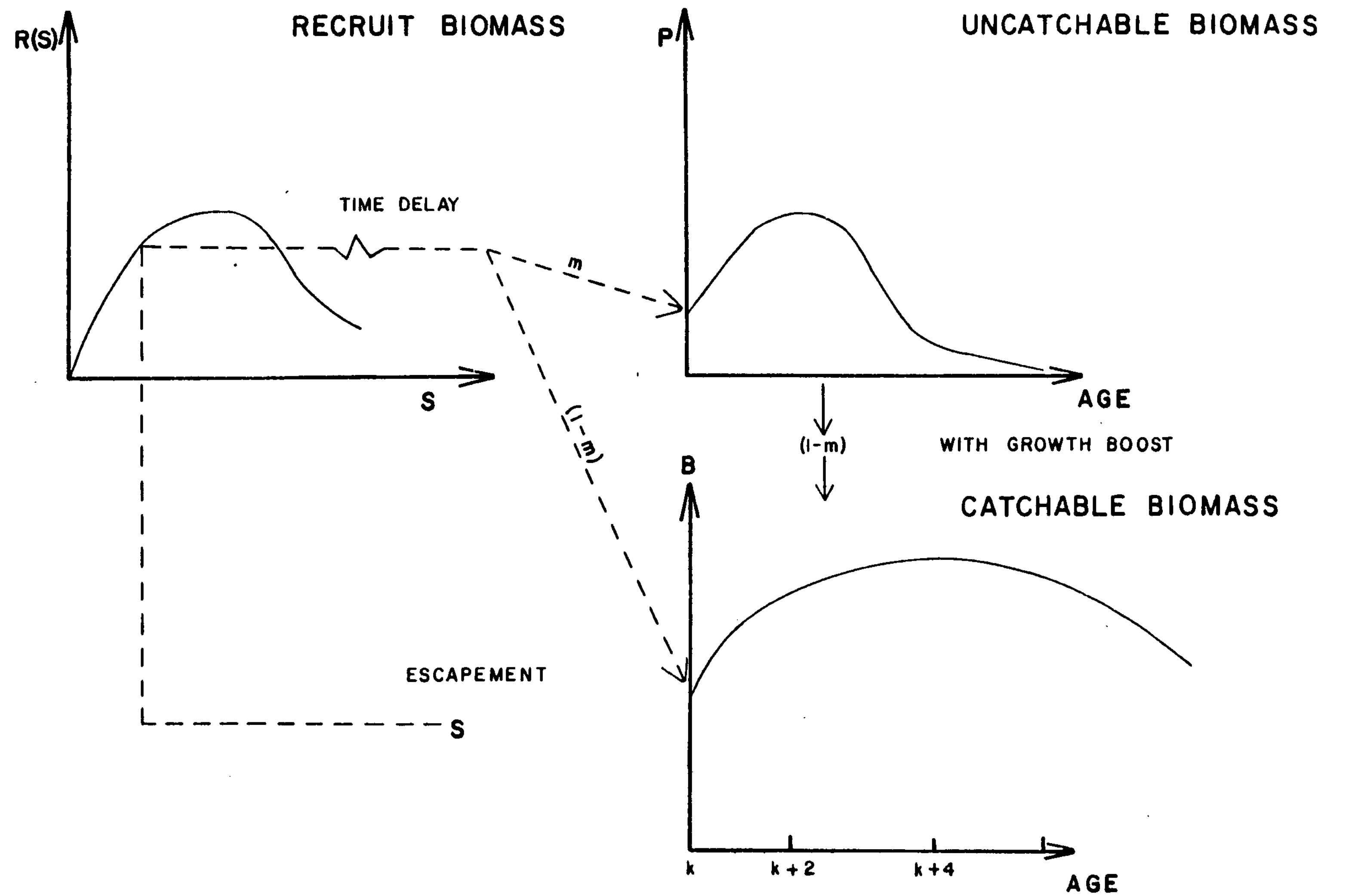

Fig. 4. A graphical representation of population dynamics with incomplete recruitment. Recruits enter both the uncatchable and catchable adult subpopulations. Spawners are those individuals in the catchable adult subpopulation that survive annual fishery exploitation. (Adapted from Deriso 1980).

model", after much algebraic manipulation yields,

$$\begin{aligned} c_{t+1} = {} & (1+\rho)\ \ell\ (1-q\ E_t+m)\ c_t \\ & - \ell^2\ \{\rho\ (1-q\ E_t)\ (1-q\ E_{t-1}) + (1+p)^2(1-q\ E_{t-1})m + pm^2\}c_{t-1} \\ & + (1+\rho)\ p\ell^2 m\ (1-q\ E_{t-2})\ (1-q\ E_{t-1} + m)\ c_{t-2} \\ & - (\rho\ell^2)^2 m^{\ 2}\ (1-q\ E_{t-2})\ (1-q\ E_{t-2})\ c_{t-3} \\ & + q\ (1-m)\ R\ \{\ (1-q\ E_{t+1-k})\ \frac{c_{t+1-k}}{q}\ \} \end{aligned}$$

(Deriso's equation 9)

While the result is complex, the parameters $(\rho, \ell, q, \alpha, \beta, m)$ should, in theory, be obtained from a catch-effort time series using non-linear parameter estimation techniques. Before applying the red snapper data to the model, a few comments on some of the statistical properties and problems of the model are in order.

The objective of the analysis is to find the values of the parameters that minimize the sum of squares of the predictive variable (c_{t+1} on the left side of the equation) given the explanatory variables (the c_t and E_t on the right side of the equation). There are two statistically distinct views of the explanatory variables. First, as Deriso recommends, we may assume that c_t and E_t constitute a fixed and known sequence, and that for each value of t the model is valid up to an additive, normally-distributed random variable, such that, under fairly general conditions, the least-square parameter estimates will tend to be asymptotic to a normal distribution around the "true" parameter values. In other words c_t and E_t are known exactly and any error in model prediction arises because the model is only an approximation of the true population dynamics. Unfortunately, catch and effort statistics are notoriously inaccurate. Therefore, we recommend an alternative view of the explanatory variables. That is, assume that the model exactly depicts the population dynamics, but the c_t and E_t are only known approximately. If the errors in measurement are normally distributed, then all previously predicted explanatory variables c_t, c_{t-1}, c_{t-2} and c_{t-3}, are used to predict C_{t+1}. Figure 5 graphically depicts the two views. In addition, measurement error in E_t may easily be incorporated into most non-linear, least-squares algorithms,

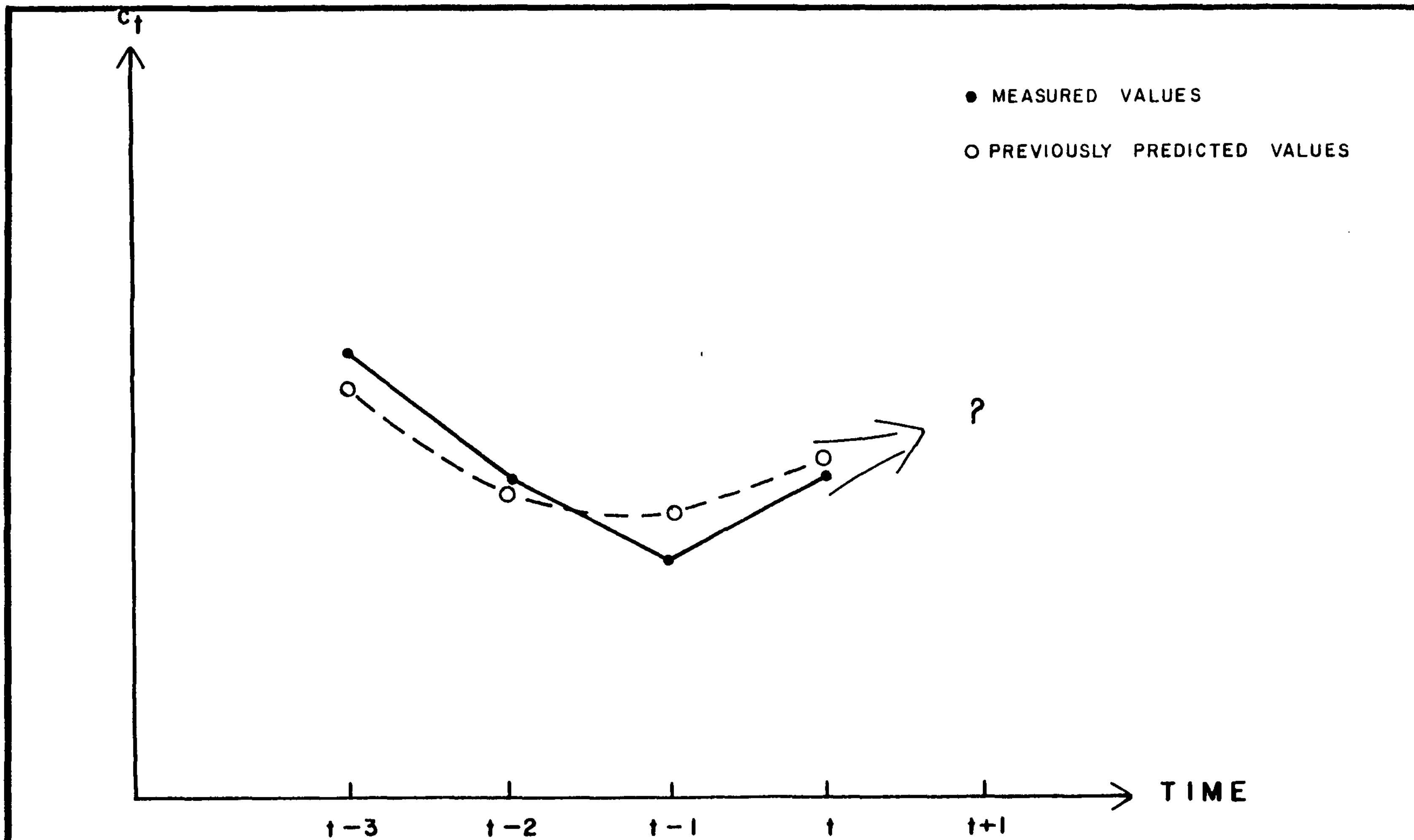

Fig. 5. Process error versus measurement error. All process error uses observed values (solid line) while all measurement error (dashed line) uses past predictions to predict C_{t+1}.

if *a priori* knowledge is available. In both the process and measurement error viewpoints, departure from the assumed normally distributed residuals is not that important for obtaining unbiased estimates of the parameters; however, it is extremely important for hypothesis testing.

Another statistical problem of the model is that the parameters are structually confounded, thus many of the parameters will be highly correlated. For example, any regression procedure will have difficulty in deciding (statistically) whether the data consisted of a large number of small fish or whether a few large fish were present in the data. The result, in the least-squares response surface, is the presence of many local minima. Using the "all measurement error approach" will help, as any initial values chosen for the parameters that are highly inconsistant with the data will result in instability, since previous predictions of c_t are used to predict c_{t+1}. An additional improvement would be to use a Bayesian approach to the estimation of the parameters where auxillary information is available. For instance, if age-specific weights of fish in the catch were available, the weight equation (3) could be fitted to obtain an estimate of ρ and its associated variance. The ρ value could then be used as a starting point in regressions, with the variance used to weight all subsequent estimates of ρ.

All of the above statistical problems dictate that the estimated parameters should be viewed as "ballpark" values in the absence of independent corroborating evidence. However, even such ballpark values can greatly increase the understanding of the population dynamics of a fishery with a paucity of data other than catch and effort statistics. The addition of Bayesian approaches to account for prior knowledge is especially exciting for management of commercially important species in which stock and recruit information is difficult or impossible to obtain, yet mortality and growth are well determined.

MODEL DATA

Catch and effort data used in the Deriso model must meet two requirements. First, the measure of effort must be consistent over time and any technological improvement yielding increased effective effort must be taken into account. Second, the effort must apply to the fish caught. Therefore some evaluation of the data used was required.

Three types of effort data (the geographical location in which the effort was expended is unknown) are consistently reported in the published statistics for red snapper: number of handline vessels, number of handline fishermen on vessels and number of handlines. Based upon the available range of data (1957-74) the number of handlines was characteristically about the same as the number of handline fishermen during these years. A marked exception to this generality (1 line per fisherman) was that the number of handlines per fisherman in Louisiana ranged from 2.9 to 29.6 between 1958 and 1966. GMFMC (1980) reports that the data describing the number of handlines is viewed as suspect over this period. Based upon the apparent problems this category was eliminated as a contender for the measure of effort. Of the remaining two measures of effort, the number of handline fishermen on vessels was believed to more accurately reflect effort, since the number of vessels would not be sensitive to changing conditions. The only technological advance in the fishery has been the introduction of power reels. However, their use is not particularly widespread in the fishery as they are expensive and do not necessarily reduce the number of men required to tend the lines of a vessel.

The catch statistics are available both by landings (total mass landed in a state regardless of where caught), as well as by the mass actually captured from a specific area. However, since the effort (handline fishermen) cannot likewise be adjusted to reflect the distribution of effort by area, we must use the total landings data. The total landings are directly related to the number of handline fishermen licensed in each state. Given the fishing patterns, we believe that the majority of both the Louisiana and Texas landings are comprised of fish representing the local red snapper stocks of the northwestern gulf, and are not mainly fish from other areas (e.g. eastern gulf, Mexico). The same would not be true for the Florida landings, where as much as 50% of the landings may be from Louisiana waters.

Figure 6 shows the catch and effort data which were used in the analyses, while Fig. 7 shows the catch per unit effort (CPUE) over time. An immediate observation is that the steep decline in catch and effort (from 1961 in Louisiana and 1965 in Texas) is not reflected by the CPUE data which exhibit an ocillatory pattern. Since CPUE is an index of available biomass of catchable fish, one cannot immediately attribute the decline in catch to dwindling stocks. We can only speculate that either economic factors have increased the fisherman's real cost, thus forcing him to reduce effort (or inducing him to move to an alternative fishery), or that a real decline has occurred but has been masked by increased vulnerability to fishing due to a reduction in the number (or area) of reefs utilized by the fish.

PARAMETER ESTIMATION AND MODEL OUTPUTS

We assumed "all measurement error" as described in the previous section. The non-linear optimization algorithm utilized was quasi-linearization following Bard (1974). The computer program was written in BASIC with options for a Deriso, Ricker or Beverton and Holt recruitment curves. A microcomputer (Apple 2 plus) was used to execute the program, demonstrating that large and expensive computing facilities are not required. Results are shown by Table 2. We could find no combination of initial parameter estimates that would converge with the fully unconstrained problem. However, by fixing any three of the parameters the algorithm would converge. We believe that, given the structual problems in the model (see previous section), that the data did not have sufficient contrast (i.e. degree of difference between the observed variables relative to sample size) to accurately derive the required parameters.

We found that no sensible parameter values (e.g. $\rho > 1$ $m < 0$), could be obtained when using a Beverton and Holt recruitment curve. However, the Ricker curve yielded reasonable results. The lag between spawning and recruitment (k) was set to 3 years reflecting maturity after the second year of life. Other regressions were attempted at different lags.

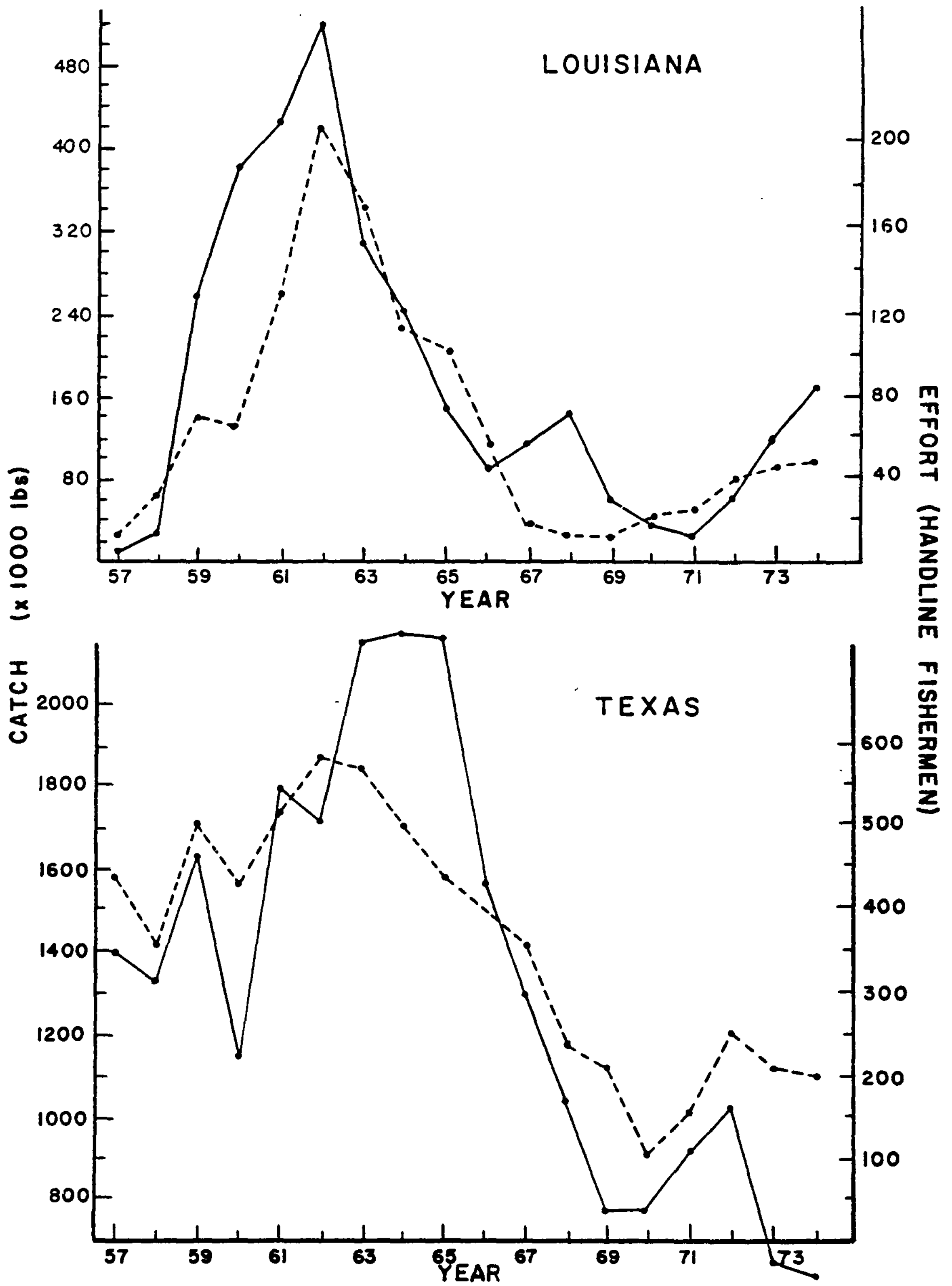

Fig. 6. Catch (solid line) and effort (dashed line) time series used in the regressions for (a) Louisiana, (b) Texas.

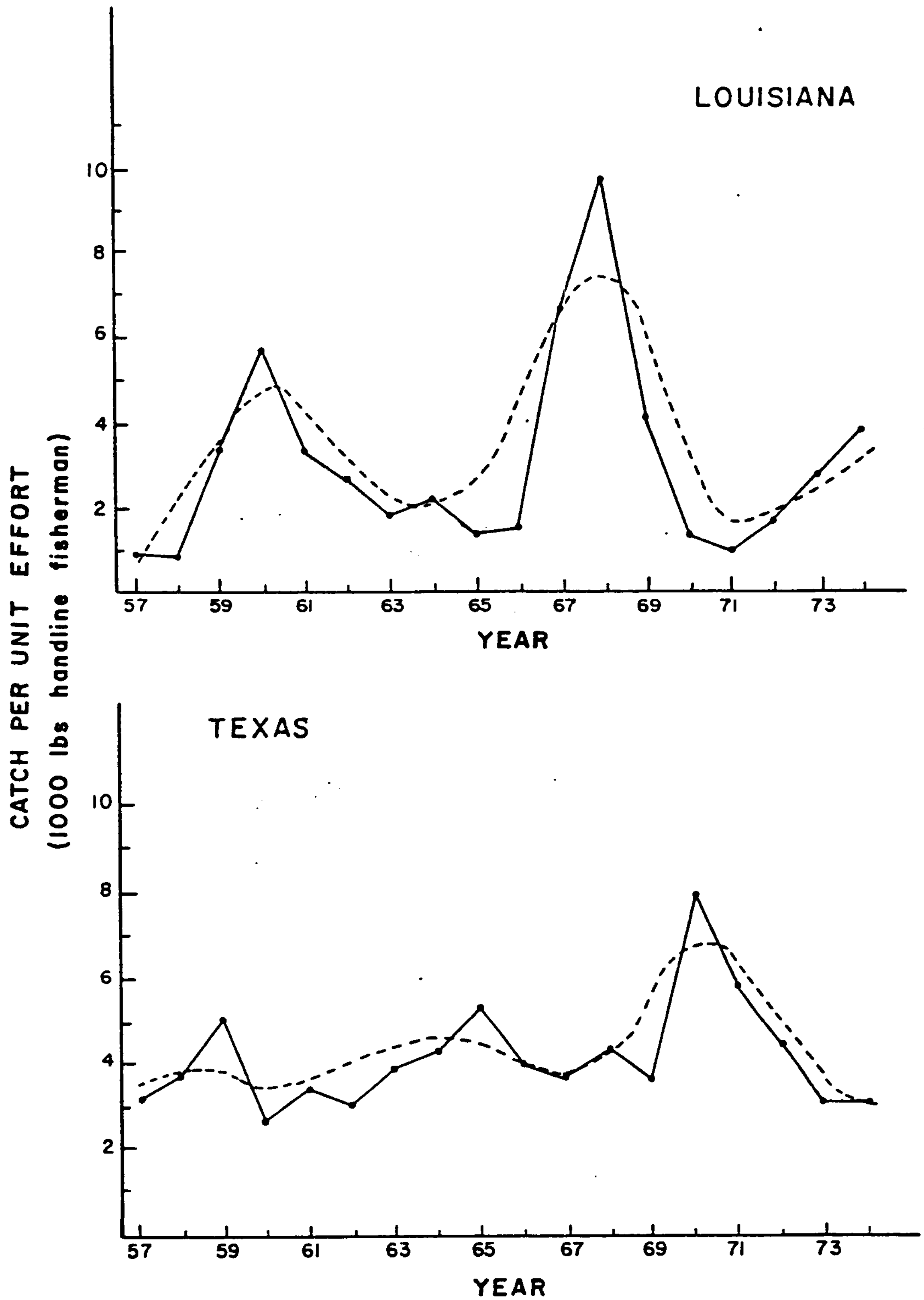

Fig. 7. Observed catch per unit effort (solid line) and model prediction (dashed line) for (a) Louisiana, (b) Texas.

Table 2. Deriso's model parameters for populations of red snapper in (a) Louisiana and (b) Texas using Ricker recruitment curves. Beverton-Holt recruitment curves did not fit the data.

(a) Louisiana

k = 3

R^2 = .63

Parameter	Estimate	Standard Deviation	Units
ρ	.71	.06	-
l	.52	.12	-
q	2.7×10^{-3}	5.1×10^{-4}	$(\text{handline fisherman})^{-1}$
α	2.5	.28	-
β	100	11	1,000 lbs
m	.01	3.4×10^{-3}	-

(b) Texas

k = 3

R^2 = .76

Parameter	Estimate	Standard Deviation	Units
ρ	.96	.21	-
l	.59	.04	-
q	8.5×10^{-4}	2.2×10^{-4}	(handline fisherman)
α	1.9	.57	-
β	660	59	1,000 lbs
m	.16	.07	-

Values of k greater than 3 fit the data poorly while a lag of 2 produced results very similar to a lag of 3. We set the parameter values at a lag of 3 (maturity at age 2) since this agrees with published values of reproductive condition.

The generalized squared correlation coefficient R^2,

$$R^2 = 1 - \frac{\text{Residual Sum of Squares}}{\text{Total Sum of Squares Around the Mean}}$$

for the regressions were .63 for Louisiana and .76 for Texas. The standard deviation (the inverse of the Hessian was used at a measure of variance) are not accurate as only combinations of three parameters were used. The deviations do illustrate that any confidence interval would be large.

The two dimensioned parameters (q, β) reflect the scale differences between the two fisheries. The replacement abundance β, (stock size required to produce the equivalent number of recruits) suggests that the Texas habitat (mainly natural reefs) has approximately seven times the carrying capacity as Louisiana habitat (mainly artificial reefs). The catchability coefficient (q) indicates that while the fish are more vulnerable in Louisiana, the mean instantaneous fishing mortality ($F = q\bar{E}$) is higher in Texas (.30) than in Louisiana (.18). On the other hand the dimensionless parameters (ρ, ℓ, m) have values similar in magnitude. They indicate that snapper are fast growing, have relatively low natural mortality (for a subtropical fish) and a large fraction of the adult population is vulnerable to fishing. The results are consistant with the available life history features of red snapper.

The high values (>1) of α which completely describe the shape of the recruitment curve, resulting from the model were not expected based upon theoretical considerations. As adult snappers are thought to have a ceiling in abundance imposed by the amount of available reef habitat, we initially believed that the recruitment curves which would be indicated from the analyses would be either a Beverton and Holt type curve or a Ricker curve with $\alpha < 1$. The recruitment maximum for Ricker curves having $\alpha < 1$ occurs at a stock level greater than replacement. For Ricker curves having $\alpha > 1$, the maximum recruitment occurs when spawners are less than replacement level, and the curve becomes steeper and more dome-like as α increases.

The dotted line in Fig. 7 displays the fitted model to the observed catch per unit effort. We note that both regressions found parameter values that generated similar dynamics but 3 years out of phase. We emphasize that the oscillating nature of the catch per unit effort data can only be duplicated with a dome-shaped recruitment curve. Figure 8 demonstrates a theoretical population that has no fishing and spawns only once to illustrate how such an oscillation may be generated. The first spawning occurs at time t and the second at t+1, etc. The oscillations occur because the maximum level of recruitment occurs at a lower stock level than the replacement abundance.

There has been much speculation over the rationale for the decline in recruitment at higher stock levels (see Cushing and Harris 1973); however, such oscillations are generally believed to result (1) when cannibalism of young by adults is an important regulatory mechanism, or (2) when the effect of greater density is to increase the time needed by young fish to grow through a particularly vulnerable size range, or (3) when there is a density-dependent response (functional or numerical) of a predator or parasite to the abundance of the young fish it consumes.

DISCUSSION

Several important findings emerged from our analysis of red snapper catch effort data for 1957-74. Although catch of red snapper in the northwestern Gulf of Mexico declined markedly during the 1960's, effort also declined. The resulting CPUE data, an index to the population biomass, indicated a rather stable, but oscillatory, pattern over the period. Such a pattern does not indicate dwindling stocks unless there has been a concomitant increase in the vulnerability of the fish due to, say, reduction in the number of reefs utilized by the fish. We consider the latter unlikely, and believe that the reduced effort (and catch) by Texas and Louisiana commercial fishermen is more a matter of economics than stock problems.

Although Texas and Louisiana stocks appeared to have held up rather well over the period investigated, the total stocks of red snapper in the gulf appear to have declined. This statement is based upon the observed CPUE data for Florida for the period analyzed (Fig. 9). As described in

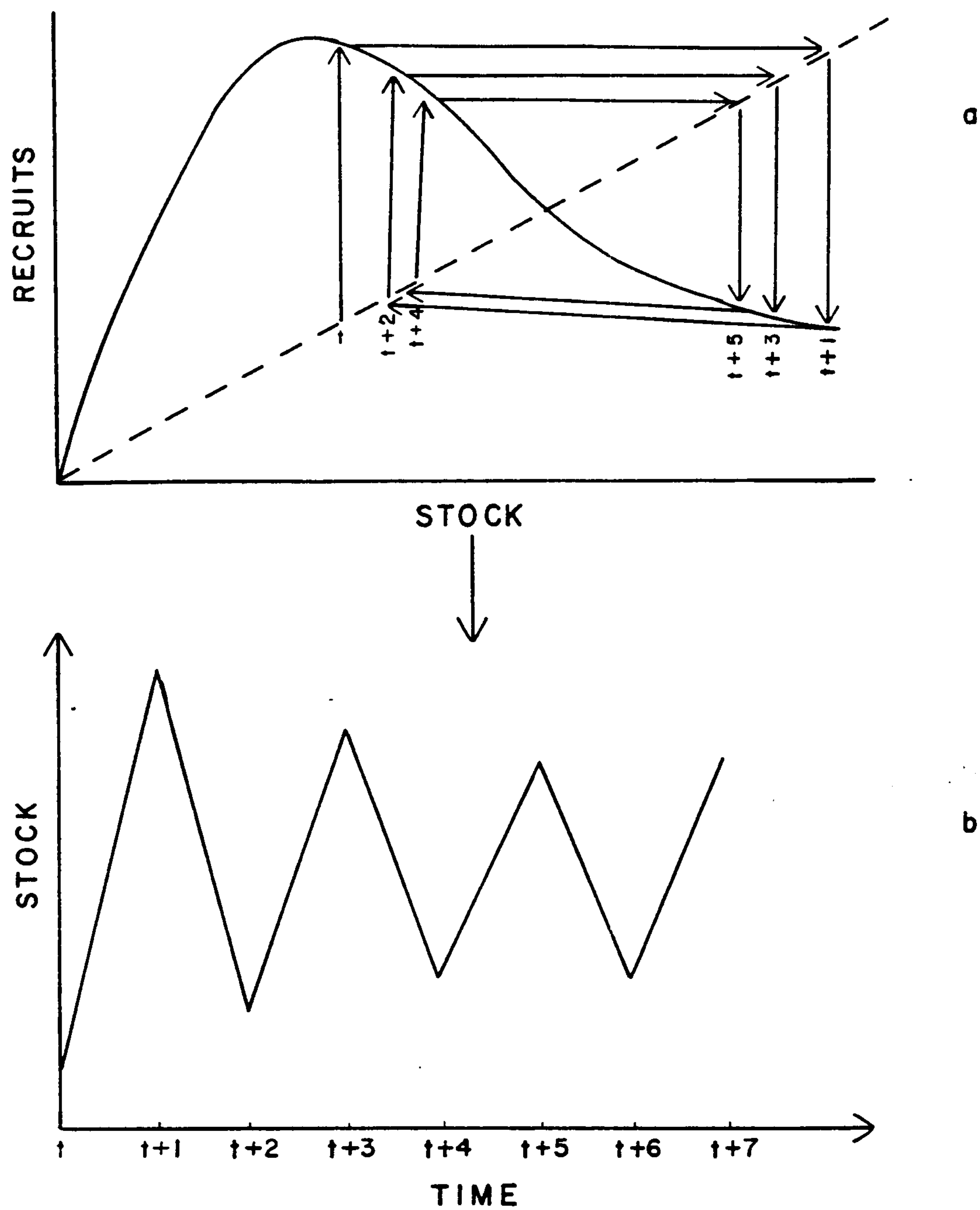

Fig. 8. Oscillations in stock size produced by recruitment curve with $\alpha>1$. See text for explanation.

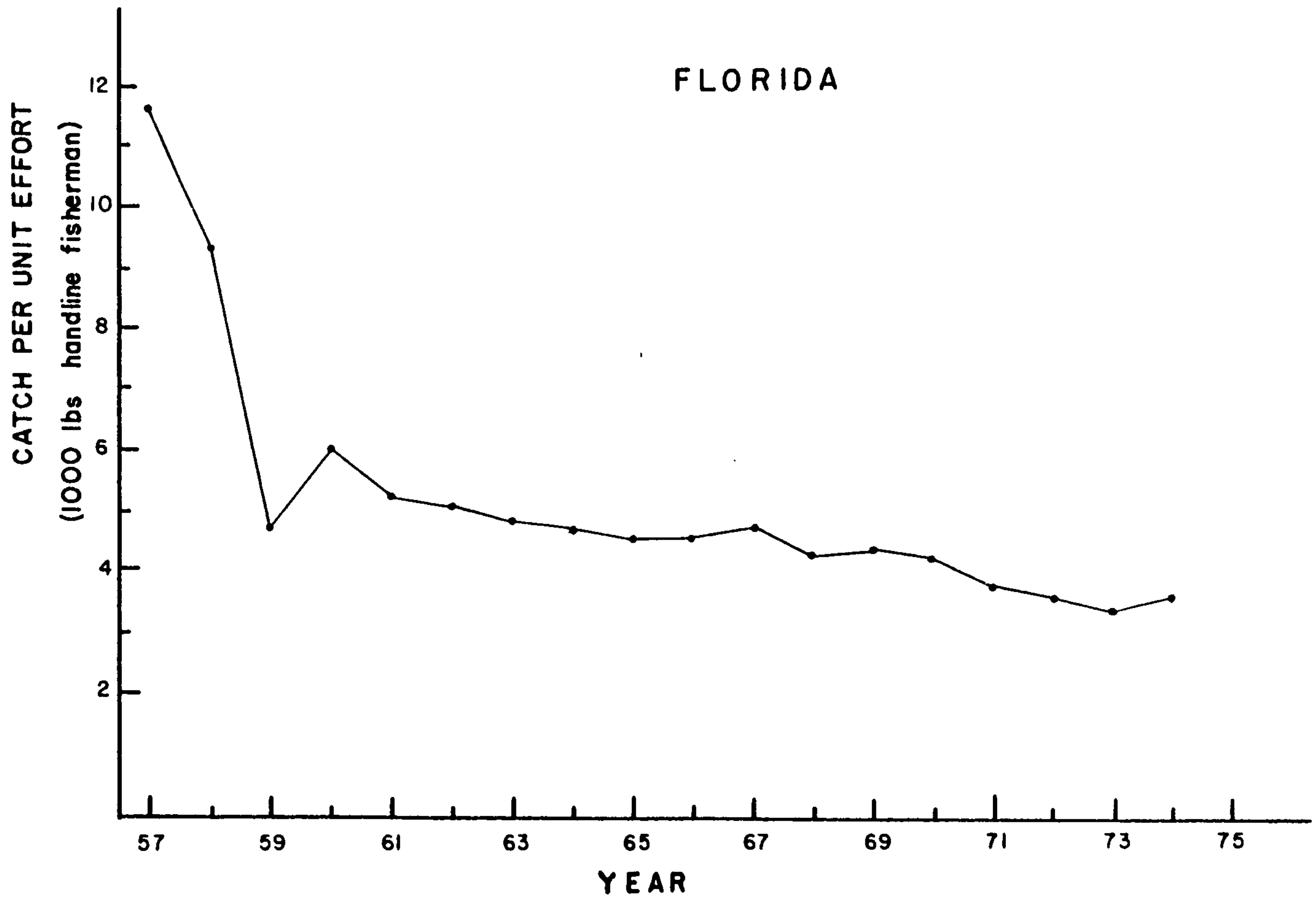

Fig. 9. Observed catch per unit effort for Florida.

the introduction, Florida snapper fishermen essentially sample the entire gulf, including Texas and Louisiana. It would appear, given that the northwestern gulf stocks are withstanding the fishing pressure being exerted on them but that the overall population of red snapper in the gulf might be declining, that the extensive habitat provided in the northwestern Gulf of Mexico in the form of offshore petroleum structures may have increased red snapper production.

We believe that the oscillations in Texas-Louisiana red snapper populations result from a density-dependent (functional and numerical) response of the major predator on Age 1 fish, the inshore fishery (Fig. 10). The inshore fishery includes both recreational and commercial fishermen and is largely a petroleum platform fishery. When population levels of red snapper at inshore reefs are high, word is quickly spread to the inshore reef fishermen in various fish and game reports (daily newscasts, newspapers, trade magazines, etc.) and effort is directed towards snapper (bottom fishing). When population levels are low, fishing effort is switched from bottom fishing to other kinds of effort (trolling, drift fishing, etc.) more appropriate for pelagic species.

Gallaway and Martin (1980) have shown that populations of red snapper at inshore reefs are predominantly resident, Age 1 fish and that the entire population can be (and, for the platform studied, apparently was) harvested on an annual basis. What this would mean, extrapolated to inshore reefs in general, is that little reproduction would be realized from inshore reefs--except during periods when populations were low and/or fishing pressure light. As shown by Fig. 10, we envision most of the reproduction coming from offshore reefs where populations, based upon samples from the Flower Gardens, are almost entirely characterized by reproductive-aged fish (Fig. 11). The offshore fishery associated with these reefs is predominantly commercial, mainly because the limited range of most recreational craft prohibits them from fishing these reefs. Young fish occupy soft bottoms, with many being lost to the by-catch of the shrimp fleet. At Age 1, the young fish occupy inshore reefs where, unless temperature forces them to move offshore, most are either harvested the first year or sometime later, depending upon overall density and fishing pressure. Observed size distributions of red snapper taken from an inshore

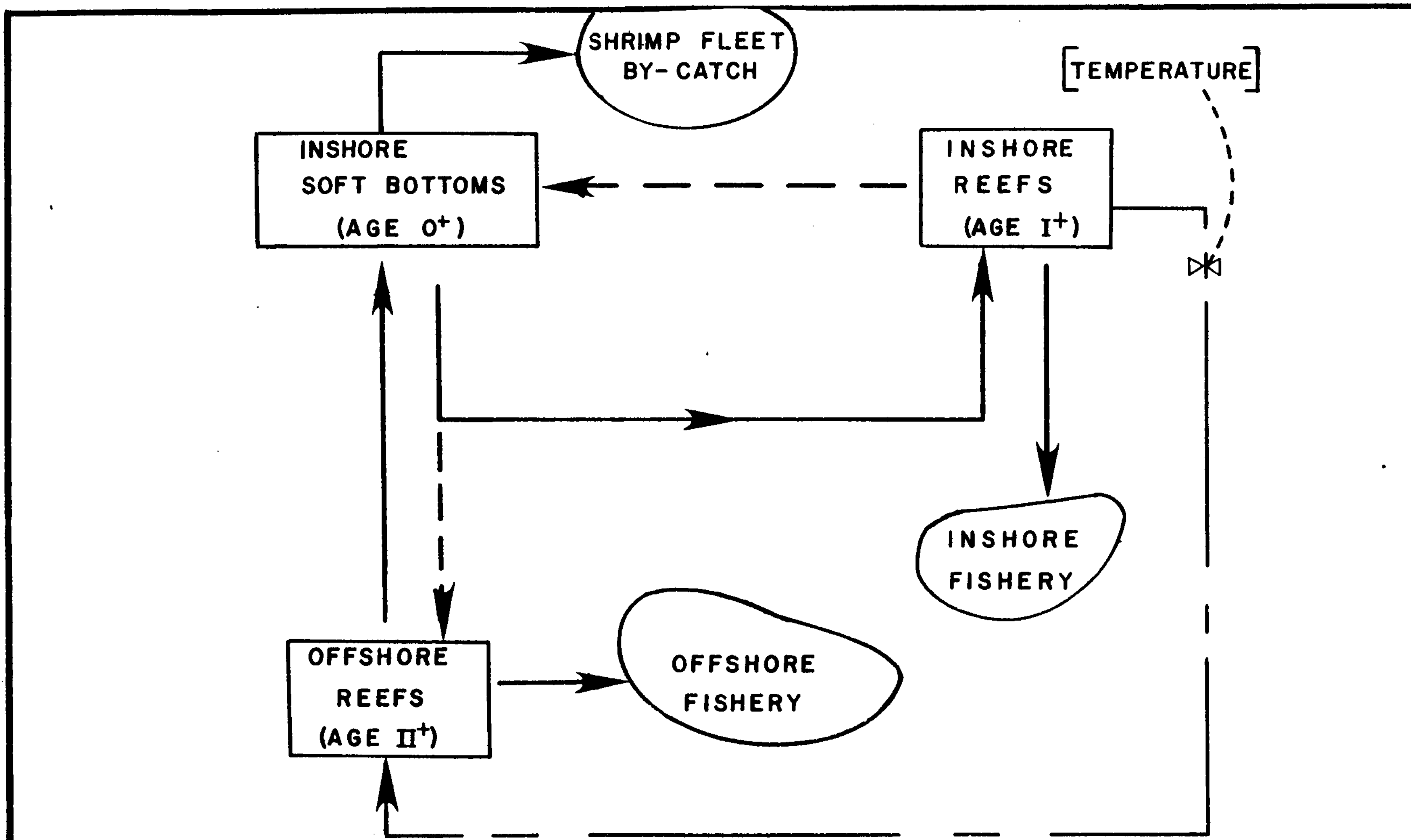

Fig. 10. Conceptual model of the red snapper fishery in the northwestern Gulf of Mexico. Major flows depicted by solid arrows. Movement from inshore to offshore can be major or insignificant, depending upon severity of winter temperatures.

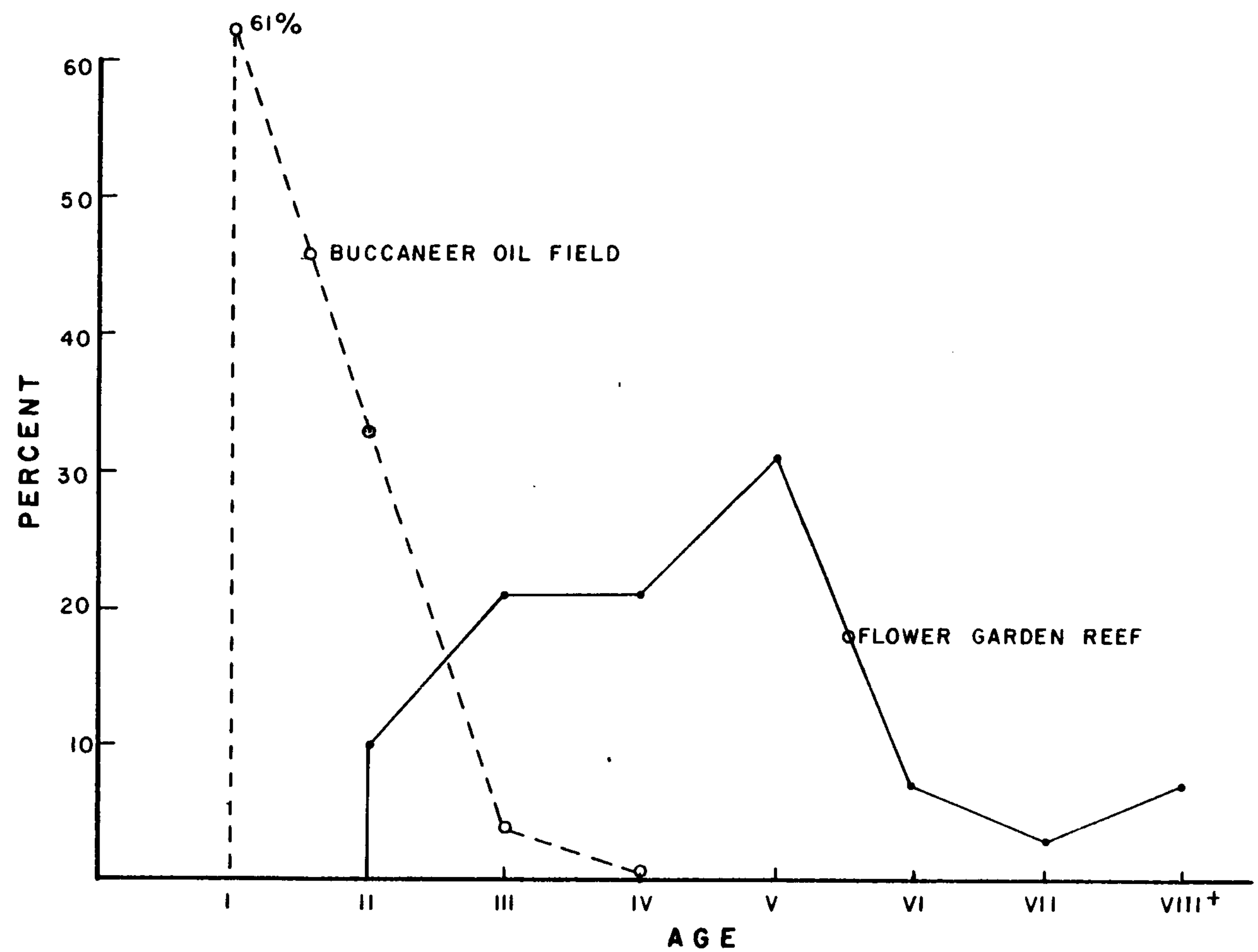

Fig. 11. Observed age distributions of red snapper populations at an inshore reef (Buccaneer Oil Field, dashed line) and an offshore reef (Flower Garden Banks, solid line).

reef studied by Gallaway and Martin (1980) support this idea as most fish in the population were recent recruits (Age 1) and few, if any, specimens were older than Age 4 (Fig. 11).

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Appendix 6-1. Total fish counts by species from video transect analyses, Cruises 1-4, East and West Flower Garden Banks.

	Cruise 1		Cruise 2	Cruise 3		Cruise 4	
Species	EFG	WFG	WFG	EFG	WFG	EFG	WFG
Ginglymostoma cirratum	-	-	-	-	1	-	1
Isurus oxyrinchus	-	-	-	-	1	-	-
Carcharhinus spp.	-	1	-	-	-	-	-
Dasyatis spp.	-	1	-	1	1	-	-
Rhinoptera bonasus	-	-	-	-	2	-	-
Manta birostris	-	-	1	1	-	-	-
Gymnothorax spp.	-	-	-	1	-	1	1
Order Clupeiformes	1500	9	-	-	400	-	1990
Family Synodontidae	-	4	-	-	-	-	-
Synodus intermedius	-	1	-	-	2	-	1
Family Batrachoididae	-	7	-	-	-	-	-
Holocentrus spp.	2	6	16	1	28	8	22
Aulostomus maculatus	-	-	1	1	-	-	1
Family Serranidae (barred)	-	1	-	-	-	-	-
Centropristis philadelphica	-	-	-	-	-	-	4
Cephalopholis fulva	-	-	-	-	-	1	-
Dermatolepis inermis	1	-	2	1	-	3	2
Epinephelus adscensionis	3	4	-	-	4	5	3
Epinephelus morio	-	-	3	-	1	-	-
Liopropoma eukrines	-	1	-	-	-	-	1
Mycteroperca bonaci	-	2	2	-	-	-	-
Mycteroperca tigris	-	-	1	-	-	1	3
Holanthias martinicensis	75	397	201	-	939	6	1870
Paranthias furcifer	665	9936	5544	3185	2665	7231	6495
Serranus phoebe	2	31	6	-	18	-	13
Family Serranidae (small,without bars)	-	-	-	-	-	-	110
Serranus spp. small sea bass	-	-	-	-	2	1	-
Mycteroperca/Epinephelus spp.	-	-	2	2	1	1	-
Epinephelus spp.	-	-	1	-	1	-	-
Family Serranidae (barred)	-	15	-	-	17	-	2
Family Serranidae (Pikea/Hemanthias)	-	944	1107	-	3726	-	1450
Mycteroperca spp.	5	28	22	84	38	25	52
Priacanthus arenatus	9	31	2	2	41	4	58
Malacanthus plumieri	-	6	2	-	11	4	4
Family Branchiostegidae	-	-	-	-	-	-	1
Caranx crysos	-	-	-	-	-	30	531
Caranx hippos	-	7	110	1	372	32	10
Caranx latus	-	-	-	-	-	-	3
Caranx lugubris	3	12	-	7	-	3	3
Caranx ruber	-	17	29	116	143	86	80
Elagatis bipinnulata	-	28	-	-	-	-	-
Seriola dumerili	6	81	16	12	24	8	43
Seriola rivoliana	1	22	15	35	15	4	9
Seriola zonata	-	1	-	1	-	-	-
Caranx spp.	3	23	-	-	-	-	55
Family Lutjanidae	-	66	-	-	-	-	-
Lutjanus apodus	-	-	-	1	-	-	-
Lutjanus campechanus	4	16	99	-	51	1	57
Lutjanus griseus	-	9	-	21	25	4	7
Lutjanus jocu	-	-	3	-	-	-	-
Rhomboplites aurorubens	1	75	7	-	109	-	164
Lutjanus spp.	-	-	2	-	-	-	-
Haemulon melanurum	58	13	95	507	132	9	39
Calamus nodosus	2	5	10	8	6	15	8
Pagrus sedecim	-	18	3	2	34	-	1
Stenotomus caprinus	-	53	-	-	-	-	-
Calamus spp.	-	-	-	-	1	-	-
Equetus lanceolatus	1	-	-	-	4	-	2
Equetus umbrosus	-	-	-	-	-	-	1
Equetus spp.	-	1	2	-	-	1	1
Mulloidichthys martinicus	14	35	23	125	94	35	121
Pseudupeneus maculatus	-	4	1	6	-	9	1

Appendix 6-1 (cont'd)

Species	Cruise 1 EFG	Cruise 1 WFG	Cruise 2 WFG	Cruise 3 EFG	Cruise 3 WFG	Cruise 4 EFG	Cruise 4 WFG
Family Mullidae	-	-	2	8	-	-	-
Kyphosus spp.	4	255	179	384	96	44	82
Centropyge argi	-	3	32	-	7	4	45
Chaetodon aya	-	2	-	-	6	-	8
Chaetodon ocellatus	-	7	-	4	-	7	2
Chaetodon sedentarius	168	129	67	57	168	68	227
Chaetodon striatus	3	-	-	1	-	-	-
Holacanthus bermudensis	-	-	-	1	3	3	1
Holacanthus ciliaris	-	1	2	-	1	7	7
Holacanthus tricolor	1	29	20	7	16	7	16
Pomacanthus paru	2	10	15	21	35	24	26
Prognathodes aculeatus	-	1	-	-	2	-	-
Holacanthus spp.	-	-	3	3	15	1	2
Chaetodon spp.	-	6	6	5	10	11	12
Family Pomacentridae	3	8	-	-	-	-	-
Chromis cyaneus	1	85	17	72	49	87	100
Chromis enchrysurus	52	192	348	17	1277	332	1616
Chromis multilineatus	586	1461	604	2218	1203	3647	2020
Chromis scotti	-	-	-	6	-	-	-
Microspathodon chrysurus	-	1	3	-	1	2	1
Pomacentrus fuscus	-	1	-	-	-	-	-
Pomacentrus partitus	9	2	18	8	12	45	29
Chromis/Pomacentrus spp.	-	-	7	212	46	150	164
Chromis spp.	22	498	152	360	331	2646	2610
Pomacentrus spp.	16	104	238	404	322	318	355
Amblycirrhitus pinos	-	-	-	-	-	-	4
Bodianus pulchellus	6	9	17	9	33	38	45
Bodianus rufus	1	3	5	5	9	5	9
Clepticus parrai	197	2090	24	446	105	1868	881
Halichoeres garnoti	2	-	-	-	-	1	2
Halichoeres radiatus	-	1	2	-	-	-	-
Thalassoma bifasciatum	-	27	48	27	6	40	21
Family Labridae	-	-	-	5	2	-	4
Family Scaridae	-	2	-	-	-	-	-
Scarus taeniopterus	1	-	2	3	-	6	9
Scarus vetula	1	1	9	3	12	6	18
Sparisoma aurofrenatum	-	1	-	-	-	-	-
Sparisoma viride	6	5	4	13	21	25	15
Scarus/Sparisoma spp.	-	9	7	18	11	9	10
Sphyraena barracuda	2	91	54	2	13	23	11
Ophioblennius atlanticus	-	-	-	-	-	1	-
Family Blenniidae	-	-	-	-	-	1	-
Ioglossus spp.	-	-	2	-	-	-	-
Acanthurus bahianus	-	1	-	-	-	-	-
Acanthurus coeruleus	-	1	-	6	-	5	2
Acanthurus spp.	-	-	5	20	9	17	14
Family Bothidae	1	1	-	-	-	-	-
Family Balistidae	-	3	-	-	1	-	-
Aluterus monoceros	-	-	-	-	-	6	-
Aluterus scriptus	-	-	-	-	3	-	-
Balistes capriscus	1	-	5	1	8	12	5
Balistes vetula	2	9	9	6	64	10	30
Cantherhines macrocerus	-	-	3	3	-	1	1
Cantherhines pullus	-	-	1	-	-	-	-
Canthidermis sufflamen	56	58	5	15	47	19	81
Melichthys niger	7	145	207	33	75	38	101
Xanthichthys ringens	-	-	1	-	1	-	9
Lactophrys quadricornis	-	-	-	-	2	-	4
Lactophrys triqueter	1	-	1	2	-	3	4
Family Ostraciidae	-	-	1	-	-	1	-
Canthigaster rostrata	-	-	-	-	-	5	-
Diodon holocanthus	1	-	4	2	-	2	2
Family Diodontidae	-	-	-	-	1	-	-
Total	3507	17163	9457	8528	12932	17073	21825

Appendix 6-2. Total fish counts by species from video transect analyses, Cruises 5-8, East Flower Garden Bank.

Species	Cruise 5	Cruise 6	Cruise 7	Cruise 8
Ginglymostoma cirratum	-	1	-	1
Carcharhinus spp.	-	-	-	1
Dasyatis spp.	-	1	-	-
Manta birostris	2	-	3	-
Gymnothorax spp.	5	1	-	2
Order Clupeiformes	240	-	-	-
Family Synodontidae	2	-	-	-
Synodus intermedius	-	1	-	-
Synodus spp.	-	-	-	2
Halieutichthys aculeatus	1	-	-	-
Family Ogcocephalidae	1	1	2	-
Family Gadidae	1	1	-	-
Holocentrus spp.	32	48	32	67
Aulostomus maculatus	1	-	1	2
Cephalopholis fulva	-	1	-	-
Dermatolepis inermis	3	4	5	-
Epinephelus adscensionis	1	9	8	6
Epinephelus guttatus	2	-	-	-
Epinephelus nigritus	-	-	-	2
Liopropoma eukrines	-	2	5	7
Mycteroperca bonaci	1	-	1	-
Mycteroperca tigris	1	-	2	-
Holanthias martinicensis	359	1530	445	390
Paranthias furcifer	7527	11686	8235	10811
Serranus phoebe	12	15	14	8
Family Serranidae (small,without bars)	2	3	-	-
Serranus spp. small sea bass	-	-	-	3
Mycteroperca/Epinephelus spp.	8	6	13	6
Epinephelus spp.	-	2	-	3
Family Serranidae (barred)	21	158	72	18
Family Serranidae (Pikea/Hemanthias)	94	2306	2460	2619
Mycteroperca spp.	151	162	125	169
Priacanthus arenatus	29	17	15	8
Malacanthus plumieri	12	3	12	9
Caranx crysos	-	-	-	28
Caranx hippos	8	183	-	-
Caranx latus	2	-	263	-
Caranx lugubris	3	2	5	3
Caranx ruber	133	35	693	27
Elagatis bipinnulata	12	-	-	40
Selar crumenophthalmus	11	-	-	-
Seriola dumerili	28	68	44	35
Seriola rivoliana	7	8	18	3
Family Carangidae	19	-	-	-
Caranx spp.	-	4	33	-
Family Lutjanidae	-	-	2	-
Lutjanus campechanus	16	54	77	32
Lutjanus griseus	3	-	6	4
Lutjanus jocu	-	-	1	-
Rhomboplites aurorubens	50	4	11	-
Haemulon melanurum	7	582	193	5
Calamus nodosus	91	26	61	51
Pagrus sedecim	21	14	14	-
Calamus spp.	1	-	-	1
Equetus lanceolatus	-	2	1	1
Equetus umbrosus	-	1	8	2
Mulloidichthys martinicus	320	480	331	264
Pseudupeneus maculatus	42	114	63	37
Family Mullidae	-	8	-	-
Kyphosus spp.	127	570	444	390
Centropyge argi	40	20	60	152
Chaetodon aya	-	8	-	-
Chaetodon ocellatus	7	13	12	20
Chaetodon sedentarius	265	332	451	448
Chaetodon striatus	-	4	-	2

Appendix 6-2 (cont'd)

Species	Cruise 5	Cruise 6	Cruise 7	Cruise 8
Holacanthus bermudensis	19	12	9	2
Holacanthus ciliaris	7	11	16	27
Holacanthus tricolor	30	33	37	31
Pomacanthus paru	46	51	54	56
Prognathodes aculeatus	-	1	3	1
Holacanthus spp.	27	17	33	25
Chaetodon spp.	18	13	16	7
Chromis cyaneus	19	59	74	64
Chromis enchrysurus	1644	1509	2690	2945
Chromis multilineatus	472	1889	1657	939
Microspathodon chrysurus	-	2	1	1
Pomacentrus partitus	78	39	141	133
Chromis/Pomacentrus spp.	256	456	502	370
Chromis spp.	1005	1885	1487	2910
Pomacentrus spp.	328	439	560	467
Amblycirrhitus pinos	2	-	-	-
Bodianus pulchellus	133	280	209	214
Bodianus rufus	12	46	95	79
Clepticus parrai	1401	3640	2544	2232
Decodon puellaris	-	-	-	3
Halichoeres garnoti	-	1	4	2
Halichoeres radiatus	1	-	1	2
Lachnolaimus maximus	-	3	-	-
Thalassoma bifasciatum	77	257	448	228
Family Labridae	36	48	88	27
Scarus taeniopterus	29	27	63	56
Scarus vetula	10	35	75	44
Sparisoma aurofrenatum	2	3	17	18
Sparisoma viride	54	43	70	71
Scarus/Sparisoma spp.	30	31	26	27
Sphyraena barracuda	29	4	10	8
Ophioblennius atlanticus	1	1	-	-
Family Gobiidae	2	1	-	8
Ioglossus spp.	2	1	2	5
Acanthurus coeruleus	13	9	20	8
Acanthurus spp.	22	30	48	73
Scomberomorus cavalla	-	-	1	-
Family Scorpaenidae	-	1	-	-
Prionotus spp.	-	1	1	-
Family Bothidae	1	-	3	-
Aluterus scriptus	6	3	3	-
Balistes capriscus	29	20	21	73
Balistes vetula	46	11	18	27
Cantherhines macrocerus	3	4	4	11
Canthidermis sufflamen	147	26	202	10
Melichthys niger	37	57	55	80
Xanthichthys ringens	3	10	41	21
Family Balistidae	3	-	-	-
Lactophrys quadricornis	1	5	5	7
Lactophrys triqueter	6	3	6	4
Family Ostraciidae	-	-	2	-
Canthigaster rostrata	-	6	10	4
Family Tetraodontidae	-	1	1	-
Diodon holocanthus	5	3	9	5
Diodon hystrix	-	1	-	-
Family Diodontidae	2	-	1	-
Class Osteichthyes	4	18	2	4
Fistularia tabacaria	-	-	1	-
Total	15819	29536	25627	27008

Appendix 6-3. Summary of total area transected (m^2) by habitat types, West Flower Garden Bank.

Habitat	Cruise 1	Cruise 2	Cruise 3	Cruise 4	Total
Coral Reef Bank	49590	21892	20360	23010	114852
>50% Live Coral					
Type A >50% outcrops	46320	14012	20360	22350	103042
Type B <50% outcrops	1520	720	-	-	2240
<50% Live Coral					
Type A >50% outcrops	1750	3600	-	180	5530
Type B <50% outcrops	-	3560	-	480	4040
Finger Coral w/outcrops	-	-	-	-	-
Finger Coral w/o outcrops	-	-	-	-	-
Coral Detritus Zone	6760	3100	1150	-	11010
Coarse carbonate sand	6760	3100	790	-	10650
Coral rubble no algae	-	-	-	-	-
Coral rubble with algae	-	-	360	-	360
Algal-Nodule Sponge Zone	27530	5030	30720	24620	87900
With algae	27500	5030	16630	8310	57470
Without algae	30	-	14090	16310	30430
Shallow Transition Mixtures	13320	2470	3960	1510	21260
With algae					
Up to 25% nodules	2680	-	450	-	3130
25%-50% nodules	7440	1630	700	-	9770
50%-75% nodules	400	840	1970	-	3210
Without algae					
Up to 25% nodules	-	-	-	-	-
25%-50% nodules	-	-	-	1510	1510
50%-75% nodules	2800	-	840	-	3640
Deep Transition Zone	5170	1360	6690	2190	15410
Shallow Drowned Reef	2680	6760	19466	20080	48986
Low	1440	6760	18050	17420	43670
Medium	1240	-	1416	2660	5316
High	-	-	-	-	-
Deep Drowned Reef	32600	4400	28220	16720	81940
Low	-	2200	15630	9200	27030
Medium	4520	-	2290	760	7570
High	28080	2200	10300	6760	47340
Soft Bottom	14305	2600	32700	18720	68325
With crinoids	-	1300	16350	9360	27010
Without crinoids	5170	1360	6690	2190	15410
Artificial Reef Zone PLA	-	2840	2010	13890	18740
Near or inside legs	-	1190	-	-	1190
Adjacent soft bottom	-	1650	2010	13890	17550
Total	137650	49152	128926	111380	427108

Appendix 6-4. Summary of total area transected (m^2) by habitat types, East Flower Garden Bank.

Habitat	Cruise 1	Cruise 2	Cruise 3	Cruise 4	Cruise 5	Cruise	Cruise 7	Cruise 8	Total
Coral Reef Bank	15230	-	46840	33615	74100	117900	70050	44240	401975
>50% Live Coral									
Type A >50% outcrops	10320	-	20140	20975	36660	61120	40145	23470	212830
Type B <50% outcrops	-	-	9880	7320	10110	11860	4070	2615	45855
<50% Live Coral									
Type A >50% outcrops	2010	-	1050	-	3640	10740	7600	3745	28785
Type B <50% outcrops	-	-	5730	2260	12360	23030	8620	6545	58545
Finger Coral w/outcrops	474	-	10040	3060	9690	7650	9615	7865	48394
Finger Coral w/o outcrops	-	-	-	-	1640	3500	-	-	5140
Coral Detritus Zone	-	-	4310	700	1630	-	-	80	6720
Coarse carbonate sand	-	-	960	-	480	-	-	-	1440
Coral rubble no algae	-	-	3350	700	250	-	-	80	4380
Coral rubble with algae	-	-	-	-	900	-	-	-	900
Algal-Nodule Sponge Zone	14890	-	6400	6260	50300	84660	73890	40370	276770
With algae	14890	-	6400	4060	43770	84660	71630	37440	262850
Without algae	-	-	-	2200	6530	-	2260	2930	13920
Shallow Transition Mixtures	2620	-	11650	17910	15580	41180	12840	15590	117370
With algae									
Up to 25% nodules	-	-	-	950	1850	5600	330	-	8730
25%-50% nodules	-	-	6240	5670	9960	10140	5370	5130	42510
50%-75% nodules	-	-	3360	9790	3770	24640	7140	10160	58860
Without algae									
Up to 25% nodules	-	-	850	-	-	-	-	300	1150
25%-50% nodules	-	-	1200	-	-	-	-	-	1200
50%-75% nodules	2620	-	-	1500	-	800	-	-	4920
Deep Transition Zone	474	-	5920	660	4790	4130	6225	5315	27514
Shallow Drowned Reef	-	-	1520	10700	57930	93100	89070	55805	308125
Low	-	-	1520	10460	43090	72240	67590	48795	243695
Medium	-	-	-	240	13220	18370	18625	5630	56085
High	-	-	-	-	1620	2490	2855	1380	8345
Deep Drowned Reef	1742	-	2000	-	18900	24160	12070	9850	68722
Low	-	-	1000	-	9450	12080	6035	4925	33490
Medium	220	-	1000	-	8060	7415	4835	4185	25715
High	1522	-	-	-	1390	4665	1200	740	9517
Soft Bottom	976	-	9300	14240	39580	43810	31210	19160	158276
With crinoids	-	-	6420	7120	25130	25815	18235	11195	93915
Without crinoids	976	-	2880	7120	14450	17995	12975	7965	64361
Total	33032	-	82020	83425	258020	404810	289130	185095	1335532

Appendix 6-5. Species names and species groups observed by video techniques. Cruises 1-8.

Species Code	Common Name	Scientific Name
00601	Nurse shark	*Ginglymostoma cirratum*
01003	Shortfin mako	*Isurus oxyrinchus*
01200	Requiem shark	Family Carcharhinidae
01204	Silky shark	*Carcharhinus falciformis*
01299	Requiem shark	*Carcharhinus* spp.
02099	Sting ray	*Dasyatis* spp.
02105	Cownose ray	*Rhinoptera bonasus*
02201	Atlantic manta	*Manta birostris*
03304	Green moray	*Gymnothorax funebris*
03399	Moray spp.	*Gymnothorax* spp.
03698	Giant snake eel	*Ophichthus rex*
03699	Unknown snake eel	*Ophichthus* spp.
04199	Herring or anchovie	Order Clupeiformes
05400	Lizard fish	Family Synodontidae
05404	Inshore lizardfish	*Synodus foetens*
05405	Sand diver	*Synodus intermedius*
05499	Lizard fish	*Synodus* spp.
07000	Toadfishes	Family Batrachoididae
07401	Pancake batfish	*Halieutichthys aculeatus*
07499	Batfish	Family Ogcocephalidae
07823	Southern hake	*Urophycis floridanus*
07899	Hake	Family Gadidae
07999	Cusk-eel	Family Ophidiidae
09002	Squirrelfish	*Holocentrus ascensionis*
09099	Squirrelfish	*Holocentrus* spp.
09901	Trumpetfish	*Aulostomus maculatus*
10001	Bluespotted cornetfish	*Fistularia tabacaria*
10500	Sea basses	Family Serranidae
10504	Bank sea bass	*Centropristis ocyurus*
10505	Rock sea bass	*Centropristis philadelphica*
10507	Coney	*Cephalopholis fulva*
10508	Marbled grouper	*Dermatolepis inermis*
10511	Rock hind	*Epinephelus adscensionis*
10515	Red hind	*Epinephelus guttatus*
10517	Red grouper	*Epinephelus morio*
10519	Warsaw grouper	*Epinephelus nigritus*
10534	Wrasse bass	*Liopropoma eukrines*
10536	Peppermint bass	*Liopropoma rubre*
10537	Black grouper	*Mycteroperca bonaci*
10542	Tiger grouper	*Mycteroperca tigris*
10545	Roughtongue bass	*Holanthius martinicensis*
10549	Creole-fish	*Paranthias furcifer*
10556	Blackear bass	*Serranus atrobranchus*
10560	Tattler	*Serranus phoebe*
10593	Unknown sea bass	Family Serranidae (small without bars)
10594	Unknown sea bass	*Serranus* spp. small sea bass
10595	Grouper	*Mycteroperca/Epinephelus* spp.
10596	Grouper	*Epinephelus* spp.
10597	Unknown sea bass A	Family Serranidae (barred)
10598	Unknown sea bass B	Family Serranidae (Pikea/ Hemanthias)
10599	Grouper	*Mycteroperca* spp.
10902	Bigeye	*Priacanthus arenatus*
11104	Sand tilefish	*Malacanthus plumieri*
11105	Gulf bar-eye tilefish	*Caulolatilus intermedius*
11199	Tilefish unknown	Family Branchiostegidae
11502	Yellowjack	*Caranx bartholomaei*
11504	Blue runner	*Caranx crysos*
11505	Crevalle jack	*Caranx hippos*
11506	Horse-eye jack	*Caranx latus*
11507	Black jack	*Caranx lugubris*
11508	Bar jack	*Caranx ruber*
11515	Rainbow runner	*Elagatis bipinnulata*

Appendix 6-5 (cont'd)

Species Code	Common Name	Scientific Name
11520	Bigeye scad	Selar crumenophthalmus
11524	Greater amberjack	Seriola dumerili
11526	Almaco jack	Seriola rivoliana
11527	Banded rudderfish	Seriola zonata
11533	Rough scad	Trachurus lathami
11598	Small scad or runner	Family Carangidae
11599	Jack	Caranx spp.
11900	Snapper	Family Lutjanidae
11904	Schoolmaster	Lutjanus apodus
11906	Red Snapper	Lutjanus campechanus
11908	Grey snapper	Lutjanus griseus
11909	Dog snapper	Lutjanus jocu
11914	Wenchman	Pristipomoides aquilonaris
11915	Vermilion snapper	Rhomboplites aurorubens
11999	Snapper	Lutjanus spp.
12212	Cottonwick	Haemulon melanurum
12308	Knobbed porgy	Calamus nodosus
12314	Red porgy	Pagrus sedecim
12315	Longspine porgy	Stenotomus caprinus
12399	Unknown porgy	Calamus spp.
12415	Jackknife-fish	Equetus lanceolatus
12417	Cubbyu	Equetus umbrosus
12498	Sea trout	Cynoscion spp.
12499	Drum	Equetus spp.
12502	Red goatfish	Mullus auratus
12501	Yellow goatfish	Mulloidichthys martinicus
12504	Spotted goatfish	Pseudupeneus maculatus
12599	Goatfish	Family Mullidae
12799	Chub	Kyphosus spp.
12901	Cherubfish	Centropyge argi
12902	Bank butterflyfish	Chaetodon aya
12905	Spotfin butterflyfish	Chaetodon ocellatus
12906	Reef butterflyfish	Chaetodon sedentarius
12907	Banded butterflyfish	Chaetodon striatus
12908	Blue angelfish	Holacanthus bermudensis
12909	Queen angelfish	Holacanthus ciliaris
12910	Rock beauty	Holacanthus tricolor
12912	French angelfish	Pomacanthus paru
12913	Longsnout butterflyfish	Prognathodes aculeatus
12998	Angelfish	Holacanthus spp.
12999	Butterflyfish	Chaetodon spp.
13300	Damselfish	Family Pomacentridae
13303	Blue chromis	Chromis cyaneus
13304	Yellowtail reeffish	Chromis enchrysurus
13306	Brown chromis	Chromis multilineatus
13308	Purple reeffish	Chromis scotti
13310	Yellowtail damselfish	Microspathodon chrysurus
13311	Dusky damselfish	Pomacentrus fuscus
13313	Bicolor damselfish	Pomacentrus partitus
13397	Damselfish	Chromis/Pomacentrus spp.
13398	Damselfish	Chromis spp.
13399	Damselfish	Pomacentrus spp.
13401	Redspotted hawkfish	Amblycirrhitus pinos
13501	Spotfin hogfish	Bodianus pulchellus
13502	Spanish hogfish	Bodianus rufus
13503	Creole wrasse	Clepticus parrai
13504	Red hogfish	Decodon puellaris
13510	Yellowhead wrasse	Halichoeres garnoti
13514	Puddingwife	Halichoeres radiatus
13519	Hogfish	Lachnolaimus maximus
13524	Bluehead	Thalassoma bifasciatum
13599	Unknown wrasse	Family Labridae
13600	Parrotfish	Family Scaridae
13607	Princess parrotfish	Scarus taeniopterus
13608	Queen parrotfish	Scarus vetula
13610	Redband parrotfish	Sparisoma aurofrenatum
13614	Stoplight parrotfish	Sparisoma viride
13699	Parrotfish	Scarus/Sparisoma spp.

Appendix 6-5 (cont'd)

Species Code	Common Name	Scientific Name
13802	Great barracuda	Sphyraena barracuda
14399	Flathead	Bembrops spp.
14716	Redlip blenny	Ophioblennius atlanticus
14799	Unknown blenny	Family Blenniidae
15898	Unknown goby	Family Gobiidae
15899	Goby (burrowing)	Ioglossus sp.
16001	Ocean surgeon	Acanthurus bahianus
16003	Blue tang	Acanthurus coeruleus
16099	Surgeonfish	Acanthurus spp.
16203	Atlantic cutlassfish	Trichiurus lepturus
16314	King mackerel	Scomberomorus cavalla
16999	Unknown scorpionfish	Family Scorpaenidae
17019	Shortwing searobin	Prionotus stearnsi
17099	Unknown searobin	Prionotus spp.
17700	Lefteye flounder	Family Bothidae
18200	Triggerfish	Family Balistidae
18202	Unicorn filefish	Aluterus monoceros
18204	Scrawled filefish	Aluterus scriptus
18205	Grey triggerfish	Balistes capriscus
18207	Queen triggerfish	Balistes vetula
18208	Whitespotted filefish	Cantherhines macrocerus
18209	Orangespotted filefish	Cantherhines pullus
18211	Ocean triggerfish	Canthidermis sufflamen
18212	Black durgon	Melichthys niger
18218	Sargassum triggerfish	Xanthichthys ringens
18298	Filefish	Family Balistidae
18303	Scrawled cowfish	Lactophrys quadricornis
18305	Smooth trunkfish	Lactophrys triqueter
18399	Boxfish	Family Ostraciidae
18401	Sharpnose puffer	Canthigaster rostrata
18499	Puffer	Family Tetraodontidae
18506	Balloonfish	Diodon holocanthus
18507	Porcupinefish	Diodon hystrix
18599	Unknown porcupinefish	Family Diodontidae
19999	Unknown fish	Class Osteichthyes

Appendix 6-6. Density of fish/1000 m^2 by habitat type, Cruises 2-8, East and West Flower Garden Banks.

Cruise: 2
Station: West Flower Gardens

Species	Habitat Type 1	2	3	4	5	72	7	6
Manta birostris	.05	-	-	-	-	-	-	-
Holocentrus spp.	.32	-	-	.40	-	1.18	-	-
Aulostomus maculatus	.05	-	-	-	-	-	-	-
Dermatolepis inermis	-	-	-	-	-	.30	-	-
Epinephelus morio	.09	-	-	-	-	.15	-	-
Mycteroperca bonaci	.09	-	-	-	-	-	-	-
Mycteroperca tigris	.05	-	-	-	-	-	-	-
Holanthias martinicensis	-	-	-	-	-	.15	45.45	-
Paranthias furcifer	233.05	-	-	-	-	65.24	.23	-
Serranus phoebe	-	-	-	.40	-	.15	.91	.77
Mycteroperca/Epinephelus spp.	.09	-	-	-	-	-	-	-
Epinephelus spp.	.05	-	-	-	-	-	-	-
Family Serranidae (Pikea/Hemanthias)	-	-	-	51.42	-	144.97	-	-
Mycteroperca spp.	.32	-	-	-	-	1.63	.91	-
Priacanthus arenatus	.09	-	-	-	-	-	-	-
Malacanthus plumieri	-	.32	-	-	-	.15	-	-
Caranx hippos	5.02	-	-	-	-	-	-	-
Caranx ruber	.18	8.06	-	-	-	-	-	-
Seriola dumerili	.18	-	.20	1.21	-	.89	.45	-
Seriola rivoliana	.05	-	-	.40	-	-	2.95	-
Lutjanus campechanus	-	-	-	-	-	14.50	.23	-
Lutjanus jocu	.14	-	-	-	-	-	-	-
Rhomboplites aurorubens	-	-	-	-	-	-	1.59	-
Lutjanus spp.	.09	-	-	-	-	-	-	-
Haemulon melanurum	4.34	-	-	-	-	-	-	-
Calamus nodosus	.18	-	.20	-	-	.30	.68	-
Pagrus sedecim	.14	-	-	-	-	-	-	-
Equetus spp.	-	-	-	-	-	-	.45	-
Mulloidichthys martinicus	1.05	-	-	-	-	-	-	-
Pseudupeneus maculatus	.05	-	-	-	-	-	-	-
Family Mullidae	.09	-	-	-	-	-	-	-
Kyphosus spp.	8.18	-	-	-	-	-	-	-
Centropyge argi	-	-	.60	-	-	4.29	-	-
Chaetodon sedentarius	.78	-	.20	1.21	-	6.36	.68	-
Holacanthus ciliaris	-	-	-	-	-	.30	-	-
Holacanthus tricolor	.87	-	-	-	-	.15	-	-
Pomacanthus paru	.27	-	.40	-	-	1.04	-	-
Holacanthus spp.	-	-	.20	-	-	.30	-	-
Chaetodon spp.	.27	-	-	-	-	-	-	-
Chromis cyaneus	.78	-	-	-	-	-	-	-
Chromis enchrysurus	-	-	1.19	2.43	-	48.22	2.27	-
Chromis multilineatus	27.59	-	-	-	-	-	-	-
Microspathodon chrysurus	.14	-	-	-	-	-	-	-
Pomacentrus partitus	.82	-	-	-	-	-	-	-
Chromis/Pomacentrus spp.	.09	-	-	-	-	.74	-	-
Chromis spp.	6.94	-	-	-	-	-	-	-
Pomacentrus spp.	10.87	-	-	-	-	-	-	-
Bodianus pulchellus	.27	-	.20	-	-	.59	1.36	-
Bodianus rufus	.23	-	-	-	-	-	-	-
Clepticus parrai	1.10	-	-	-	-	-	-	-
Halichoeres radiatus	.09	-	-	-	-	-	-	-
Thalassoma bifasciatum	2.19	-	-	-	-	-	-	-
Scarus taeniopterus	.09	-	-	-	-	-	-	-
Scarus vetula	.41	-	-	-	-	-	-	-
Sparisoma viride	.18	-	-	-	-	-	-	-
Scarus/Sparisoma spp.	.32	-	-	-	-	-	-	-
Sphyraena barracuda	1.96	.32	.20	2.43	-	.30	.23	-
Ioglossus spp.	-	-	-	-	-	.15	.23	-
Acanthurus spp.	.18	-	-	-	-	.15	-	-
Balistes capriscus	-	-	-	-	-	.74	-	-
Balistes vetula	-	-	.40	-	-	1.04	-	-
Cantherhines macrocerus	.14	-	-	-	-	-	-	-
Cantherhines pullus	.05	-	-	-	-	-	-	-
Canthidermis sufflamen	.05	.32	.20	-	-	.30	-	-
Melichthys niger	9.46	-	-	-	-	-	-	-
Xanthichthys ringens	-	-	-	-	-	.15	-	-
Lactophrys triqueter	-	-	-	-	-	.15	-	-
Family Ostraciidae	.05	-	-	-	-	-	-	-
Diodon holocanthus	-	-	.40	-	-	.30	-	-

Appendix 6-6 (cont'd)

Cruise: 3
Station: West Flower Gardens

Species	Habitat Type 1	2	3	4	5	72	7	6
Ginglymostoma cirratum	.05	-	-	-	-	-	-	-
Isurus oxyrinchus	.05	-	-	-	-	-	-	-
Dasyatis spp.	.05	-	-	-	-	-	-	-
Rhinoptera bonasus	-	-	.07	-	-	-	-	-
Order Clupeiformes	-	-	-	-	-	20.55	-	-
Synodus intermedius	-	-	-	-	-	-	.07	-
Urophycis floridanus	-	-	-	-	-	-	-	.03
Holocentrus spp.	-	-	.20	-	-	1.13	-	-
Epinephelus adscensionis	-	-	-	-	-	.21	-	-
Epinephelus morio	-	-	-	-	-	.05	-	-
Holanthias martinicensis	-	-	-	-	-	.67	36.78	-
Paranthias furcifer	118.32	-	.03	-	-	13.10	-	-
Serranus atrobranchus	-	-	-	-	-	-	-	.06
Serranus phoebe	-	-	-	-	-	-	.78	.12
Serranus spp. small sea bass	-	-	-	.32	-	.05	-	-
Mycteroperca/Epinephelus spp.	.05	-	-	-	-	-	-	-
Epinephelus spp.	-	-	-	-	-	.05	-	-
Family Serranidae (Barred)	-	-	.10	-	-	-	.53	.49
Family Serranidae (Pikes/Hemanthias)	-	-	15.66	-	-	44.69	84.16	-
Mycteroperca spp.	.15	-	-	-	-	1.08	.50	-
Priacanthus arenatus	-	-	.20	-	-	1.08	.64	.12
Malacanthus plumieri	-	.87	.16	-	-	.15	-	-
Caranx hippos	18.27	-	-	-	-	-	-	-
Caranx ruber	7.02	-	-	-	-	-	-	-
Seriola dumerili	.54	-	-	.64	-	.31	.18	-
Seriola rivoliana	.74	-	-	-	-	-	-	-
Lutjanus campechanus	-	-	-	-	-	.21	1.67	-
Lutjanus griseus	1.23	-	-	-	-	-	-	-
Rhomboplites aurorubens	-	-	.03	-	-	-	3.83	-
Haemulon melanurum	6.34	-	.07	-	-	.05	-	-
Calamus nodosus	.05	-	-	-	-	.26	-	-
Pagrus sedecim	-	-	.07	-	-	.15	1.03	-
Calamus spp.	-	-	-	.32	-	-	-	-
Equetus lanceolatus	-	-	-	-	-	-	.14	-
Equetus spp.	-	-	-	-	-	-	-	.03
Mulloidichthys martinicus	4.62	-	-	-	-	-	-	-
Kyphosus spp.	4.72	-	-	-	-	-	-	-
Centropyge argi	-	-	.10	-	-	.21	-	-
Chaetodon aya	-	-	-	-	-	-	.21	-
Chaetodon sedentarius	.15	-	1.99	-	-	4.16	.99	-
Holacanthus bermudensis	-	-	.03	-	-	.10	-	-
Holacanthus ciliaris	-	-	-	-	-	.05	-	-
Holacanthus tricolor	.15	-	.07	-	-	.51	.04	-
Pomacanthus paru	.20	-	.23	.96	-	1.08	-	-
Prognathodes aculeatus	.10	-	-	-	-	-	-	-
Holacanthus spp.	-	-	-	-	-	.77	-	-
Chaetodon spp.	.39	-	-	-	-	.10	-	-
Chromis cyaneus	2.41	-	-	-	-	-	-	-
Chromis enchrysurus	-	-	7.71	2.56	-	39.35	9.71	-
Chromis multilineatus	58.60	-	-	-	-	.51	-	-
Microspathodon chrysurus	.05	-	-	-	-	-	-	-
Pomacentrus partitus	.25	-	.10	-	-	.21	-	-
Chromis/Pomacentrus spp.	1.87	-	.13	-	-	.21	-	-
Chromis spp.	16.06	-	-	-	-	.21	-	-
Pomacentrus spp.	15.82	-	-	-	-	-	-	-
Bodianus pulchellus	.25	-	.03	-	-	.98	.28	-
Bodianus rufus	.25	-	-	-	-	.21	-	-
Clepticus parrai	5.16	-	-	-	-	-	-	-
Thalassoma bifasciatum	.15	-	-	-	-	.15	-	-
Family Labridae	-	-	.03	-	-	-	.04	-
Scarus vetula	.54	-	-	-	-	.05	-	-
Sparisoma viride	.20	-	-	-	-	.87	-	-
Scarus/Sparisoma spp.	.44	-	-	-	-	.10	-	-
Sphyraena barracuda	.64	-	-	-	-	-	-	-
Acanthurus spp.	.10	-	-	-	-	.36	-	-
Family Balistidae	-	-	.03	-	-	-	-	-
Aluterus scriptus	-	-	.07	-	-	.05	-	-
Balistes capriscus	-	-	.23	-	-	.05	-	-
Balistes vetula	-	-	.46	-	-	2.57	-	-
Canthidermis sufflamen	.34	-	.03	-	-	2.00	-	-
Melichthys niger	3.68	-	-	-	-	-	-	-
Xanthichthys ringens	-	-	-	-	-	.05	-	-
Lactophrys quadricornis	-	-	-	-	-	.05	.04	-
Family Diodontidae	-	-	.03	-	-	-	-	-

Appendix 6-6 (cont'd)

Cruise: 3
Station: East Flower Gardens

Species	Habitat Type 1	2	3	4	5	72	7	6
Dasyatis spp.	.02	-	-	-	-	-	-	-
Manta birostris	.02	-	-	-	-	-	-	-
Gymnothorax spp.	.02	-	-	-	-	-	-	-
Holocentrus spp.	-	-	-	-	-	.66	-	-
Aulostomus maculatus	.02	-	-	-	-	-	-	-
Dermatolepis inermis	.02	-	-	-	-	-	-	-
Paranthias furcifer	68.00	-	-	-	-	-	27.50	-
Mycteroperca/Epinephelus spp.	.02	.23	-	-	-	-	-	-
Mycteroperca spp.	1.77	.23	-	-	-	-	2.50	-
Priacanthus arenatus	.04	-	-	-	-	-	.50	-
Caranx hippos	.02	-	-	-	-	-	-	-
Caranx lugubris	.15	-	-	-	-	-	-	-
Caranx ruber	2.48	-	-	-	-	-	-	-
Seriola dumerili	.19	-	.16	.17	-	-	.50	.22
Seriola rivoliana	.75	-	-	-	-	-	-	-
Seriola zonata	.02	-	-	-	-	-	-	-
Lutjanus apodus	.02	-	-	-	-	-	-	-
Lutjanus griseus	.45	-	-	-	-	-	-	-
Haemulon melanurum	10.82	-	-	-	-	-	-	-
Calamus nodosus	.17	-	-	-	-	-	-	-
Pagrus sedecim	.04	-	-	-	-	-	-	-
Mulloidichthys martinicus	2.67	-	-	-	-	-	-	-
Pseudupeneus maculatus	.13	-	-	-	-	-	-	-
Family Mullidae	.17	-	-	-	-	-	-	-
Kyphosus spp.	8.20	-	-	-	-	-	-	-
Chaetodon ocellatus	.09	-	-	-	-	-	-	-
Chaetodon sedentarius	1.11	.70	-	-	-	1.32	-	-
Chaetodon striatus	.02	-	-	-	-	-	-	-
Holacanthus bermudensis	.02	-	-	-	-	-	-	-
Holacanthus tricolor	.15	-	-	-	-	-	-	-
Pomacanthus paru	.36	.46	-	-	-	1.32	.50	-
Holacanthus spp.	.04	.23	-	-	-	-	-	-
Chaetodon spp.	.11	-	-	-	-	-	-	-
Chromis cyaneus	1.54	-	-	-	-	-	-	-
Chromis enchrysurus	.28	-	-	-	-	2.63	-	-
Chromis multilineatus	47.35	-	-	-	-	-	-	-
Chromis scotti	.13	-	-	-	-	-	-	-
Pomacentrus partitus	.17	-	-	-	-	-	-	-
Chromis/Pomacentrus spp.	4.50	-	-	-	-	.66	-	-
Chromis spp.	7.69	-	-	-	-	-	-	-
Pomacentrus spp.	8.63	-	-	-	-	-	-	-
Bodianus pulchellus	.19	-	-	-	-	-	.50	-
Bodianus rufus	.11	-	-	-	-	-	-	-
Clepticus parrai	9.52	-	-	-	-	-	-	-
Thalassoma bifasciatum	.58	-	-	-	-	-	-	-
Family Labridae	.11	-	-	-	-	-	-	-
Scarus taeniopterus	.06	-	-	-	-	-	-	-
Scarus vetula	.06	-	-	-	-	-	-	-
Sparisoma viride	.28	-	-	-	-	-	-	-
Scarus/Sparisoma spp.	.38	-	-	-	-	-	-	-
Sphyraena barracuda	.04	-	-	-	-	-	-	-
Acanthurus coeruleus	.13	-	-	-	-	-	-	-
Acanthurus spp.	.43	-	-	-	-	-	-	-
Balistes capriscus	.02	-	-	-	-	-	-	-
Balistes vetula	.11	-	-	.09	-	-	-	-
Cantherhines macrocerus	.06	-	-	-	-	-	-	-
Canthidermis sufflamen	.17	-	-	-	-	4.61	1.00	-
Melichthys niger	.70	-	-	-	-	-	-	-
Lactophrys triqueter	.04	-	-	-	-	-	-	-
Diodon holocanthus	.02	-	.16	-	-	-	-	-

Appendix 6-6 (cont'd)

Cruise: 4
Station: West Flower Gardens

Species	Habitat Type 1	2	3	4	5	72	7	6
Ginglymostoma cirratum	.04	-	-	-	-	-	-	-
Gymnothorax spp.	.04	-	-	-	-	-	-	-
Order Clupeiformes	16.95	-	64.99	-	-	-	-	-
Synodus intermedius	-	-	-	-	-	-	.06	-
Holocentrus spp.	.04	-	.04	-	-	.95	.06	-
Aulostomus maculatus	.04	-	-	-	-	-	-	-
Centropristis philadelphica	-	-	-	-	-	-	.24	-
Dermatolepis inermis	-	-	-	-	-	.10	-	-
Epinephelus adscensionis	-	-	-	-	-	.15	-	-
Liopropama eukrines	-	-	-	-	-	-	.18	-
Mycteroperca tigris	.13	-	-	-	-	-	-	-
Holanthias martinicensis	-	-	-	-	-	21.22	96.41	-
Paranthias furcifer	234.77	-	-	-	-	54.23	.24	-
Serranus phoebe	-	-	-	-	-	.10	.78	.11
Family Serranidae (small, without bars)	-	-	4.47	-	-	-	-	.16
Family Serranidae (Barred)	-	-	-	-	-	-	.12	.32
Family Serranidae (Pikea/Hemanthias)	-	-	9.99	-	-	32.77	33.43	-
Mycteroperca spp.	.39	-	.04	-	-	1.29	1.08	-
Priacanthus arenatus	-	-	.08	-	-	.90	2.57	-
Malacanthus plumieri	-	-	.12	-	-	.05	-	-
Family Branchiostegidae	-	-	-	-	-	-	.06	-
Caranx crysos	20.64	-	2.27	-	-	-	-	-
Caranx hippos	.39	-	-	.66	-	-	-	-
Caranx latus	-	-	-	1.99	-	-	-	-
Caranx lugubris	.13	-	-	-	-	-	-	-
Caranx ruber	1.48	-	.32	25.17	-	-	-	-
Seriola dumerili	.35	-	.45	4.64	-	.60	.30	-
Seriola rivoliana	.22	-	.12	-	-	.05	-	-
Caranx spp.	.65	-	-	26.49	-	-	-	-
Lutjanus campechanus	-	-	-	-	-	-	3.41	-
Lutjanus griseus	- .30	-	-	-	-	-	-	-
Pristipomoides aquilonaris	-	-	-	-	-	-	-	.05
Rhomboplites aurorubens	-	-	-	-	-	2.54	6.94	-
Haemulon melanurum	1.52	-	-	-	-	.05	.18	-
Calamus nodosus	.35	-	-	-	-	-	-	-
Pagrus sedecim	-	-	-	-	-	-	.06	-
Equetus lanceolatus	-	-	-	-	-	.10	-	-
Equetus umbrosus	-	-	-	-	-	-	.30	-
Equetus spp.	-	-	-	-	-	-	.06	-
Mulloidichthys martinicus	5.26	-	-	-	-	-	-	-
Pseudupeneus maculatus	.04	-	-	-	-	-	-	-
Kyphosus spp.	3.56	-	-	-	-	-	-	-
Centropyge argi	-	-	1.18	-	-	.70	.12	-
Chaetodon aya	-	-	.04	-	-	.10	.36	-
Chaetodon ocellatus	-	-	-	-	-	.10	-	-
Chaetodon sedentarius	1.09	-	.20	1.32	-	8.47	1.61	-
Holacanthus bermudensis	-	-	-	-	-	.05	-	-
Holacanthus ciliaris	-	-	-	-	-	.35	-	-
Holacanthus tricolor	.26	-	.04	-	-	.45	-	-
Pomacanthus paru	.13	-	.49	-	-	.55	-	-
Holacanthus spp.	.04	-	.04	-	-	-	-	-
Chaetodon spp.	.13	-	.04	-	-	.30	.12	-
Chromis cyaneus	3.95	-	-	-	-	.35	.12	-
Chromis enchrysurus	5.87	-	16.49	-	-	48.41	6.52	-
Chromis multilineatus	87.79	-	-	-	-	-	-	-
Microspathodon chrysurus	.04	-	-	-	-	-	-	-
Pomacentrus partitus	1.04	-	.16	-	-	.05	-	-
Chromis/Pomacentrus spp.	2.26	-	4.31	-	-	.30	-	-
Chromis spp.	112.17	-	-	-	-	1.44	-	-
Pomacentrus spp.	14.95	-	.08	-	-	.45	-	-
Amblycirrhitus pinos	-	-	-	-	-	.15	.06	-
Bodianus pulchellus	.35	-	.04	-	-	.90	1.08	-
Bodianus rufus	.26	-	-	-	-	.15	-	-
Clepticus parrai	38.29	-	-	-	-	-	-	-
Halichoeres garnoti	.09	-	-	-	-	-	-	-
Thalassoma bifasciatum	.70	-	.04	-	-	.20	-	-
Family Labridae	.04	-	-	-	-	-	.18	-
Scarus taeniopterus	.39	-	-	-	-	-	-	-
Scarus vetula	.65	-	-	-	-	.15	-	-
Sparisoma viride	.22	-	-	-	-	.50	-	-
Scarus/Sparisoma spp.	.43	-	-	-	-	-	-	-
Sphyraena barracuda	.43	-	.04	-	-	-	-	-
Ioglossus spp.	-	-	-	-	-	-	-	.05

Appendix 6-6 (cont'd)

Cruise: 4
Station: West Flower Gardens

Species	Habitat Type							
	1	2	3	4	5	72	7	6
Acanthurus coeruleus	.09	-	-	-	-	-	-	-
Acanthurus spp.	.26	-	.04	-	-	.35	-	-
Family Scorpaenidae	-	-	-	-	-	-	-	.05
Balistes capriscus	-	-	.08	-	-	.10	.06	-
Balistes vetula	.04	-	.81	-	-	.45	-	-
Cantherhines macrocerus	-	-	-	-	-	.05	-	-
Canthidermis sufflamen	3.00	-	.04	6.62	-	-	.06	-
Melichthys niger	4.39	-	-	-	-	-	-	-
Xanthichthys ringens	.22	-	-	-	-	.20	-	-
Lactophrys quadricornis	.04	-	.08	-	-	.05	-	-
Lactophrys triqueter	.13	-	-	-	-	.05	-	-
Diodon holocanthus	-	-	-	-	-	.10	-	-
Class Osteichthyes	-	-	-	-	-	-	-	.11

Appendix 6-6 (cont'd)

Cruise: 4
Station: East Flower Gardens

Species	Habitat Type 1	2	3	4	5	72	7	6
Gymnothorax spp.	-	-	-	-	-	.09	-	-
Ophichthus spp.	-	-	-	-	-	-	-	.07
Holocentrus spp.	-	-	-	-	-	.75	-	-
Cephalopholis fulva	.03	-	-	-	-	-	-	-
Dermatolepis inermis	.09	-	-	-	-	-	-	-
Epinephelus adscensionis	.03	-	-	-	-	.37	-	-
Mycteroperca tigris	.03	-	-	-	-	-	-	-
Holanthias martinicensis	-	-	-	.12	-	.37	-	-
Paranthias furcifer	210.11	-	-	-	-	15.70	-	-
Serranus phoebe	-	-	-	-	-	-	-	.07
Serranus spp. small sea bass	-	-	-	-	-	.09	-	-
Mycteroperca/Epinephelus spp.	.03	-	-	-	-	-	-	-
Family Serranidae (Barred)	-	-	-	-	-	-	-	.35
Mycteroperca spp.	.33	-	-	-	-	1.31	-	-
Priacanthus arenatus	.03	-	-	-	-	.28	-	-
Malacanthus plumieri	-	-	.16	.12	-	.09	-	-
Caranx crysos	-	-	-	1.83	-	-	-	-
Caranx hippos	.95	-	-	-	-	-	-	-
Caranx lugubris	.09	-	-	-	-	-	-	-
Caranx ruber	2.44	5.71	-	-	-	-	-	-
Seriola dumerili	.06	-	-	.24	-	.19	-	-
Seriola rivoliana	.12	-	-	-	-	-	-	-
Lutjanus campechanus	-	-	-	-	-	.09	-	-
Lutjanus griseus	.12	-	-	-	-	-	-	-
Haemulon melanurum	.27	-	-	-	-	-	-	-
Calamus nodosus	.24	4.29	-	-	-	.37	-	-
Equetus spp.	-	-	-	-	-	.09	-	-
Mulloidichthys martinicus	1.04	-	-	-	-	-	-	-
Pseudupeneus maculatus	.27	-	-	-	-	-	-	-
Kyphosus spp.	1.31	-	-	-	-	-	-	-
Centropyge argi	-	-	-	-	-	.37	-	-
Chaetodon ocellatus	.21	-	-	-	-	-	-	-
Chaetodon sedentarius	1.13	-	.80	.49	-	1.59	-	-
Holacanthus bermudensis	.06	-	-	-	-	.09	-	-
Holacanthus ciliaris	.12	-	-	-	-	.28	-	-
Holacanthus tricolor	.21	-	-	-	-	-	-	-
Pomacanthus paru	.15	1.43	.48	.49	-	.65	-	-
Holacanthus spp.	.03	-	-	-	-	-	-	-
Chaetodon spp.	.24	-	-	-	-	.28	-	-
Chromis cyaneus	2.56	-	-	-	-	.09	-	-
Chromis enchrysurus	.42	-	.64	.37	-	28.79	-	-
Chromis multilineatus	108.49	-	-	-	-	-	-	-
Microspathodon chrysurus	.06	-	-	-	-	-	-	-
Pomacentrus partitus	1.31	-	-	-	-	.09	-	-
Chromis/Pomacentrus spp.	4.37	-	.16	-	-	.19	-	-
Chromis spp.	78.71	-	-	-	-	-	-	-
Pomacentrus spp.	9.25	-	-	-	-	.65	-	-
Bodianus pulchellus	.59	-	.32	-	-	1.50	-	-
Bodianus rufus	.15	-	-	-	-	-	-	-
Clepticus parrai	55.57	-	-	-	-	-	-	-
Halichoeres garnoti	.03	-	-	-	-	-	-	-
Thalassoma bifasciatum	1.19	-	-	-	-	-	-	-
Scarus taeniopterus	.18	-	-	-	-	-	-	-
Scarus vetula	.18	-	-	-	-	-	-	-
Sparisoma viride	.65	-	-	-	-	.28	-	-
Scarus/Sparisoma spp.	.24	-	-	.06	-	-	-	-
Sphyraena barracuda	.59	-	-	.18	-	-	-	-
Ophioblennius atlanticus	.03	-	-	-	-	-	-	-
Family Blenniidae	.03	-	-	-	-	-	-	-
Ioglossus spp.	-	-	-	-	-	-	-	.07
Acanthurus coeruleus	.15	-	-	-	-	-	-	-
Acanthurus spp.	.42	-	-	-	-	.28	-	-
Family Bothidae	-	-	-	-	-	-	-	.14
Aluterus monoceros	-	-	.96	-	-	-	-	-
Balistes capriscus	-	-	-	.30	-	.47	-	-
Balistes vetula	.06	-	-	.18	-	.47	-	-
Cantherhines macrocerus	-	-	-	-	-	.09	-	-
Canthidermis sufflamen	.51	-	-	-	-	.19	-	-
Melichthys niger	1.13	-	-	-	-	-	-	-
Lactophrys triqueter	.06	-	-	-	-	.09	-	-
Family Ostraciidae	.03	-	-	-	-	-	-	-
Canthigaster rostrata	.12	-	-	-	-	.09	-	-
Diodon holocanthus	-	-	-	.12	-	-	-	-

Appendix 6-6 (cont'd)

Cruise: 5
Station: East Flower Gardens

Species	Habitat Type 1	2	3	4	5	72	7	6
Manta birostris	.01	-	-	-	-	-	-	.03
Gymnothorax spp.	.01	-	.04	-	-	.03	-	-
Ophichthus rex	-	-	-	-	-	-	-	.03
Order Clupeiformes	3.24	-	-	-	-	-	-	-
Family Synodontidae	.01	-	-	-	-	.02	-	.20
Halieutichthys aculeatus	-	-	-	-	-	-	-	.05
Family Ogcocephalidae	-	-	-	-	-	-	-	.08
Family Gadidae	-	-	-	-	-	-	-	.13
Family Ophidiidae	-	-	-	-	-	-	-	.05
Holocentrus spp.	.08	-	-	.06	-	.43	.05	-
Aulostomus maculatus	.01	-	-	-	-	-	-	-
Dermatolepis inermis	.04	-	-	-	-	-	-	-
Epinephelus adscensionis	-	-	-	-	-	.02	-	-
Epinephelus guttatus	-	-	-	-	-	.03	-	-
Mycteroperca bonaci	-	-	-	-	-	.02	-	-
Mycteroperca tigris	.01	-	-	-	-	-	-	-
Holanthias martinicensis	-	-	-	-	-	3.21	19.47	-
Paranthias furcifer	97.25	-	-	.19	-	5.44	.21	-
Serranus phoebe	-	-	.02	.26	-	.10	1.11	.18
Family Serranidae (small,without bars)	-	-	-	-	-	.02	-	.30
Mycteroperca/Epinephelus spp.	.07	-	-	-	-	.05	-	-
Family Serranidae (Barred)	-	-	-	-	-	.05	.21	1.67
Family Serranidae (Pikea/Hemanthias)	-	-	-	-	-	1.55	.58	-
Mycteroperca spp.	.69	1.23	.08	.06	-	1.42	1.53	-
Priacanthus arenatus	-	-	.04	.13	-	.19	2.12	-
Malacanthus plumieri	-	-	.10	.13	-	.09	-	-
Caranx hippos	.07	-	-	-	-	.05	-	-
Caranx latus	.03	-	-	-	-	-	-	-
Caranx lugubris	.04	-	-	-	-	-	-	-
Caranx ruber	.99	-	-	1.16	-	.73	-	-
Elagatis bipinnulata	.16	-	-	-	-	-	-	-
Selar crumenophthalmus	-	-	.22	-	-	-	-	-
Seriola dumerili	.08	-	.14	.26	-	.17	.11	.05
Seriola rivoliana	.03	-	.02	.06	-	.03	-	.03
Family Carangidae	-	-	-	-	-	.33	-	-
Lutjanus campechanus	-	-	-	-	-	.24	.79	-
Lutjanus griseus	.04	-	-	-	-	-	-	-
Rhomboplites aurorubens	-	-	-	-	-	.35	2.38	-
Haemulon melanurum	.04	-	-	-	-	.07	-	-
Calamus nodosus	.61	-	.06	.06	-	.67	.16	-
Pagrus sedecim	-	-	-	-	-	-	1.11	-
Calamus spp.	-	-	-	-	-	.02	-	-
Equetus lanceolatus	-	-	-	-	-	-	.05	-
Equetus umbrosus	-	-	-	-	-	-	-	.03
Mulloidichthys martinicus	4.32	-	-	-	-	-	-	-
Pseudupeneus maculatus	.55	-	-	-	-	.02	-	-
Kyphosus spp.	1.44	-	.14	-	-	.22	-	-
Centropyge argi	-	-	.46	.13	-	.26	-	-
Chaetodon ocellatus	.09	-	-	-	-	-	-	-
Chaetodon sedentarius	1.78	1.23	.50	.13	-	1.67	1.32	-
Holacanthus bermudensis	.07	-	.02	-	-	.22	-	-
Holacanthus ciliaris	.07	-	-	-	-	.03	-	-
Holacanthus tricolor	.24	-	.02	-	-	.19	-	-
Pomacanthus paru	.24	-	.24	-	-	.28	-	-
Holacanthus spp.	.20	-	-	-	-	.19	.05	-
Chaetodon spp.	.22	-	-	-	-	.03	-	-
Chromis cyaneus	.26	-	-	-	-	-	-	-
Chromis enchrysurus	2.89	-	3.92	.19	-	20.70	2.38	-
Chromis multilineatus	6.37	-	-	-	-	-	-	-
Pomacentrus partitus	.63	-	.42	-	-	.17	-	-
Chromis/Pomacentrus spp.	3.00	-	.08	-	-	.52	-	-
Chromis spp.	13.55	-	-	-	-	.02	-	-
Pomacentrus spp.	4.40	-	-	-	-	.03	-	-
Amblycirrhitus pinos	.01	-	.02	-	-	-	-	-
Bodianus pulchellus	1.01	-	.08	-	-	.81	.37	-
Bodianus rufus	.13	-	-	-	-	.03	-	-
Clepticus parrai	18.80	-	-	-	-	.14	-	-
Halichoeres radiatus	.01	-	-	-	-	-	-	-
Thalassoma bifasciatum	1.04	-	-	-	-	-	-	-

Cruise: 5
Station: East Flower Gardens

Species	Habitat Type							
	1	2	3	4	5	72	7	6
Family Labridae	.43	-	-	-	-	.07	-	-
Scarus taeniopterus	.39	-	-	-	-	-	-	-
Scarus vetula	.13	-	-	-	-	-	-	-
Sparisoma aurofrenatum	.03	-	-	-	-	-	-	-
Sparisoma viride	.39	-	-	-	-	.43	-	-
Scarus/Sparisoma spp.	.40	-	-	-	-	-	-	-
Sphyraena barracuda	.26	-	.10	.13	-	.05	-	-
Ophioblennius atlanticus	-	-	.02	-	-	-	-	-
Family Gobiidae	-	-	.04	-	-	-	.05	.08
Ioglossus spp.	-	-	-	-	-	.03	.05	-
Acanthurus coeruleus	.18	-	-	-	-	-	-	-
Acanthurus spp.	.22	-	-	-	-	.10	-	-
Family Scorpaenidae	-	-	-	-	-	-	-	.03
Prionotus spp.	-	-	-	-	-	-	-	.28
Family Bothidae	-	-	-	-	-	-	-	.08
Aluterus scriptus	.04	-	.04	-	-	.02	-	-
Balistes capriscus	.01	-	.14	.06	-	.35	-	-
Balistes vetula	.19	-	.12	-	-	.45	-	-
Cantherhines macrocerus	.03	-	-	-	-	.02	-	-
Canthidermis sufflamen	.30	-	-	.83	-	1.93	-	-
Melichthys niger	.50	-	-	-	-	-	-	-
Xanthichthys ringens	-	-	-	-	-	.05	-	-
Family Balistidae	.01	-	-	-	-	.03	-	-
Lactophrys quadricornis	-	-	.02	-	-	-	.05	-
Lactophrys triqueter	.07	-	.02	-	-	-	-	-
Diodon holocanthus	.01	-	.06	-	-	-	-	.03
Family Diodontidae	-	-	-	-	-	.03	-	-
Class Osteichthyes	-	-	.02	-	-	-	-	.13

Cruise: 6
Station: East Flower Gardens

Species	Habitat Type 1	2	3	4	5	72	7	6
Ginglymostoma cirratum	.01	-	-	-	-	-	-	-
Dasyatis spp.	.01	-	-	-	-	-	-	-
Gymnothorax spp.	-	-	-	-	-	.01	-	-
Synodus intermedius	.01	-	-	-	-	-	-	-
Synodus spp.	-	-	-	-	-	-	.04	-
Family Ogcocephalidae	-	-	-	-	-	-	-	.05
Family Gadidae	-	-	-	-	-	-	-	.07
Holocentrus spp.	.08	-	-	-	-	.42	-	-
Centropristis philadelphica	-	-	-	-	-	-	-	.02
Cephalopholis fulva	-	-	-	-	-	.01	-	-
Dermatolepis inermis	.01	-	-	-	-	.03	-	-
Epinephelus adscensionis	.02	-	-	-	-	.08	-	-
Liopropoma eukrines	-	-	-	-	-	.02	.04	-
Holanthias martinicensis	-	-	.01	.02	-	4.40	68.67	-
Paranthias furcifer	93.31	-	-	-	-	4.98	9.15	-
Serranus phoebe	-	-	-	.07	-	.10	.37	.09
Family Serranidae (small, without bars)	-	-	-	.02	-	-	.33	.05
Mycteroperca/Epinephelus spp.	.03	-	-	-	-	.02	.08	.02
Epinephelus spp.	.01	-	-	-	-	.01	-	-
Family Serranidae (Barred)	-	-	-	.10	-	-	.04	1.10
Family Serranidae (Pikea/Hemanthias)	-	-	1.55	-	-	14.02	42.18	-
Mycteroperca spp.	.57	-	.02	-	-	.90	1.74	.02
Priacanthus arenatus	.01	-	-	-	-	.15	2.07	.02
Malacanthus plumieri	-	-	.02	.02	-	-	-	-
Family Branchiostegidae	-	-	-	-	-	-	-	.05
Caranx hippos	.75	-	-	-	-	1.02	-	3.20
Caranx lugubris	.02	-	-	-	-	-	-	-
Caranx ruber	.30	-	-	-	-	-	-	-
Seriola dumerili	.24	-	.12	.12	-	.13	.12	.34
Seriola rivoliana	.05	-	.01	.02	-	-	-	-
Caranx spp.	.02	-	.02	-	-	-	-	-
Lutjanus campechanus	-	-	-	-	-	.41	2.44	-
Rhomboplites aurorubens	-	-	-	-	-	-	.58	-
Haemulon melanurum	3.49	-	-	-	-	1.83	.08	-
Calamus nodosus	.15	-	-	-	-	.09	-	-
Pagrus sedecim	-	-	-	-	-	.13	.29	-
Equetus lanceolatus	.01	-	-	-	-	-	.04	-
Equetus umbrosus	-	-	-	-	-	-	.04	-
Mulloidichthys martinicus	4.07	-	-	-	-	-	-	-
Pseudupeneus maculatus	.80	-	-	-	-	.21	-	-
Family Mullidae	.07	-	-	-	-	-	-	-
Kyphosus spp.	4.83	-	-	-	-	-	-	-
Centropyge argi	.01	-	.06	.05	-	.13	-	-
Chaetodon aya	-	-	-	-	-	.01	.33	-
Chaetodon ocellatus	.11	-	-	-	-	-	-	-
Chaetodon sedentarius	1.53	-	.14	-	-	1.32	.83	-
Chaetodon striatus	.03	-	-	-	-	-	-	-
Holacanthus bermudensis	.01	-	-	-	-	.11	.04	-
Holacanthus ciliaris	.03	-	-	-	-	.08	-	-
Holacanthus tricolor	.23	-	-	-	-	.04	.08	-
Pomacanthus paru	.18	-	.14	.05	-	.17	-	-
Prognathodes aculeatus	.01	-	-	-	-	-	-	-
Holacanthus spp.	.06	-	-	-	-	.11	-	-
Chaetodon spp.	.04	-	-	-	-	.09	-	-
Chromis cyaneus	.50	-	-	-	-	-	-	-
Chromis enchrysurus	.36	-	.65	-	-	14.66	2.73	-
Chromis multilineatus	16.02	-	-	-	-	-	-	-
Microspathodon chrysurus	.02	-	-	-	-	-	-	-
Pomacentrus partitus	.28	-	.04	-	-	.03	-	-
Chromis/Pomacentrus spp.	3.17	-	-	-	-	.88	-	-
Chromis spp.	15.99	-	-	-	-	-	-	-
Pomacentrus spp.	3.72	-	-	-	-	-	-	-
Bodianus pulchellus	1.87	-	.01	-	-	.61	.08	-
Bodianus rufus	.33	-	.04	-	-	.04	-	-

Cruise: 6
Station: East Flower Gardens

Species	Habitat Type 1	2	3	4	5	72	7	6
Clepticus parrai	30.87	-	-	-	-	-	-	-
Halichoeres garnoti	.01	-	-	-	-	-	-	-
Lachnolaimus maximus	.02	-	-	.02	-	-	-	-
Thalassoma bifasciatum	2.17	-	-	-	-	.01	-	-
Family Labridae	.33	-	.01	-	-	.09	-	-
Scarus taeniopterus	.23	-	-	-	-	-	-	-
Scarus vetula	.30	-	-	-	-	-	-	-
Sparisoma aurofrenatum	.02	-	-	-	-	.01	-	-
Sparisoma viride	.32	-	-	-	-	.05	-	-
Scarus/Sparisoma spp.	.24	-	-	-	-	.03	-	-
Sphyraena barracuda	.03	-	.01	-	-	-	-	-
Ophioblennius atlanticus	.01	-	-	-	-	-	-	-
Family Gobiidae	-	-	-	-	-	.01	-	-
Ioglossus spp.	-	-	-	-	-	.01	-	-
Acanthurus coeruleus	.08	-	-	-	-	-	-	-
Acanthurus spp.	.22	-	-	-	-	.04	-	-
Family Scorpaenidae	-	-	-	-	-	.01	-	-
Prionotus spp.	-	-	-	-	-	-	-	.02
Family Bothidae	-	-	-	-	-	-	-	.05
Aluterus scriptus	.03	-	-	-	-	-	-	-
Balistes capriscus	.02	-	.02	.02	-	.16	-	-
Balistes vetula	.03	-	-	-	-	.09	-	-
Cantherhines macrocerus	.02	-	-	-	-	.02	-	-
Canthidermis sufflamen	.21	-	.01	-	-	-	-	-
Melichthys niger	.48	-	-	-	-	-	-	-
Xanthichthys ringens	-	-	-	-	-	.11	-	-
Lactophrys quadricornis	.01	-	.01	-	-	.03	-	-
Lactophrys triqueter	.03	-	-	-	-	-	-	-
Canthigaster rostrata	.02	-	-	-	-	.04	-	-
Family Tetraodontidae	-	-	-	-	-	-	-	.02
Diodon holocanthus	.01	-	-	-	-	.02	-	-
Diodon hystrix	.01	-	-	-	-	-	-	-
Class Osteichthyes	-	-	-	.02	-	-	.62	.21

Appendix 6-6 (cont'd)

Cruise: 7
Station: East Flower Gardens

Species	Habitat Type 1	2	3	4	5	72	7	6
Carcharhinus spp.	-	-	-	-	-	-	-	.03
Manta birostris	.03	-	-	.08	-	-	-	-
Gymnothorax spp.	-	-	-	-	-	-	.08	-
Synodus spp.	-	-	-	-	-	-	-	.03
Family Ogcocephalidae	-	-	-	-	-	-	.08	.19
Family Gadidae	-	-	-	-	-	-	.17	-
Holocentrus spp.	.10	-	-	-	-	.28	-	-
Aulostomus maculatus	.01	-	-	-	-	-	-	-
Dermatolepis inermis	.03	-	-	-	-	.03	-	-
Epinephelus adscensionis	.09	-	-	-	-	.02	-	-
Liopropama eukrines	-	-	.01	.08	-	.03	.17	-
Mycteroperca bonaci	.01	-	-	-	-	-	-	-
Mycteroperca tigris	.03	-	-	-	-	-	-	-
Holanthias martinicensis	-	-	-	-	-	4.00	39.02	-
Paranthias furcifer	102.44	-	-	-	-	11.89	-	-
Serranus phoebe	-	-	-	.16	-	.09	1.24	.26
Family Serranidae (small, without bars)	-	-	-	-	-	-	.58	.13
Mycteroperca/Epinephelus spp.	.10	-	-	-	-	.06	.17	.06
Family Serranidae (Barred)	-	-	-	-	-	.01	.50	1.63
Family Serranidae (Pikea/Hemanthias)	-	-	.27	-	-	28.05	1.57	-
Mycteroperca spp.	.53	-	-	-	-	.95	1.24	-
Priacanthus arenatus	.06	-	.01	-	-	.08	4.39	-
Malacanthus plumieri	-	-	.08	.39	-	.01	-	-
Family Branchiostegidae	-	-	-	-	-	-	-	.03
Caranx crysos	-	-	-	-	-	-	1.91	-
Caranx latus	3.75	-	-	-	-	-	-	-
Caranx lugubris	-.07	-	-	-	-	-	-	-
Caranx ruber	9.89	-	-	-	-	-	-	-
Seriola dumerili	.33	-	.05	.23	-	.16	-	.03
Seriola rivoliana	.21	-	.01	.16	-	-	.08	-
Caranx spp.	.13	-	-	1.87	-	-	-	-
Family Lutjanidae	.03	-	-	-	-	-	-	-
Lutjanus campechanus	-	-	-	-	-	.86	1.74	-
Lutjanus griseus	.09	-	-	-	-	-	-	-
Lutjanus jocu	.01	-	-	-	-	-	-	-
Rhomboplites aurorubens	-	-	-	-	-	.12	.25	-
Haemulon melanurum	1.87	-	.03	-	-	.67	-	-
Calamus nodosus	.47	-	.01	-	-	.30	-	-
Pagrus sedecim	-	-	-	-	-	.16	-	-
Equetus lanceolatus	-	-	-	-	-	-	.17	-
Equetus umbrosus	-	-	-	-	-	-	.75	-
Mulloidichthys martinicus	4.73	-	-	-	-	-	-	-
Pseudupeneus maculatus	.49	-	-	-	-	.33	-	-
Kyphosus spp.	6.32	-	-	-	-	.01	-	-
Centropyge argi	.09	-	.32	.16	-	.31	-	-
Chaetodon aya	-	-	-	-	-	-	.25	-
Chaetodon ocellatus	.11	-	-	-	-	.04	-	-
Chaetodon sedentarius	3.01	-	.64	.23	-	2.11	.83	-
Holacanthus bermudensis	.03	-	-	-	-	.08	-	-
Holacanthus ciliaris	.07	-	-	-	-	.12	-	-
Holacanthus tricolor	.34	-	-	-	-	.15	-	-
Pomacanthus paru	.31	-	.12	.47	-	.19	-	-
Prognathodes aculeatus	.04	-	-	-	-	-	-	-
Holacanthus spp.	.11	-	-	-	-	.27	.08	-
Chaetodon spp.	.23	-	-	-	-	-	-	-
Chromis cyaneus	.90	-	-	-	-	.12	-	-
Chromis enchrysurus	2.90	-	2.96	.23	-	25.32	2.73	-
Chromis multilineatus	23.65	-	-	-	-	-	-	-
Microspathodon chrysurus	.01	-	-	-	-	-	-	-
Pomacentrus partitus	1.76	-	.16	-	-	.07	-	-
Chromis/Pomacentrus spp.	6.71	-	.03	-	-	.34	-	-
Chromis spp.	21.11	-	-	-	-	.09	-	-
Pomacentrus spp.	7.94	-	-	-	-	.04	-	-
Bodianus pulchellus	1.23	-	.03	-	-	1.36	.08	-
Bodianus rufus	.93	-	.12	-	-	.24	-	-
Clepticus parrai	36.17	-	-	-	-	.11	-	-
Decodon puellaris	-	-	-	-	-	-	.17	-
Halichoeres garnoti	.06	-	-	-	-	-	-	-
Halichoeres radiatus	-	-	-	-	-	.01	-	-

Appendix 6-6 (cont'd)

Cruise: 7
Station: East Flower Gardens

	Habitat Type							
Species	1	2	3	4	5	72	7	6
Thalassoma bifasciatum	6.32	-	.01	-	-	.04	-	-
Family Labridae	1.04	-	.01	-	-	.16	.08	-
Scarus taeniopterus	.84	-	-	-	-	.04	-	-
Scarus vetula	1.04	-	-	-	-	.02	-	-
Sparisoma aurofrenatum	.21	-	-	-	-	.02	-	-
Sparisoma viride	.51	-	-	-	-	.38	-	-
Scarus/Sparisoma spp.	.33	-	-	-	-	.03	-	-
Sphyraena barracuda	.14	-	-	-	-	-	-	-
Bembrops spp.	-	-	-	-	-	-	-	.03
Ioglossus spp.	-	-	-	-	-	-	.50	.10
Acanthurus coeruleus	.29	-	-	-	-	-	-	-
Acanthurus spp.	.64	-	-	-	-	.03	-	-
Scomberomorus cavalla	-	-	.01	-	-	-	-	-
Prionotus spp.	-	-	-	-	-	-	-	.06
Family Bothidae	-	-	-	-	-	-	-	.13
Aluterus scriptus	.01	-	-	-	-	.02	-	-
Balistes capriscus	-	-	-	-	-	.24	-	-
Balistes vetula	.16	-	.01	-	-	.07	-	-
Cantherhines macrocerus	.03	-	-	-	-	.02	-	-
Canthidermis sufflamen	2.87	-	-	-	-	.01	-	-
Melichthys niger	.79	-	-	-	-	-	-	-
Xanthichthys ringens	-	-	-	-	-	.46	-	-
Lactophrys quadricornis	.01	-	-	.08	-	.03	-	-
Lactophrys triqueter	.09	-	-	-	-	-	-	-
Family Ostraciidae	.03	-	-	-	-	-	-	-
Canthigaster rostrata	.10	-	.01	.08	-	.01	-	-
Family Tetraodontidae	-	-	.01	-	-	-	-	-
Diodon holocanthus	.03	-	.07	-	-	.02	-	-
Family Diodontidae	-	-	.01	-	-	-	-	-
Class Osteichthyes	-	-	-	-	-	-	-	.38
Fistularia tabacaria	-	-	-	.08	-	-	-	-

Appendix 6-6 (cont'd)

Cruise: 8
Station: East Flower Gardens

Species	Habitat Type 1	2	3	4	5	72	7	6
Ginglymostoma cirratum	-	-	-	-	-	.02	-	-
Carcharhinus spp.	-	-	.02	-	-	-	-	-
Gymnothorax spp.	-	-	-	-	-	.04	-	-
Ophichthus spp.	-	-	-	-	-	-	-	.05
Family Synodontidae	-	-	-	-	-	-	-	.05
Synodus spp.	-	-	.02	-	-	-	-	.16
Family Ogcocephalidae	-	-	-	-	-	-	-	.37
Holocentrus spp.	.20	-	-	-	-	1.04	-	-
Aulostomus maculatus	.05	-	-	-	-	-	-	-
Epinephelus adscensionis	-	-	-	-	-	.11	-	-
Epinephelus nigritus	-	-	-	-	-	-	.20	-
Liopropama eukrines	.02	-	-	-	-	.11	.10	-
Holanthias martinicensis	-	-	-	.06	-	4.52	53.40	-
Paranthias furcifer	168.33	-	18.65	-	-	46.79	-	-
Serranus phoebe	-	-	-	.13	-	.07	1.83	.05
Serranus spp. small sea bass	.02	-	-	-	-	.04	-	-
Mycteroperca/Epinephelus spp.	.02	-	-	-	-	.09	-	-
Epinephelus spp.	-	-	-	-	-	.05	-	-
Family Serranidae (Barred)	-	-	-	.13	-	-	-	2.19
Family Serranidae (Pikea/Hemanthias)	-	-	10.95	.26	-	38.44	20.81	-
Mycteroperca spp.	1.18	-	.02	.32	-	1.90	2.84	-
Priacanthus arenatus	-	-	-	.13	-	.05	3.25	-
Malacanthus plumieri	-	-	.10	.26	-	.02	-	-
Caranx crysos	-	-	.02	.13	-	.09	2.03	-
Caranx lugubris	.02	-	-	-	-	.04	-	-
Caranx ruber	.61	-	-	-	-	-	-	-
Elagatis bipinnulata	-	-	-	-	-	.72	-	-
Seriola dumerili	.41	-	.10	.26	-	.14	.51	-
Seriola rivoliana	-	-	-	-	-	.05	-	-
Lutjanus campechanus	-	-	-	-	-	.57	.20	.05
Lutjanus griseus	.07	-	-	-	-	.02	-	-
Pristipomoides aquilonaris	-	-	-	-	-	-	-	.05
Haemulon melanurum	.05	-	.05	-	-	.02	.10	-
Calamus nodosus	.45	-	-	-	-	.56	.10	-
Calamus spp.	-	-	-	-	-	-	.10	-
Equetus lanceolatus	-	-	-	-	-	.02	-	-
Equetus umbrosus	-	-	-	-	-	.04	-	-
Mulloidichthys martinicus	5.97	-	-	-	-	-	-	-
Pseudupeneus maculatus	.32	-	-	-	-	.41	-	-
Kyphosus spp.	8.82	-	-	-	-	-	-	-
Centropyge argi	.45	-	1.41	.06	-	1.33	-	-
Chaetodon ocellatus	.34	-	-	-	-	.09	-	-
Chaetodon sedentarius	4.11	-	.82	.19	-	4.12	1.22	-
Chaetodon striatus	.05	-	-	-	-	-	-	-
Holacanthus bermudensis	.02	-	-	-	-	.02	-	-
Holacanthus ciliaris	.27	-	-	-	-	.27	-	-
Holacanthus tricolor	.36	-	.07	-	-	.22	-	-
Pomacanthus paru	.52	-	.32	.45	-	.23	-	-
Prognathodes aculeatus	.02	-	-	-	-	-	-	-
Holacanthus spp.	.20	-	-	-	-	.29	-	-
Chaetodon spp.	.16	-	-	-	-	-	-	-
Chromis cyaneus	1.22	-	-	-	-	.18	-	-
Chromis enchrysurus	3.07	-	7.31	1.41	-	44.60	.81	-
Chromis multilineatus	19.08	-	-	-	-	1.70	-	-
Microspathodon chrysurus	-	-	-	-	-	.02	-	-
Pomacentrus partitus	1.67	-	.64	.06	-	.57	-	-
Chromis/Pomacentrus spp.	7.80	-	-	-	-	.45	-	-
Chromis spp.	62.09	-	-	-	-	-	-	-
Pomacentrus spp.	10.49	-	-	-	-	.05	-	-
Bodianus pulchellus	1.97	-	.10	.06	-	2.19	.10	-
Bodianus rufus	1.08	-	.45	.06	-	.22	-	-
Clepticus parrai	49.71	-	-	-	-	.59	-	-
Decodon puellaris	.02	-	-	-	-	.04	.10	-
Halichoeres garnoti	.02	-	-	-	-	.02	-	-
Halichoeres radiatus	.05	-	-	-	-	-	-	-
Lachnolaimus maximus	-	-	-	-	-	-	.20	-
Thalassoma bifasciatum	5.04	-	-	-	-	.09	-	-
Family Labridae	.38	-	.07	-	-	.13	.20	-
Scarus taeniopterus	1.15	-	-	-	-	.09	-	-
Scarus vetula	.97	-	-	-	-	.02	-	-
Sparisoma aurofrenatum	.38	-	-	-	-	.02	-	-
Sparisoma viride	1.04	-	-	-	-	.45	-	-
Scarus/Sparisoma spp.	.57	-	-	-	-	.04	-	-
Sphyraena barracuda	.16	-	.02	-	-	-	-	-
Family Gobiidae	-	-	.17	-	-	-	.20	-

Appendix 6-6 (cont'd)

Cruise: 8
Station: East Flower Gardens

Species	Habitat Type 1	2	3	4	5	72	7	6
Ioglossus spp.	-	-	-	.06	-	.05	-	.05
Acanthurus coeruleus	.18	-	-	-	-	-	-	-
Acanthurus spp.	1.31	-	-	-	-	.27	-	-
Balistes capriscus	.02	-	.30	.13	-	1.04	-	-
Balistes vetula	.20	-	.05	.06	-	.27	-	-
Cantherhines macrocerus	.16	-	-	-	-	.07	-	-
Canthidermis sufflamen	.07	-	.02	-	-	.11	-	-
Melichthys niger	1.81	-	-	-	-	-	-	-
Xanthichthys ringens	-	-	-	-	-	.38	-	-
Lactophrys quadricornis	.02	-	-	.06	-	.07	-	.05
Lactophrys triqueter	.07	-	-	-	-	.02	-	-
Canthigaster rostrata	.07	-	.02	-	-	-	-	-
Diodon holocanthus	-	-	.07	-	-	.02	-	.05
Class Osteichthyes	-	-	-	-	-	.04	-	.26

Appendix 6-7. Density of fish/1000 m^2 by 5 m depth intervals, Cruises 2-8, East (E) and West (W) Flower Garden Banks.

Cruise: 2 Station: W

Species						Depth in Meters	
	15-19	20-24	25-29	30-34	35-39	40-44	45-49
Manta birostris	-	-	-	-	-	.310	-
Holocentrus spp.	-	-	-	-	-	2.171	.500
Aulostomus maculatus	-	.113	-	-	-	-	-
Dermatolepis inermis	-	-	-	-	-	-	.334
Epinephelus morio	-	-	-	-	-	-	-
Mycteroperca bonaci	-	.113	.233	-	-	-	-
Holanthias martinicensis	-	-	-	-	-	-	-
Paranthias furcifer	-	258.483	472.282	104.570	104.130	25.427	85.903
Serranus phoebe	-	-	-	-	-	-	-
Mycteroperca/Epinephelus spp.	-	-	.233	-	-	.310	-
Epinephelus spp.	-	-	-	-	-	.310	-
Family Serranidae (Pikea/Hemanthias)	-	-	-	-	-	-	-
Mycteroperca spp.	-	.340	-	.510	.443	-	.500
Malacanthus plumieri	-	-	-	-	-	-	.167
Caranx hippos	-	3.404	-	-	-	24.807	-
Caranx ruber	-	-	.931	-	-	-	-
Seriola dumerili	-	.340	.233	-	-	-	.500
Seriola rivoliana	-	-	-	-	.443	-	-
Lutjanus campechanus	-	-	-	-	-	-	-
Lutjanus jocu	-	-	-	-	.886	.310	-
Rhomboplites aurorubens	-	-	-	-	-	-	-
Lutjanus spp.	-	-	-	-	-	-	-
Haemulon melanurum	-	.227	-	-	-	28.838	-
Calamus nodosus	-	-	-	.510	-	.930	.167
Pagrus sedecim	-	-	-	.510	-	.310	-
Equetus spp.	-	-	-	-	-	-	-
Mulloidichthys martinicus	-	2.610	-	-	-	-	-
Family Mullidae	-	-	.465	-	-	-	-
Kyphosus spp.	-	20.311	-	-	-	-	-
Centropyge argi	-	-	-	-	-	-	-
Chaetodon sedentarius	-	1.135	.233	-	-	1.240	2.335
Holacanthus tricolor	-	.681	1.629	-	1.329	.930	-
Pomacanthus paru	-	.454	-	-	-	.620	.667
Holacanthus spp.	-	-	-	-	-	-	.167
Chaetodon spp.	-	.340	.465	-	-	.310	-
Chromis enchrysurus	-	-	-	-	-	-	3.002
Pomacentrus partitus	-	1.589	.931	-	-	-	-
Chromis/Pomacentrus spp.	-	-	-	-	-	-	.834
Chromis spp.	-	58.323	44.902	1.020	-	-	-
Pomacentrus spp.	-	63.429	55.138	13.263	1.772	2.171	-
Bodianus pulchellus	-	.113	.931	-	-	.310	-
Bodianus rufus	-	-	.931	-	-	.310	-
Clepticus parrai	-	1.816	.931	2.040	-	-	-
Halichoeres radiatus	-	.227	-	-	-	-	-
Thalassoma bifasciatum	-	4.425	.698	-	-	-	-
Scarus taeniopterus	-	-	.465	-	-	-	-
Scarus vetula	-	.454	1.163	-	-	-	-
Sparisoma viride	-	.227	.233	-	-	-	-
Scarus/Sparisoma spp.	-	.454	.465	-	-	-	.167
Sphyraena barracuda	-	4.198	1.163	-	-	.620	1.501
Ioglossus spp.	-	-	-	-	-	-	-
Acanthurus spp.	-	.227	.465	-	-	-	.167
Balistes capriscus	-	-	-	-	-	-	-
Balistes vetula	-	-	-	-	-	.310	.334
Cantherhines macrocerus	-	-	-	-	-	-	.500
Canthidermis sufflamen	-	-	-	.510	-	-	.167
Melichthys niger	-	18.382	8.608	3.571	.443	-	-
Lactophrys triqueter	-	-	-	-	-	-	.167
Family Ostraciidae	-	-	-	.510	-	-	-
Diodon holocanthus	-	-	-	-	-	-	-

Appendix 6-7 (cont'd)

Cruise: 2 Station: W

Species	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89
Manta birostris	-	-	-	-	-	-	-	-
Holocentrus spp.	.366	.694	-	-	-	-	-	-
Aulostomus maculatus	-	-	-	-	-	-	-	-
Dermatolepis inermis	-	-	-	-	-	-	-	-
Epinephelus morio	-	.231	-	-	-	-	-	-
Mycteroperca bonaci	-	-	-	-	-	-	-	-
Holanthias martinicensis	-	-	-	-	-	75.777	-	-
Paranthias furcifer	1.466	41.411	-	-	-	.389	-	-
Serranus phoebe	-	.231	-	-	-	1.166	-	1.429
Mycteroperca/Epinephelus spp.	-	-	-	-	-	-	-	-
Epinephelus spp.	-	-	-	-	-	-	-	-
Family Serranidae (Pikea/Hemanthias)	65.048	127.241	49.662	92.927	-	-	-	-
Mycteroperca spp.	.550	1.619	-	-	-	1.554	-	-
Malacanthus plumieri	.183	-	-	-	-	-	-	-
Caranx hippos	-	-	-	-	-	-	-	-
Caranx ruber	-	-	-	-	-	-	-	-
Seriola dumerili	-	.925	-	.732	-	1.554	-	-
Seriola rivoliana	-	-	-	-	-	5.440	-	-
Lutjanus campechanus	-	22.672	-	-	-	.389	-	-
Lutjanus jocu	-	-	-	-	-	-	-	-
Rhomboplites aurorubens	-	-	-	-	-	2.332	-	-
Lutjanus spp.	.366	-	-	-	-	-	-	-
Haemulon melanurum	-	-	-	-	-	-	-	-
Calamus nodosus	-	.463	-	-	-	1.166	-	-
Pagrus sedecim	.183	-	-	-	-	-	-	-
Equetus spp.	-	-	-	-	-	.777	-	-
Mulloidichthys martinicus	-	-	-	-	-	-	-	-
Family Mullidae	-	-	-	-	-	-	-	-
Kyphosus spp.	-	-	-	-	-	-	-	-
Centropyge argi	2.932	3.008	1.986	-	-	-	-	-
Chaetodon sedentarius	1.466	5.552	-	2.195	-	.777	-	-
Holacanthus tricolor	-	.231	-	-	-	-	-	-
Pomacanthus paru	.550	.463	-	-	-	-	-	-
Holacanthus spp.	-	.925	-	-	-	-	-	-
Chaetodon spp.	-	-	-	-	-	-	-	-
Chromis enchrysurus	28.035	37.247	-	3.659	-	3.886	-	-
Pomacentrus partitus	-	-	-	-	-	-	-	-
Chromis/Pomacentrus spp.	.366	-	-	-	-	-	-	-
Chromis spp.	-	-	-	-	-	-	-	-
Pomacentrus spp.	.183	-	-	-	-	-	-	-
Bodianus pulchellus	-	.925	.662	-	-	2.332	-	-
Bodianus rufus	-	-	-	-	-	-	-	-
Clepticus parrai	-	-	-	-	-	-	-	-
Halichoeres radiatus	-	-	-	-	-	-	-	-
Thalassoma bifasciatum	-	-	-	-	-	-	-	-
Scarus taeniopterus	-	-	-	-	-	-	-	-
Scarus vetula	-	-	-	-	-	-	-	-
Sparisoma viride	-	-	-	-	-	-	-	-
Scarus/Sparisoma spp.	-	-	-	-	-	-	-	-
Sphyraena barracuda	-	-	-	-	-	.389	-	-
Ioglossus spp.	.183	-	-	-	-	.389	-	-
Acanthurus spp.	-	-	-	-	-	-	-	-
Balistes capriscus	-	1.157	-	-	-	-	-	-
Balistes vetula	.183	1.157	-	-	-	-	-	-
Cantherhines macrocerus	-	-	-	-	-	-	-	-
Canthidermis sufflamen	.183	.231	-	.732	-	-	-	-
Melichthys niger	-	-	-	-	-	-	-	-
Lactophrys triqueter	-	-	-	-	-	-	-	-
Family Ostraciidae	-	-	-	-	-	-	-	-
Diodon holocanthus	-	.925	-	-	-	-	-	-

Appendix 6-7 (cont'd)

Cruise: 2   Station: W

Species	Depth in Meters 90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129
Manta birostris	-	-	-	-	-	-	-	-
Holocentrus spp.	-	-	-	-	-	-	-	-
Aulostomus maculatus	-	-	-	-	-	-	-	-
Dermatolepis inermis	-	-	-	-	-	-	-	-
Epinephelus morio	-	-	-	-	-	-	-	-
Mycteroperca bonaci	-	-	-	-	-	-	-	-
Holanthias martinicensis	-	-	-	-	-	-	-	-
Paranthias furcifer	-	-	-	-	-	-	-	-
Serranus phoebe	1.408	-	-	-	-	-	-	-
Mycteroperca/Epinephelus spp.	-	-	-	-	-	-	-	-
Epinephelus spp.	-	-	-	-	-	-	-	-
Family Serranidae (Pikea/Hemanthias)	-	-	-	-	-	-	-	-
Mycteroperca spp.	-	-	-	-	-	-	-	-
Malacanthus plumieri	-	-	-	-	-	-	-	-
Caranx hippos	-	-	-	-	-	-	-	-
Caranx ruber	-	-	-	-	-	-	-	-
Seriola dumerili	-	-	-	-	-	-	-	-
Seriola rivoliana	-	-	-	-	-	-	-	-
Lutjanus campechanus	-	-	-	-	-	-	-	-
Lutjanus jocu	-	-	-	-	-	-	-	-
Rhomboplites aurorubens	-	-	-	-	-	-	-	-
Lutjanus spp.	-	-	-	-	-	-	-	-
Haemulon melanurum	-	-	-	-	-	-	-	-
Calamus nodosus	-	-	-	-	-	-	-	-
Pagrus sedecim	-	-	-	-	-	-	-	-
Equetus spp.	-	-	-	-	-	-	-	-
Mulloidichthys martinicus	-	-	-	-	-	-	-	-
Family Mullidae	-	-	-	-	-	-	-	-
Kyphosus spp.	-	-	-	-	-	-	-	-
Centropyge argi	-	-	-	-	-	-	-	-
Chaetodon sedentarius	-	-	-	-	-	-	-	-
Holacanthus tricolor	-	-	-	-	-	-	-	-
Pomacanthus paru	-	-	-	-	-	-	-	-
Holacanthus spp.	-	-	-	-	-	-	-	-
Chaetodon spp.	-	-	-	-	-	-	-	-
Chromis enchrysurus	.704	-	-	-	-	-	-	-
Pomacentrus partitus	-	-	-	-	-	-	-	-
Chromis/Pomacentrus spp.	-	-	-	-	-	-	-	-
Chromis spp.	-	-	-	-	-	-	-	-
Pomacentrus spp.	-	-	-	-	-	-	-	-
Bodianus pulchellus	-	-	-	-	-	-	-	-
Bodianus rufus	-	-	-	-	-	-	-	-
Clepticus parrai	-	-	-	-	-	-	-	-
Halichoeres radiatus	-	-	-	-	-	-	-	-
Thalassoma bifasciatum	-	-	-	-	-	-	-	-
Scarus taeniopterus	-	-	-	-	-	-	-	-
Scarus vetula	-	-	-	-	-	-	-	-
Sparisoma viride	-	-	-	-	-	-	-	-
Scarus/Sparisoma spp.	-	-	-	-	-	-	-	-
Sphyraena barracuda	-	-	-	-	-	-	-	-
Ioglossus spp.	-	-	-	-	-	-	-	-
Acanthurus spp.	-	-	-	-	-	-	-	-
Balistes capriscus	-	-	-	-	-	-	-	-
Balistes vetula	-	-	-	-	-	-	-	-
Cantherhines macrocerus	-	-	-	-	-	-	-	-
Canthidermis sufflamen	-	-	-	-	-	-	-	-
Melichthys niger	-	-	-	-	-	-	-	-
Lactophrys triqueter	-	-	-	-	-	-	-	-
Family Ostraciidae	-	-	-	-	-	-	-	-
Diodon holocanthus	-	-	-	-	-	-	-	-

Appendix 6-7 (cont'd)

Cruise: 3 Station: W

Species						Depth in Meters	
	15-19	20-24	25-29	30-34	35-39	40-44	45-49
Ginglymostoma cirratum	-	.068	-	-	-	-	-
Isurus oxyrinchus	-	.068	-	-	-	-	-
Dasyatis spp.	-	.068	-	-	-	-	-
Rhinoptera bonasus	-	-	-	-	-	.321	-
Order Clupeiformes	-	-	-	-	-	-	-
Synodus intermedius	-	-	-	-	-	-	-
Holocentrus spp.	-	-	-	-	-	-	.920
Epinephelus adscensionis	-	-	-	-	-	-	.184
Epinephelus morio	-	-	-	-	-	-	.046
Holanthias martinicensis	-	-	-	-	-	-	-
Paranthias furcifer	67.566	113.845	53.939	770.483	50.161	39.791	-
Serranus phoebe	-	-	-	-	-	-	-
Serranus spp. small sea bass	-	-	-	-	-	-	-
Mycteroperca/Epinephelus spp.	-	.068	-	-	-	-	-
Epinephelus spp.	-	-	-	-	-	-	.046
Family Serranidae (Barred)	-	-	-	-	-	-	-
Family Serranidae (Pikea/Hemanthias)	-	-	-	-	-	-	-
Mycteroperca spp.	-	.205	-	-	-	.321	.460
Priacanthus arenatus	-	-	-	-	-	-	.690
Malacanthus plumieri	-	-	-	-	-	.321	.230
Caranx hippos	-	25.466	-	-	-	-	-
Caranx ruber	-	9.789	-	-	-	-	-
Seriola dumerili	5.197	.479	.638	-	-	.481	.230
Seriola rivoliana	20.789	.137	2.873	-	-	-	-
Lutjanus campechanus	-	-	-	-	-	-	-
Lutjanus griseus	-	.411	6.064	-	-	-	-
Rhomboplites aurorubens	-	-	-	-	-	-	-
Haemulon melanurum	-	-	.638	-	38.166	14.761	.138
Calamus nodosus	-	-	.319	-	-	-	.138
Pargrus sedecim	-	-	-	-	-	-	.046
Calamus spp.	-	-	-	-	-	-	-
Equetus lanceolatus	-	-	-	-	-	-	-
Equetus spp.	-	-	-	-	-	-	-
Mulloidichthys martinicus	-	-	-	-	-	14.119	-
Kyphosus spp.	5.197	5.682	3.830	-	-	-	-
Centropyge argi	-	-	-	-	-	-	-
Chaetodon aya	-	-	-	-	-	-	-
Chaetodon sedentarius	-	.068	.638	-	-	-	2.116
Holacanthus tricolor	-	.137	-	-	1.090	-	.460
Pomacanthus paru	-	.137	-	-	1.090	1.284	.874
Prognathodes aculeatus	-	-	.638	-	-	-	-
Holacanthus spp.	-	-	-	-	-	-	.782
Chaetodon spp.	-	.548	-	-	-	-	.092
Chromis enchrysurus	-	-	-	-	-	-	9.017
Pomacentrus partitus	-	.342	-	-	-	-	.184
Chromis/Pomacentrus spp.	-	-	12.128	-	-	-	.230
Chromis spp.	358.618	100.838	7.660	5.707	-	.160	.184
Pomacentrus spp.	374.211	89.748	37.662	25.683	3.271	.481	-
Bodianus pulchellus	-	.137	-	-	3.271	-	.644
Bodianus rufus	-	.137	.319	-	2.181	-	.184
Clepticus parrai	-	6.846	1.596	-	-	-	-
Thalassoma bifasciatum	-	.137	.319	-	-	-	.092
Family Labridae	-	-	-	-	-	-	-
Scarus vetula	10.395	.479	.638	-	-	-	.046
Sparisoma viride	-	.274	-	-	-	-	.782
Scarus/Sparisoma spp.	5.197	.548	-	-	-	.160	.046
Sphyraena barracuda	5.197	.548	1.277	-	-	-	-
Acanthurus spp.	-	.137	-	-	-	-	.322
Family Balistidae	-	-	-	-	-	.160	-
Aluterus scriptus	-	-	-	-	-	-	-
Balistes capriscus	-	-	-	-	-	-	.046
Balistes vetula	-	-	-	-	-	.160	2.484
Canthidermis sufflamen	-	.479	-	-	-	-	.414
Melichthys niger	10.395	4.860	.638	-	-	-	-
Xanthichthys ringens	-	-	-	-	-	-	.046
Lactophrys quadricornis	-	-	-	-	-	-	.046
Family Diodontidae	-	-	-	-	-	-	.046

Appendix 6-7 (cont'd)

Cruise: 3 Station: W

Depth in Meters

Species	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89
Ginglymostoma cirratum	-	-	-	-	-	-	-	-
Isurus oxyrinchus	-	-	-	-	-	-	-	-
Dasyatis spp.	-	-	-	-	-	-	-	-
Rhinoptera bonasus	-	-	-	-	-	-	-	-
Order Clupeiformes	-	-	-	-	79.551	-	-	-
Synodus intermedius	-	-	-	-	-	-	-	.092
Holocentrus spp.	-	.325	.382	-	.398	-	-	-
Epinephelus adscensionis	-	-	-	-	-	-	-	-
Epinephelus morio	-	-	-	-	-	-	-	-
Holanthias martinicensis	-	-	-	-	1.989	1.471	38.795	47.176
Paranthias furcifer	-	-	-	.235	35.997	10.889	-	-
Serranus phoebe	-	-	-	-	-	-	.339	1.193
Serranus spp. small sea bass	-	.108	-	.235	-	-	-	-
Mycteroperca/Epinephelus spp.	-	-	-	-	-	-	-	-
Epinephelus spp.	-	-	-	-	-	-	-	-
Family Serranidae (Barred)	-	-	-	-	.597	-	-	.551
Family Serranidae (Pikea/Hemanthias)	21.722	9.218	53.688	89.283	-	58.858	210.035	7.434
Mycteroperca spp.	-	.217	-	-	.597	.441	.905	.184
Priacanthus arenatus	.161	.217	.191	-	-	.736	.792	.551
Malacanthus plumieri	.161	.108	.382	-	-	-	-	-
Caranx hippos	-	-	-	-	-	-	-	-
Caranx ruber	-	-	-	-	-	-	-	-
Seriola dumerili	-	-	-	.235	-	-	.113	.275
Seriola rivoliana	-	-	-	-	-	-	-	-
Lutjanus campechanus	-	-	-	.235	.796	-	.679	-
Lutjanus griseus	-	-	-	-	-	-	-	-
Rhomboplites aurorubens	-	.108	-	-	14.518	-	2.262	.184
Haemulon melanurum	-	-	-	-	-	-	-	-
Calamus nodosus	-	-	.191	.235	-	-	-	-
Pargrus sedecim	-	-	-	-	1.989	-	1.697	.459
Calamus spp.	-	-	-	-	-	.147	-	-
Equetus lanceolatus	-	-	-	-	-	-	.113	.184
Equetus spp.	-	-	-	-	-	-	-	-
Mulloidichthys martinicus	-	-	-	-	-	-	-	-
Kyphosus spp.	-	-	-	-	-	-	-	-
Centropyge argi	.483	.434	-	-	-	-	-	-
Chaetodon aya	-	-	-	-	-	-	.679	-
Chaetodon sedentarius	1.448	6.941	1.528	.705	2.585	.589	1.131	.826
Holacanthus tricolor	.322	-	-	-	-	-	.113	-
Pomacanthus paru	.322	.108	-	-	-	-	-	-
Prognathodes aculeatus	-	-	-	-	-	-	-	-
Holacanthus spp.	-	.108	-	-	-	-	-	-
Chaetodon spp.	-	-	-	-	-	-	-	-
Chromis enchrysurus	9.815	15.292	41.078	16.212	57.277	5.003	16.287	4.130
Pomacentrus partitus	-	-	-	-	-	-	-	-
Chromis/Pomacentrus spp.	-	.325	-	-	-	-	-	-
Chromis spp.	1.609	-	-	-	-	-	-	-
Pomacentrus spp.	1.609	-	-	-	-	-	-	-
Bodianus pulchellus	.322	-	-	.235	.597	-	.792	.092
Bodianus rufus	-	-	-	-	-	-	-	-
Clepticus parrai	-	-	-	-	-	-	-	-
Thalassoma bifasciatum	-	-	-	-	-	-	-	-
Family Labridae	-	.108	-	-	-	-	.113	-
Scarus vetula	-	-	-	-	-	-	-	-
Sparisoma viride	-	-	-	-	-	-	-	-
Scarus/Sparisoma spp.	-	-	-	-	-	-	-	-
Sphyraena barracuda	-	-	-	-	-	-	-	-
Acanthurus spp.	-	-	-	-	-	-	-	-
Family Balistidae	-	-	-	-	-	-	-	-
Aluterus scriptus	-	.217	-	-	-	-	-	-
Balistes capriscus	-	.759	-	-	-	-	-	-
Balistes vetula	.805	.217	-	.235	.199	-	-	-
Canthidermis sufflamen	-	-	.382	5.404	1.193	-	-	-
Melichthys niger	-	-	-	-	-	-	-	-
Xanthichthys ringens	-	-	-	-	-	-	-	-
Lactophrys quadricornis	-	-	-	-	-	-	-	-
Family Diodontidae	-	-	-	-	-	-	-	-

Appendix 6-7 (cont'd)

Cruise: 3 Station: W

Species	Depth in Meters							
	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129
Ginglymostoma cirratum	-	-	-	-	-	-	-	-
Isurus oxyrinchus	-	-	-	-	-	-	-	-
Dasyatis spp.	-	-	-	-	-	-	-	-
Rhinoptera bonasus	-	-	-	-	-	-	-	-
Order Clupeiformes	-	-	-	-	-	-	-	-
Synodus intermedius	.150	-	-	-	-	-	-	-
Holocentrus spp.	-	-	-	-	-	-	-	-
Epinephelus adscensionis	-	-	-	-	-	-	-	-
Epinephelus morio	-	-	-	-	-	-	-	-
Holanthias martinicensis	25.095	1.948	-	-	-	-	-	-
Paranthias furcifer	-	-	-	-	-	-	-	-
Serranus phoebe	1.052	-	-	-	-	-	-	-
Serranus spp. small sea bass	-	-	-	-	-	-	-	-
Mycteroperca/Epinephelus spp.	-	-	-	-	-	-	-	-
Epinephelus spp.	-	-	-	-	-	-	-	-
Family Serranidae (Barred)	2.404	1.391	4.751	-	-	-	-	-
Family Serranidae (Pikea/Hemanthias)	65.669	-	-	-	-	-	-	-
Mycteroperca spp.	.601	-	-	-	-	-	-	-
Priacanthus arenatus	.902	-	-	-	-	-	-	-
Malacanthus plumieri	-	-	-	-	-	-	-	-
Caranx hippos	-	-	-	-	-	-	-	-
Caranx ruber	-	-	-	-	-	-	-	-
Seriola dumerili	.150	-	-	-	-	-	-	-
Seriola rivoliana	-	-	-	-	-	-	-	-
Lutjanus campechanus	1.803	7.791	-	-	-	-	-	-
Lutjanus griseus	-	-	-	-	-	-	-	-
Rhomboplites aurorubens	-	-	-	-	-	-	-	-
Haemulon melanurum	-	-	-	-	-	-	-	-
Calamus nodosus	-	-	-	-	-	-	-	-
Pargrus sedecim	-	-	-	-	-	-	-	-
Calamus spp.	-	-	-	-	-	-	-	-
Equetus lanceolatus	.150	-	-	-	-	-	-	-
Equetus spp.	.150	-	-	-	-	-	-	-
Mulloidichthys martinicus	-	-	-	-	-	-	-	-
Kyphosus spp.	-	-	-	-	-	-	-	-
Centropyge argi	-	-	-	-	-	-	-	-
Chaetodon aya	-	-	-	-	-	-	-	-
Chaetodon sedentarius	.451	-	-	-	-	-	-	-
Holacanthus tricolor	-	-	-	-	-	-	-	-
Pomacanthus paru	-	-	-	-	-	-	-	-
Prognathodes aculeatus	-	-	-	-	-	-	-	-
Holacanthus spp.	-	-	-	-	-	-	-	-
Chaetodon spp.	-	-	-	-	-	-	-	-
Chromis enchrysurus	12.022	-	-	-	-	-	-	-
Pomacentrus partitus	-	-	-	-	-	-	-	-
Chromis/Pomacentrus spp.	-	-	-	-	-	-	-	-
Chromis spp.	-	-	-	-	-	-	-	-
Pomacentrus spp.	-	-	-	-	-	-	-	-
Bodianus pulchellus	-	-	-	-	-	-	-	-
Bodianus rufus	-	-	-	-	-	-	-	-
Clepticus parrai	-	-	-	-	-	-	-	-
Thalassoma bifasciatum	-	-	-	-	-	-	-	-
Family Labridae	-	-	-	-	-	-	-	-
Scarus vetula	-	-	-	-	-	-	-	-
Sparisoma viride	-	-	-	-	-	-	-	-
Scarus/Sparisoma spp.	-	-	-	-	-	-	-	-
Sphyraena barracuda	-	-	-	-	-	-	-	-
Acanthurus spp.	-	-	-	-	-	-	-	-
Family Balistidae	-	-	-	-	-	-	-	-
Aluterus scriptus	-	-	-	-	-	-	-	-
Balistes capriscus	-	-	-	-	-	-	-	-
Balistes vetula	-	-	-	-	-	-	-	-
Canthidermis sufflamen	-	-	-	-	-	-	-	-
Melichthys niger	-	-	-	-	-	-	-	-
Xanthichthys ringens	-	-	-	-	-	-	-	-
Lactophrys quadricornis	.150	-	-	-	-	-	-	-
Family Diodontidae	-	-	-	-	-	-	-	-

Appendix 6-7 (cont'd)

Cruise: 3 Station: E

Species	Depth in Meters						
	15-19	20-24	25-29	30-34	35-39	40-44	45-49
Dasyatis spp.	-	.168	-	-	-	-	-
Manta birostris	-	-	-	-	-	.116	-
Gymnothorax spp.	-	-	-	.132	-	-	-
Holocentrus spp.	-	-	-	-	-	-	.131
Aulostomus maculatus	-	.168	-	-	-	-	-
Dermatolepis inermis	-	-	-	-	-	.116	-
Paranthias furcifer	248.673	71.546	88.621	68.616	28.812	33.284	.131
Mycteroperca/Epinephelus spp.	.350	-	-	-	-	-	.131
Mycteroperca spp.	-	-	2.406	.264	4.474	.466	.262
Priacanthus arenatus	-	-	-	-	-	-	-
Caranx hippos	-	.168	-	-	-	-	-
Caranx lugubris	-	1.010	.096	-	-	-	-
Caranx ruber	26.581	6.734	-	-	-	-	-
Seriola dumerili	-	-	-	.132	.716	-	-
Seriola rivoliana	12.241	-	-	-	-	-	-
Lutjanus griseus	2.099	1.683	-	.529	-	-	-
Haemulon melanurum	.350	-	-	-	1.163	57.375	-
Calamus nodosus	-	-	-	.132	.358	.116	.262
Pagrus sedecim	-	-	-	-	.089	.116	-
Mulloidichthys martinicus	-	-	.192	3.966	3.132	6.750	-
Pseudupeneus maculatus	-	-	-	.264	.089	.116	.131
Family Mullidae	-	-	-	-	-	.931	-
Kyphosus spp.	104.925	11.952	1.155	.132	-	-	-
Chaetodon ocellatus	.350	-	.192	-	.089	-	-
Chaetodon sedentarius	.350	.337	.962	1.190	1.432	1.397	.655
Chaetodon striatus	-	-	-	-	.089	-	-
Holacanthus tricolor	-	.505	.096	.132	.089	-	-
Pomacanthus paru	-	-	.096	.661	.984	.233	-
Holacanthus spp.	-	.168	-	-	.179	-	.131
Chaetodon spp.	-	.337	-	.397	-	-	-
Chromis enchrysurus	-	-	-	-	.358	.815	.524
Pomacentrus partitus	.350	.168	.192	.264	-	.233	-
Chromis/Pomacentrus spp.	-	-	3.368	4.231	8.321	4.306	1.834
Chromis spp.	250.072	144.608	91.219	6.346	4.832	3.026	-
Pomacentrus spp.	182.570	139.053	97.859	11.899	10.648	3.841	1.310
Bodianus pulchellus	-	-	-	.397	.268	.349	-
Bodianus rufus	.350	-	-	.132	.089	.116	-
Clepticus parrai	30.079	16.498	11.258	10.709	5.190	.698	-
Thalassoma bifasciatum	1.049	.673	.481	-	.447	-	-
Family Labridae	-	-	-	-	-	.116	.524
Scarus taeniopterus	-	-	.192	-	-	.116	-
Scarus vetula	.350	-	-	.132	.089	-	-
Sparisoma viride	.350	-	-	.132	.447	.582	.131
Scarus/Sparisoma spp.	.350	.673	.096	.264	.716	.233	-
Sphyraena barracuda	.350	.168	-	-	-	-	-
Acanthurus coeruleus	-	-	.192	-	-	.466	-
Acanthurus spp.	.700	-	.289	.264	.626	-	-
Balistes capriscus	-	-	-	-	-	-	.131
Balistes vetula	-	.168	-	-	.358	.116	-
Cantherhines macrocerus	-	-	.289	-	-	-	-
Canthidermis sufflamen	-	1.347	-	-	-	-	.655
Melichthys niger	7.695	1.178	.385	-	-	-	-
Lactophrys triqueter	-	-	-	-	-	.233	-
Diodon holocanthus	-	-	.096	-	-	-	-

Appendix 6-7 (cont'd)

Cruise: 3 Station: E

Species	Depth in Meters 50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89
Dasyatis spp.	-	-	-	-	-	-	-	-
Manta birostris	-	-	-	-	-	-	-	-
Gymnothorax spp.	-	-	-	-	-	-	-	-
Holocentrus spp.	-	-	-	-	-	-	-	-
Aulostomus maculatus	-	-	-	-	-	-	-	-
Dermatolepis inermis	-	-	-	-	-	-	-	-
Paranthias furcifer	-	-	-	5.536	-	-	-	-
Mycteroperca/Epinephelus spp.	-	-	-	-	-	-	-	-
Mycteroperca spp.	-	-	-	.503	-	-	-	-
Priacanthus arenatus	-	-	-	.101	-	-	-	-
Caranx hippos	-	-	-	-	-	-	-	-
Caranx lugubris	-	-	-	-	-	-	-	-
Caranx ruber	-	-	-	-	-	-	-	-
Seriola dumerili	.187	.307	.365	.101	-	-	-	-
Seriola rivoliana	-	-	-	-	-	-	-	-
Lutjanus griseus	-	-	-	-	-	-	-	-
Haemulon melanurum	-	-	-	-	-	-	-	-
Calamus nodosus	-	-	-	-	-	-	-	-
Pagrus sedecim	-	-	-	-	-	-	-	-
Mulloidichthys martinicus	-	-	-	-	-	-	-	-
Pseudupeneus maculatus	-	-	-	-	-	-	-	-
Family Mullidae	-	-	-	-	-	-	-	-
Kyphosus spp.	-	-	-	-	-	-	-	-
Chaetodon ocellatus	-	-	-	-	-	-	-	-
Chaetodon sedentarius	.187	-	-	-	-	-	-	-
Chaetodon striatus	-	-	-	-	-	-	-	-
Holacanthus tricolor	-	-	-	-	-	-	-	-
Pomacanthus paru	.187	-	-	.101	-	-	-	-
Holacanthus spp.	-	-	-	-	-	-	-	-
Chaetodon spp.	-	-	-	-	-	-	-	-
Chromis enchrysurus	.187	-	-	-	-	-	-	-
Pomacentrus partitus	-	-	-	-	-	-	-	-
Chromis/Pomacentrus spp.	.093	-	-	-	-	-	-	-
Chromis spp.	-	-	-	-	-	-	-	-
Pomacentrus spp.	-	-	-	-	-	-	-	-
Bodianus pulchellus	-	-	-	.101	-	-	-	-
Bodianus rufus	-	-	-	-	-	-	-	-
Clepticus parrai	-	-	-	-	-	-	-	-
Thalassoma bifasciatum	-	-	-	-	-	-	-	-
Family Labridae	-	-	-	-	-	-	-	-
Scarus taeniopterus	-	-	-	-	-	-	-	-
Scarus vetula	-	-	-	-	-	-	-	-
Sparisoma viride	-	-	-	-	-	-	-	-
Scarus/Sparisoma spp.	-	-	-	-	-	-	-	-
Sphyraena barracuda	-	-	-	-	-	-	-	-
Acanthurus coeruleus	-	-	-	-	-	-	-	-
Acanthurus spp.	-	-	-	-	-	-	-	-
Balistes capriscus	-	-	-	-	-	-	-	-
Balistes vetula	-	-	-	-	-	-	-	-
Cantherhines macrocerus	-	-	-	-	-	-	-	-
Canthidermis sufflamen	.187	-	-	.201	-	-	-	-
Melichthys niger	-	-	-	-	-	-	-	-
Lactophrys triqueter	-	-	-	-	-	-	-	-
Diodon holocanthus	-	.154	-	-	-	-	-	-

Appendix 6-7 (cont'd)

Cruise: 3   Station: E

Species	Depth in Meters 90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129
Dasyatis spp.	-	-	-	-	-	-	-	-
Manta birostris	-	-	-	-	-	-	-	-
Gymnothorax spp.	-	-	-	-	-	-	-	-
Holocentrus spp.	-	-	-	-	-	-	-	-
Aulostomus maculatus	-	-	-	-	-	-	-	-
Dermatolepis inermis	-	-	-	-	-	-	-	-
Paranthias furcifer	-	-	-	-	-	-	-	-
Mycteroperca/Epinephelus spp.	-	-	-	-	-	-	-	-
Mycteroperca spp.	-	-	-	-	-	-	-	-
Priacanthus arenatus	-	-	-	-	-	-	-	-
Caranx hippos	-	-	-	-	-	-	-	-
Caranx lugubris	-	-	-	-	-	-	-	-
Caranx ruber	-	-	-	-	-	-	-	-
Seriola dumerili	-	-	-	-	-	-	-	-
Seriola rivoliana	-	-	-	-	-	-	-	-
Lutjanus griseus	-	-	-	-	-	-	-	-
Haemulon melanurum	-	-	-	-	-	-	-	-
Calamus nodosus	-	-	-	-	-	-	-	-
Pagrus sedecim	-	-	-	-	-	-	-	-
Mulloidichthys martinicus	-	-	-	-	-	-	-	-
Pseudupeneus maculatus	-	-	-	-	-	-	-	-
Family Mullidae	-	-	-	-	-	-	-	-
Kyphosus spp.	-	-	-	-	-	-	-	-
Chaetodon ocellatus	-	-	-	-	-	-	-	-
Chaetodon sedentarius	-	-	-	-	-	-	-	-
Chaetodon striatus	-	-	-	-	-	-	-	-
Holacanthus tricolor	-	-	-	-	-	-	-	-
Pomacanthus paru	-	-	-	-	-	-	-	-
Holacanthus spp.	-	-	-	-	-	-	-	-
Chaetodon spp.	-	-	-	-	-	-	-	-
Chromis enchrysurus	-	-	-	-	-	-	-	-
Pomacentrus partitus	-	-	-	-	-	-	-	-
Chromis/Pomacentrus spp.	-	-	-	-	-	-	-	-
Chromis spp.	-	-	-	-	-	-	-	-
Pomacentrus spp.	-	-	-	-	-	-	-	-
Bodianus pulchellus	-	-	-	-	-	-	-	-
Bodianus rufus	-	-	-	-	-	-	-	-
Clepticus parrai	-	-	-	-	-	-	-	-
Thalassoma bifasciatum	-	-	-	-	-	-	-	-
Family Labridae	-	-	-	-	-	-	-	-
Scarus taeniopterus	-	-	-	-	-	-	-	-
Scarus vetula	-	-	-	-	-	-	-	-
Sparisoma viride	-	-	-	-	-	-	-	-
Scarus/Sparisoma spp.	-	-	-	-	-	-	-	-
Sphyraena barracuda	-	-	-	-	-	-	-	-
Acanthurus coeruleus	-	-	-	-	-	-	-	-
Acanthurus spp.	-	-	-	-	-	-	-	-
Balistes capriscus	-	-	-	-	-	-	-	-
Balistes vetula	-	-	-	-	-	-	-	-
Cantherhines macrocerus	-	-	-	-	-	-	-	-
Canthidermis sufflamen	-	-	-	-	-	-	-	-
Melichthys niger	-	-	-	-	-	-	-	-
Lactophrys triqueter	-	-	-	-	-	-	-	-
Diodon holocanthus	-	-	-	-	-	-	-	-

Appendix 6-7 (cont'd)

Cruise: 4 Station: W	Depth in Meters						
Species	15-19	20-24	25-29	30-34	35-39	40-44	45-49
Ginglymostoma cirratum	-	.069	-	-	-	-	-
Gymnothorax spp.	-	-	.260	-	-	-	-
Order Clupeiformes	462.222	-	-	-	-	-	-
Synodus intermedius	-	-	-	-	-	-	-
Holocentrus spp.	-	-	-	-	-	.121	.881
Aulostomus maculatus	-	-	.260	-	-	-	-
Dermatolepis inermis	-	-	-	-	-	-	-
Epinephelus adscensionis	-	-	-	-	-	-	.080
Liopropama eukrines	-	-	-	-	-	-	-
Mycteroperca tigris	-	-	.520	-	.383	-	-
Holanthias martinicensis	-	-	-	-	-	-	-
Paranthias furcifer	106.667	233.498	318.991	142.098	154.553	11.377	5.048
Serranus phoebe	-	-	-	-	-	-	-
Family Serranidae (small,without bars)	-	-	-	-	-	-	-
Family Serranidae (Barred)	-	-	-	-	-	-	-
Family Serranidae (Pikea/Hemanthias)	-	-	-	-	-	-	-
Mycteroperca spp.	-	.069	.260	1.903	1.530	.726	.080
Priacanthus arenatus	-	-	-	-	-	.242	.240
Malacanthus plumieri	-	-	-	-	-	-	-
Caranx crysos	-	32.990	-	-	-	-	-
Caranx hippos	-	.347	-	-	-	.605	-
Caranx latus	-	-	-	-	.383	.242	-
Caranx lugubris	-	.208	-	-	-	-	-
Caranx ruber	1.185	.417	-	15.225	4.208	4.599	-
Seriola dumerili	-	.486	-	-	.383	1.210	.080
Seriola rivoliana	-	.069	.260	1.903	-	-	-
Caranx spp.	-	.069	3.637	-	-	4.841	-
Lutjanus campechanus	-	-	-	-	-	-	-
Lutjanus griseus	-	.278	-	1.903	-	-	-
Pristipomoides aquilonari	-	-	-	-	-	-	-
Rhomboplites aurorubens	-	-	-	-	-	-	-
Haemulon melanurum	-	-	-	-	13.389	-	.080
Calamus nodosus	-	-	.520	1.903	1.148	-	-
Equetus lanceolatus	-	-	-	-	-	-	-
Equetus umbrosus	-	-	-	-	-	-	-
Equetus spp.	-	-	-	-	-	-	-
Mulloidichthys martinicus	-	-	-	-	46.289	-	-
Pseudupeneus maculatus	-	-	-	-	-	.121	-
Kyphosus spp.	-	4.862	.260	-	4.208	-	-
Centropyge argi	-	-	-	-	-	-	.481
Chaetodon aya	-	-	-	-	-	-	-
Chaetodon ocellatus	-	-	-	-	-	-	-
Chaetodon sedentarius	-	.486	-	-	.383	.242	4.487
Holacanthus tricolor	-	.278	-	.634	-	-	.641
Pomacanthus paru	-	.069	-	1.269	-	.726	.721
Holacanthus spp.	-	-	-	-	-	.363	-
Chaetodon spp.	-	-	.260	1.269	-	.121	-
Chromis enchrysurus	100.741	-	-	-	-	8.836	40.461
Pomacentrus partitus	-	1.389	.779	.634	-	.242	.080
Chromis/Pomacentrus spp.	-	1.042	.520	21.568	.383	2.058	7.371
Chromis spp.	363.852	267.043	93.775	3.806	20.658	-	10.095
Pomacentrus spp.	190.815	130.084	80.267	3.172	.765	.121	1.282
Bodianus pulchellus	-	.139	-	1.269	-	-	1.122
Bodianus rufus	-	.347	.260	-	-	.242	-
Clepticus parrai	1.185	25.281	107.802	50.115	8.416	-	-
Halichoeres garnoti	-	.069	-	.634	-	-	-
Thalassoma bifasciatum	-	.556	.520	1.269	-	.121	-
Family Labridae	-	.069	-	-	-	-	-
Scarus taeniopterus	-	.347	-	1.269	.765	-	-
Scarus vetula	-	.625	.779	.634	.383	-	.240
Sparisoma viride	-	.208	-	-	.383	.605	.240
Scarus/Sparisoma spp.	-	.625	-	-	.383	-	-
Sphyraena barracuda	-	.486	.779	-	-	.121	-
Acanthurus coeruleus	-	.139	-	-	-	-	-
Acanthurus spp.	-	.417	-	-	-	.484	.080
Family Scorpaenidae	-	-	-	-	-	-	-
Balistes capriscus	-	-	-	-	-	-	-
Balistes vetula	-	-	-	-	-	.726	.801
Canthirhines macrocerus	-	-	-	-	-	-	.080
Canthidermis sufflamen	2.370	.972	5.975	5.075	10.329	.605	-
Melichthys niger	4.741	6.112	2.338	-	-	-	-
Xanthichthys ringens	-	-	-	-	-	-	.320
Lactophrys quadricornis	-	-	-	-	.383	.121	-
Lactophrys triqueter	-	.208	-	-	-	-	.080
Diodon holocanthus	-	-	-	-	-	-	.160

Appendix 6-7 (cont'd)

Cruise: 4 Station: W

Species	Depth in Meters 50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89
Ginglymostoma cirratum	-	-	-	-	-	-	-	-
Gymnothorax spp.	-	-	-	-	-	-	-	-
Order Clupeiformes	291.829	-	-	-	-	-	-	-
Synodus intermedius	-	-	-	-	-	-	-	.242
Holocentrus spp.	1.459	.215	-	-	-	-	-	.242
Aulostomus maculatus	-	-	-	-	-	-	-	-
Dermatolepis inermis	-	-	-	-	.297	-	-	-
Epinephelus adscensionis	.365	-	-	-	-	-	-	-
Liopropama eukrines	-	-	-	-	-	-	-	-
Mycteroperca tigris	-	-	-	-	-	-	-	-
Holanthias martinicensis	-	-	-	-	35.734	58.279	67.745	189.879
Paranthias furcifer	-	6.032	-	-	148.570	-	-	-
Serranus phoebe	-	-	-	-	-	-	-	2.416
Family Serranidae (small,without bars)	20.063	-	-	-	-	-	-	-
Family Serranidae (Barred)	-	-	-	-	-	-	-	1.933
Family Serranidae (Pikea/Hemanthias)	7.843	8.617	2.242	-	116.246	9.438	21.377	96.872
Mycteroperca spp.	.730	-	-	1.399	1.334	1.416	.314	.966
Priacanthus arenatus	-	-	-	-	-	-	1.886	10.146
Malacanthus plumieri	.547	-	-	-	-	-	-	-
Caranx crysos	10.214	-	-	-	-	-	-	-
Caranx hippos	-	-	-	-	-	-	-	-
Caranx latus	-	-	-	-	-	-	-	-
Caranx lugubris	-	-	-	-	-	-	-	-
Caranx ruber	-	-	-	-	-	-	-	-
Seriola dumerili	1.277	-	-	1.998	.297	-	.314	.483
Seriola rivoliana	.730	-	-	-	-	-	-	-
Caranx spp.	-	-	-	-	-	-	-	-
Lutjanus campechanus	-	-	-	-	1.779	1.416	.157	1.208
Lutjanus griseus	-	-	-	-	-	-	-	-
Pristipomoides aquilonari	-	-	-	-	-	-	-	-
Rhomboplites aurorubens	-	-	-	-	13.641	.236	-	3.865
Haemulon melanurum	-	-	-	-	-	-	.472	-
Calamus nodosus	-	-	-	-	-	-	-	-
Equetus lanceolatus	-	-	-	-	.148	-	.157	-
Equetus umbrosus	-	-	-	-	-	.236	-	-
Equetus spp.	-	-	-	-	-	.236	-	-
Mulloidichthys martinicus	-	-	-	-	-	-	-	-
Pseudupeneus maculatus	-	-	-	-	-	-	-	-
Kyphosus spp.	-	-	-	-	-	-	-	-
Centropyge argi	1.094	1.293	-	-	.148	.236	-	.242
Chaetodon aya	-	-	-	-	.445	.236	.157	.725
Chaetodon ocellatus	.365	-	-	-	-	-	-	-
Chaetodon sedentarius	22.434	.215	-	.400	1.186	1.416	1.415	2.657
Holacanthus tricolor	.547	-	-	-	-	-	-	-
Pomacanthus paru	.730	.862	-	-	-	-	-	-
Holacanthus spp.	1.094	-	-	-	.148	-	-	-
Chaetodon spp.	.182	1.077	-	-	-	.472	-	-
Chromis enchrysurus	113.631	7.971	6.353	3.797	11.862	7.314	10.688	10.629
Pomacentrus partitus	.182	.215	-	-	-	-	-	-
Chromis/Pomacentrus spp.	.547	-	-	-	-	-	-	-
Chromis spp.	-	6.247	-	-	-	-	-	.483
Pomacentrus spp.	-	1.723	-	.200	-	-	-	-
Bodianus pulchellus	.547	-	-	-	.445	.236	1.415	1.933
Bodianus rufus	.182	-	-	-	-	-	-	-
Clepticus parrai	-	-	-	-	-	-	-	-
Halichoeres garnoti	-	-	-	-	-	-	-	-
Thalassoma bifasciatum	-	.215	-	-	-	-	-	-
Family Labridae	-	-	-	-	-	-	.157	-
Scarus taeniopterus	-	-	-	-	-	-	-	-
Scarus vetula	-	-	-	-	-	-	-	-
Sparisoma viride	.547	-	-	-	-	-	-	-
Scarus/Sparisoma spp.	-	-	-	-	-	-	-	-
Sphyraena barracuda	-	-	-	-	-	-	-	-
Acanthurus coeruleus	-	-	-	-	-	-	-	-
Acanthurus spp.	.365	-	-	-	-	-	-	-
Family Scorpaenidae	-	-	-	-	-	-	-	-
Balistes capriscus	-	.646	-	-	-	.236	-	-
Balistes vetula	2.006	-	-	-	-	-	-	-
Canthirhines macrocerus	-	-	-	-	-	-	-	-
Canthidermis sufflamen	-	.215	-	-	.148	-	-	-
Melichthys niger	-	-	-	-	-	-	-	-
Xanthichthys ringens	.912	-	-	-	-	-	-	-
Lactophrys quadricornis	.365	-	-	-	-	-	-	-
Lactophrys triqueter	-	-	-	-	-	-	-	-
Diodon holocanthus	-	-	-	-	-	-	-	-

Appendix 6-7 (cont'd)

Cruise: 4 Station: W

Species	Depth in Meters							
	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129
Ginglymostoma cirratum	-	-	-	-	-	-	-	-
Gymnothorax spp.	-	-	-	-	-	-	-	-
Order Clupeiformes	-	-	-	-	-	-	-	-
Synodus intermedius	-	-	-	-	-	-	-	-
Holocentrus spp.	-	-	-	-	-	-	-	-
Aulostomus maculatus	-	-	-	-	-	-	-	-
Dermatolepis inermis	-	-	-	-	-	-	-	-
Epinephelus adscensionis	-	-	-	-	-	-	-	-
Liopropama eukrines	.479	-	.936	-	-	-	-	-
Mycteroperca tigris	-	-	-	-	-	-	-	-
Holanthias martinicensis	53.415	-	5.613	-	-	-	-	-
Paranthias furcifer	-	-	-	-	-	-	-	-
Serranus phoebe	.479	-	-	-	-	-	-	-
Family Serranidae (small,without bars)	-	3.516	-	-	-	-	-	-
Family Serranidae (Barred)	-	1.172	-	3.582	-	-	-	-
Family Serranidae (Pikea/Hemanthias)	3.114	-	-	-	-	-	-	-
Mycteroperca spp.	.958	-	1.871	-	-	-	-	-
Priacanthus arenatus	.958	-	-	-	-	-	-	-
Malacanthus plumieri	-	-	-	-	-	-	-	-
Caranx crysos	-	-	-	-	-	-	-	-
Caranx hippos	-	-	-	-	-	-	-	-
Caranx latus	-	-	-	-	-	-	-	-
Caranx lugubris	-	-	-	-	-	-	-	-
Caranx ruber	-	-	-	-	-	-	-	-
Seriola dumerili	.240	-	-	-	-	-	-	-
Seriola rivoliana	-	-	-	-	-	-	-	-
Caranx spp.	-	-	-	-	-	-	-	-
Lutjanus campechanus	7.665	1.172	-	-	-	-	-	-
Lutjanus griseus	-	-	-	-	-	-	-	-
Pristipomoides aquilonari	-	-	-	1.791	-	-	-	-
Rhomboplites aurorubens	6.467	-	-	-	-	-	-	-
Haemulon melanurum	-	-	-	-	-	-	-	-
Calamus nodosus	-	-	-	-	-	-	-	-
Equetus lanceolatus	-	-	-	-	-	-	-	-
Equetus umbrosus	.958	-	-	-	-	-	-	-
Equetus spp.	-	-	-	-	-	-	-	-
Mulloidichthys martinicus	-	-	-	-	-	-	-	-
Pseudupeneus maculatus	-	-	-	-	-	-	-	-
Kyphosus spp.	-	-	-	-	-	-	-	-
Centropyge argi	-	-	-	-	-	-	-	-
Chaetodon aya	.240	-	-	-	-	-	-	-
Chaetodon ocellatus	-	-	-	-	-	-	-	-
Chaetodon sedentarius	.719	-	-	-	-	-	-	-
Holacanthus tricolor	-	-	-	-	-	-	-	-
Pomacanthus paru	-	-	-	-	-	-	-	-
Holacanthus spp.	-	-	-	-	-	-	-	-
Chaetodon spp.	-	-	-	-	-	-	-	-
Chromis enchrysurus	2.156	-	-	-	-	-	-	-
Pomacentrus partitus	-	-	-	-	-	-	-	-
Chromis/Pomacentrus spp.	-	-	-	-	-	-	-	-
Chromis spp.	-	-	-	-	-	-	-	-
Pomacentrus spp.	-	-	-	-	-	-	-	-
Bodianus pulchellus	-	-	-	-	-	-	-	-
Bodianus rufus	-	-	-	-	-	-	-	-
Clepticus parrai	-	-	-	-	-	-	-	-
Halichoeres garnoti	-	-	-	-	-	-	-	-
Thalassoma bifasciatum	-	-	-	-	-	-	-	-
Family Labridae	.479	-	-	-	-	-	-	-
Scarus taeniopterus	-	-	-	-	-	-	-	-
Scarus vetula	-	-	-	-	-	-	-	-
Sparisoma viride	-	-	-	-	-	-	-	-
Scarus/Sparisoma spp.	-	-	-	-	-	-	-	-
Sphyraena barracuda	-	-	-	-	-	-	-	-
Acanthurus coeruleus	-	-	-	-	-	-	-	-
Acanthurus spp.	-	-	-	-	-	-	-	-
Family Scorpaenidae	-	-	-	1.791	-	-	-	-
Balistes capriscus	-	-	-	-	-	-	-	-
Balistes vetula	-	-	-	-	-	-	-	-
Canthirhines macrocerus	-	-	-	-	-	-	-	-
Canthidermis sufflamen	-	-	-	-	-	-	-	-
Melichthys niger	-	-	-	-	-	-	-	-
Xanthichthys ringens	-	-	-	-	-	-	-	-
Lactophrys quadricornis	-	-	-	-	-	-	-	-
Lactophrys triqueter	-	-	-	-	-	-	-	-
Diodon holocanthus	-	-	-	-	-	-	-	-

Appendix 6-7 (cont'd)

Cruise: 4 Station: E

Species	Depth in Meters 15-19	20-24	25-29	30-34	35-39	40-44	45-49
Gymnothorax spp.	-	-	-	-	-	-	.071
Ophichthus spp.	-	-	-	-	-	-	-
Holocentrus spp.	-	-	-	-	-	-	.565
Dermatolepis inermis	-	.106	.133	-	-	.053	-
Epinephelus adscensionis	-	-	-	-	-	-	.212
Mycteroperca tigris	-	-	.133	-	-	-	-
Holanthias martinicensis	-	-	-	-	-	-	-
Paranthias furcifer	419.273	196.887	263.262	133.633	59.446	73.111	-
Serranus phoebe	-	-	-	-	-	-	-
Serranus spp. small sea bass	-	-	-	-	-	.053	-
Mycteroperca/Epinephelus spp.	-	-	-	-	-	.053	-
Family Serranidae (Barred)	-	-	-	-	-	-	-
Mycteroperca spp.	1.247	.425	.133	.462	-	.105	.706
Priacanthus arenatus	-	-	-	-	.172	-	.212
Malacanthus plumieri	-	-	-	-	-	.158	.071
Caranx crysos	-	-	-	-	-	-	2.117
Caranx hippos	-	-	4.244	-	-	-	-
Caranx lugubris	-	.213	.133	-	-	-	-
Caranx ruber	-	-	.133	4.393	1.718	2.948	-
Seriola dumerili	-	-	-	-	-	.105	.141
Seriola rivoliana	-	-	.133	.231	-	.105	-
Lutjanus campechanus	-	-	-	-	-	-	.071
Lutjanus griseus	.416	.319	-	-	-	-	-
Haemulon melanurum	-	-	.265	1.387	.172	-	-
Calamus nodosus	-	.106	-	.231	.859	.211	.282
Equetus spp.	-	-	-	-	-	.053	-
Mulloidichthys martinicus	.416	.957	-	.231	2.749	.211	-
Pseudupeneus maculatus	-	-	-	-	1.374	.053	-
Kyphosus spp.	16.206	.106	.398	.231	-	-	-
Chaetodon ocellatus	-	.213	.531	-	.172	-	-
Chaetodon sedentarius	2.909	.638	.928	1.156	.515	1.000	.353
Holacanthus tricolor	.831	.319	.133	-	-	-	-
Pomacanthus paru	-	.213	.398	-	.172	.684	.353
Holacanthus spp.	-	.106	.265	-	-	.211	.282
Chaetodon spp.	-	.319	-	.925	.172	.105	.071
Chromis enchrysurus	-	-	1.194	-	.687	.105	9.597
Pomacentrus partitus	2.909	.745	2.122	2.312	.172	.211	-
Chromis/Pomacentrus spp.	-	-	3.846	13.178	4.982	1.684	.212
Chromis spp.	619.560	384.308	129.973	39.997	15.635	1.474	.071
Pomacentrus spp.	278.407	251.241	84.615	46.702	11.855	1.211	.141
Bodianus pulchellus	.416	.213	-	.231	.344	.737	.635
Bodianus rufus	-	.319	.133	.231	-	-	-
Clepticus parrai	36.982	23.401	100.530	154.904	19.758	.842	-
Halichoeres garnoti	-	.106	-	-	-	-	-
Thalassoma bifasciatum	1.662	2.766	.265	.694	-	.263	-
Scarus taeniopterus	.416	.106	.133	-	-	-	-
Scarus vetula	.416	.425	.133	-	-	-	-
Sparisoma viride	.831	.425	-	.231	.859	.632	-
Scarus/Sparisoma spp.	.416	.532	.133	.231	-	.053	-
Sphyraena barracuda	3.324	.638	.398	.462	.172	.158	-
Ophioblennius atlanticus	-	.106	-	-	-	-	-
Family Blenniidae	-	.106	-	-	-	-	-
Ioglossus spp.	-	-	-	-	-	-	-
Acanthurus coeruleus	-	-	-	.231	.515	-	-
Acanthurus spp.	.831	.106	.133	.462	.687	.316	.071
Family Bothidae	-	-	-	-	-	-	-
Aluterus monoceros	-	-	-	-	-	.316	-
Balistes capriscus	-	-	-	-	-	.263	.494
Balistes vetula	-	-	-	.231	-	.263	.282
Canthirhines macrocerus	-	-	-	-	-	-	.071
Canthidermis sufflamen	2.078	.745	.531	-	-	.053	.141
Melichthys niger	4.155	1.808	1.459	-	-	-	-
Lactophrys triqueter	-	-	-	-	-	.105	.071
Family Ostraciidae	-	.106	-	-	-	-	-
Canthigaster rostrata	.416	.106	.133	-	-	-	.071
Diodon holocanthus	-	-	-	-	-	.053	-

Appendix 6-7 (cont'd)

Cruise: 4 Station: E

Species	Depth in Meters 50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89
Gymnothorax spp.	-	-	-	-	-	-	-	-
Ophichthus spp.	-	-	-	-	-	2.424	-	-
Holocentrus spp.	-	-	-	-	-	-	-	-
Dermatolepis inermis	-	-	-	-	-	-	-	-
Epinephelus adscensionis	-	-	-	-	-	-	-	-
Mycteroperca tigris	-	-	-	-	-	-	-	-
Holanthias martinicensis	-	-	-	9.804	-	4.848	-	-
Paranthias furcifer	-	.650	-	53.922	-	-	-	-
Serranus phoebe	-	-	-	-	-	-	.714	-
Serranus spp. small sea bass	-	-	-	-	-	-	-	-
Mycteroperca/Epinephelus spp.	-	-	-	-	-	-	-	-
Family Serranidae (Barred)	-	-	-	-	-	-	-	.305
Mycteroperca spp.	-	-	-	7.353	-	-	-	-
Priacanthus arenatus	-	-	-	-	-	-	-	-
Malacanthus plumieri	-	-	-	-	-	-	-	-
Caranx crysos	-	-	-	-	-	-	-	-
Caranx hippos	-	-	-	-	-	-	-	-
Caranx lugubris	-	-	-	-	-	-	-	-
Caranx ruber	-	-	-	-	-	-	-	-
Seriola dumerili	-	-	4.614	-	-	-	-	-
Seriola rivoliana	-	-	-	-	-	-	-	-
Lutjanus campechanus	-	-	-	-	-	-	-	-
Lutjanus griseus	-	-	-	-	-	-	-	-
Haemulon melanurum	-	-	-	-	-	-	-	-
Calamus nodosus	-	-	-	-	-	-	-	-
Equetus spp.	-	-	-	-	-	-	-	-
Mulloidichthys martinicus	-	-	-	-	-	-	-	-
Pseudupeneus maculatus	-	-	-	-	-	-	-	-
Kyphosus spp.	-	-	-	-	-	-	-	-
Chaetodon ocellatus	-	-	-	-	-	-	-	-
Chaetodon sedentarius	3.686	.650	1.153	4.902	-	7.271	-	-
Holacanthus tricolor	-	-	-	-	-	-	-	-
Pomacanthus paru	-	-	-	-	-	-	-	-
Holacanthus spp.	-	-	-	-	-	-	-	-
Chaetodon spp.	-	-	-	-	-	-	-	-
Chromis enchrysurus	39.725	40.946	2.307	24.510	-	14.543	-	-
Pomacentrus partitus	-	-	-	-	-	-	-	-
Chromis/Pomacentrus spp.	-	-	-	-	-	-	-	-
Chromis spp.	-	-	-	-	-	-	-	-
Pomacentrus spp.	-	-	-	-	-	-	-	-
Bodianus pulchellus	1.229	1.300	-	9.804	-	-	-	-
Bodianus rufus	-	-	-	-	-	-	-	-
Clepticus parrai	-	-	-	-	-	-	-	-
Halichoeres garnoti	-	-	-	-	-	-	-	-
Thalassoma bifasciatum	-	-	-	-	-	-	-	-
Scarus taeniopterus	-	-	-	-	-	-	-	-
Scarus vetula	-	-	-	-	-	-	-	-
Sparisoma viride	-	-	-	-	-	-	-	-
Scarus/Sparisoma spp.	-	-	-	-	-	-	-	-
Sphyraena barracuda	-	-	-	-	-	-	-	-
Ophioblennius atlanticus	-	-	-	-	-	-	-	-
Family Blenniidae	-	-	-	-	-	-	-	-
Ioglossus spp.	-	-	-	-	-	-	-	-
Acanthurus coeruleus	-	-	-	-	-	-	-	-
Acanthurus spp.	-	-	-	-	-	-	-	-
Family Bothidae	-	-	-	-	-	-	-	.305
Aluterus monoceros	-	-	-	-	-	-	-	-
Balistes capriscus	-	-	-	-	-	-	-	-
Balistes vetula	-	-	-	-	-	-	-	-
Canthirhines macrocerus	-	-	-	-	-	-	-	-
Canthidermis sufflamen	-	-	-	-	-	-	-	-
Melichthys niger	-	-	-	-	-	-	-	-
Lactophrys triqueter	-	-	-	-	-	-	-	-
Family Ostraciidae	-	-	-	-	-	-	-	-
Canthigaster rostrata	-	-	-	-	-	-	-	-
Diodon holocanthus	.410	-	-	-	-	-	-	-

Appendix 6-7 (cont'd)

Cruise: 4 Station: E

Species	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129
Gymnothorax spp.	-	-	-	-	-	-	-	-
Ophichthus spp.	-	-	-	-	-	-	-	-
Holocentrus spp.	-	-	-	-	-	-	-	-
Dermatolepis inermis	-	-	-	-	-	-	-	-
Epinephelus adscensionis	-	-	-	-	-	-	-	-
Mycteroperca tigris	-	-	-	-	-	-	-	-
Holanthias martinicensis	-	-	-	-	-	-	-	-
Paranthias furcifer	-	-	-	-	-	-	-	-
Serranus phoebe	-	-	-	-	-	-	-	-
Serranus spp. small sea bass	-	-	-	-	-	-	-	-
Mycteroperca/Epinephelus spp.	-	-	-	-	-	-	-	-
Family Serranidae (Barred)	-	-	2.657	-	-	-	-	-
Mycteroperca spp.	-	-	-	-	-	-	-	-
Priacanthus arenatus	-	-	-	-	-	-	-	-
Malacanthus plumieri	-	-	-	-	-	-	-	-
Caranx crysos	-	-	-	-	-	-	-	-
Caranx hippos	-	-	-	-	-	-	-	-
Caranx lugubris	-	-	-	-	-	-	-	-
Caranx ruber	-	-	-	-	-	-	-	-
Seriola dumerili	-	-	-	-	-	-	-	-
Seriola rivoliana	-	-	-	-	-	-	-	-
Lutjanus campechanus	-	-	-	-	-	-	-	-
Lutjanus griseus	-	-	-	-	-	-	-	-
Haemulon melanurum	-	-	-	-	-	-	-	-
Calamus nodosus	-	-	-	-	-	-	-	-
Equetus spp.	-	-	-	-	-	-	-	-
Mulloidichthys martinicus	-	-	-	-	-	-	-	-
Pseudupeneus maculatus	-	-	-	-	-	-	-	-
Kyphosus spp.	-	-	-	-	-	-	-	-
Chaetodon ocellatus	-	-	-	-	-	-	-	-
Chaetodon sedentarius	-	-	-	-	-	-	-	-
Holacanthus tricolor	-	-	-	-	-	-	-	-
Pomacanthus paru	-	-	-	-	-	-	-	-
Holacanthus spp.	-	-	-	-	-	-	-	-
Chaetodon spp.	-	-	-	-	-	-	-	-
Chromis enchrysurus	-	-	-	-	-	-	-	-
Pomacentrus partitus	-	-	-	-	-	-	-	-
Chromis/Pomacentrus spp.	-	-	-	-	-	-	-	-
Chromis spp.	-	-	-	-	-	-	-	-
Pomacentrus spp.	-	-	-	-	-	-	-	-
Bodianus pulchellus	-	-	-	-	-	-	-	-
Bodianus rufus	-	-	-	-	-	-	-	-
Clepticus parrai	-	-	-	-	-	-	-	-
Halichoeres garnoti	-	-	-	-	-	-	-	-
Thalassoma bifasciatum	-	-	-	-	-	-	-	-
Scarus taeniopterus	-	-	-	-	-	-	-	-
Scarus vetula	-	-	-	-	-	-	-	-
Sparisoma viride	-	-	-	-	-	-	-	-
Scarus/Sparisoma spp.	-	-	-	-	-	-	-	-
Sphyraena barracuda	-	-	-	-	-	-	-	-
Ophioblennius atlanticus	-	-	-	-	-	-	-	-
Family Blenniidae	-	-	-	-	-	-	-	-
Ioglossus spp.	-	-	.886	-	-	-	-	-
Acanthurus coeruleus	-	-	-	-	-	-	-	-
Acanthurus spp.	-	-	-	-	-	-	-	-
Family Bothidae	-	-	-	-	-	-	-	-
Aluterus monoceros	-	-	-	-	-	-	-	-
Balistes capriscus	-	-	-	-	-	-	-	-
Balistes vetula	-	-	-	-	-	-	-	-
Canthirhines macrocerus	-	-	-	-	-	-	-	-
Canthidermis sufflamen	-	-	-	-	-	-	-	-
Melichthys niger	-	-	-	-	-	-	-	-
Lactophrys triqueter	-	-	-	-	-	-	-	-
Family Ostraciidae	-	-	-	-	-	-	-	-
Canthigaster rostrata	-	-	-	-	-	-	-	-
Diodon holocanthus	-	-	-	-	-	-	-	-

Cruise: 5 Station: E	Depth in Meters						
Species	15-19	20-24	25-29	30-34	35-39	40-44	45-49
Manta birostris	-	-	-	.081	-	-	-
Gymnothorax spp.	-	-	-	-	-	.028	.023
Ophichthus rex	-	-	-	-	-	-	-
Order Clupeiformes	-	7.950	-	-	-	-	-
Family Synodontidae	-	-	-	-	-	-	.023
Halieutichthys aculeatus	-	-	-	-	-	-	-
Family Ogcocephalidae	-	-	-	-	-	-	-
Holocentrus spp.	-	-	-	.081	-	.138	.350
Aulostomus maculatus	-	-	-	-	-	.028	-
Dermatolepis inermis	-	.088	-	.081	.064	-	-
Epinephelus adscensionis	-	-	-	-	-	-	-
Epinephelus guttatus	-	-	-	-	-	-	.047
Mycteroperca bonaci	-	-	-	-	-	-	.023
Mycteroperca tigris	-	-	-	-	-	.028	-
Holanthias martinicensis	-	-	-	-	-	-	-
Paranthias furcifer	53.241	79.323	75.835	78.894	83.036	59.172	28.200
Serranus phoebe	-	-	-	-	-	-	.023
Family Serranidae (small,without bars)	-	-	-	-	-	-	-
Mycteroperca/Epinephelus spp.	-	-	.137	-	.064	.055	.023
Family Serranidae	-	-	-	-	-	-	-
Family Serranidae (Pikea/Hemanthias)	-	-	-	-	-	-	-
Mycteroperca spp.	.265	.442	.411	.242	.193	.469	1.028
Priacanthus arenatus	-	-	-	-	-	-	.047
Malacanthus plumieri	-	-	-	-	-	.055	.117
Caranx hippos	-	-	-	.081	.257	-	-
Caranx latus	-	.177	-	-	-	-	-
Caranx lugubris	-	-	-	.081	.129	-	-
Caranx ruber	-	2.473	.137	1.291	.129	2.043	.117
Elagatis bipennulata	-	-	-	-	.708	-	-
Seriola dumerili	-	-	-	-	-	.166	.023
Seriola rivoliana	-	-	-	-	.064	.055	-
Family Carangidae	-	-	-	-	-	-	-
Lutjanus campechanus	-	-	-	-	-	-	-
Lutjanus griseus	.265	-	-	-	-	-	-
Rhomboplites aurorubens	-	-	-	-	-	-	-
Haemulon melanurum	-	-	-	-	-	.083	.023
Calamus nodosus	-	-	-	.081	.451	.801	.818
Pargrus sedecim	-	-	-	-	-	-	-
Calamus spp.	-	-	-	-	-	-	.023
Equetus lanceolatus	-	-	-	-	-	-	-
Mulloidichthys martinicus	-	.530	-	-	.129	6.572	1.729
Pseudupeneus maculatus	-	-	-	.081	.129	.414	.537
Kyphosus spp.	-	2.562	-	.081	.064	2.099	.164
Centropyge argi	-	-	-	-	-	.028	.374
Chaetodon ocellatus	-	-	-	-	.193	-	.093
Chaetodon sedentarius	-	1.060	1.234	.565	1.609	1.905	1.472
Holacanthus tricolor	-	.177	.137	.081	.322	.193	.164
Pomacanthus paru	.530	-	.274	.726	.129	.166	.444
Holacanthus spp.	-	-	.137	.403	.322	.304	.374
Chaetodon spp.	.795	.088	-	.242	.386	.028	.093
Chromis enchrysurus	-	-	.137	.081	-	4.142	14.299
Pomacentrus partitus	.265	.618	.274	.323	.386	.552	.701
Chromis/Pomacentrus spp.	2.119	-	1.097	4.598	2.639	2.292	1.168
Chromis spp.	68.339	50.791	28.250	5.405	8.497	7.096	.023
Pomacentrus spp.	27.812	15.812	20.022	1.694	8.046	5.108	.911
Bodianus pulchellus	-	1.413	.137	.323	.322	.911	.748
Bodianus rufus	-	-	-	.081	-	.166	.070
Clepticus parrai	3.179	31.270	10.422	57.920	5.793	3.949	-
Thalassoma bifasciatum	-	1.148	.823	.807	.322	.497	.047
Family Labridae	-	.442	-	.323	.193	.249	.327
Scarus taeniopterus	.265	.618	.823	.323	.322	.138	.023
Scarus vetula	-	.353	.274	-	.064	.083	-
Sparisoma aurofrenatum	-	-	-	.161	-	-	-
Sparisoma viride	-	-	.411	.403	.322	.249	.631
Scarus/Sparisoma spp.	.795	.530	.137	-	.322	.331	.070
Sphyraena barracuda	1.060	.442	.137	.323	-	.331	.047
Family Gobiidae	-	-	-	-	-	-	.047
Ioglossus spp.	-	-	-	-	-	-	.023
Acanthurus coeruleus	-	.177	.274	.403	.129	.055	-
Acanthurus spp.	.265	.177	.274	.161	-	.276	.117
Prionotus spp.	-	-	-	-	-	-	-
Family Bothidae	-	-	-	-	-	-	-
Aluterus scriptus	-	.088	.137	-	-	.028	.047
Balistes capriscus	-	.088	-	-	-	.028	.164
Balistes vetula	-	-	.411	.161	.257	.138	.374
Canthirhines macrocerus	-	-	-	-	.064	.028	.023
Canthirdermis sufflamen	.795	.088	.549	-	.193	.663	2.243
Melichthys niger	2.384	1.060	.274	1.129	-	-	-
Xanthichthys ringens	-	-	-	-	-	-	.023
Family Balistidae	-	-	.137	-	-	-	-
Lactophrys quadricornis	-	-	-	-	-	-	-
Lactophrys triqueter	.265	.088	-	-	.064	.055	.023
Diodon holocanthus	-	-	-	-	-	-	.023
Family Diodontidae	-	-	-	-	-	-	.023

Appendix 6-7 (cont'd)

Cruise: 5 Station: E Species	Depth in Meters 50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89
Manta birostris	-	-	-	-	-	-	-	.101
Gymnothorax spp.	.036	.086	-	-	-	-	-	-
Ophichthus rex	-	-	-	-	-	-	-	-
Order Clupeiformes	-	-	-	-	-	-	-	-
Family Synodontidae	-	.043	-	-	-	-	-	-
Halieutichthys aculeatus	-	-	-	-	-	-	-	-
Family Ogcocephalidae	-	-	-	-	-	-	-	-
Holocentrus spp.	.287	.043	-	-	.159	-	.128	.101
Aulostomus maculatus	-	-	-	-	-	-	-	-
Dermatolepis inermis	-	-	-	-	-	-	-	-
Epinephelus adscensionis	-	.043	-	-	-	-	-	-
Epinephelus guttatus	-	-	-	-	-	-	-	-
Mycteroperca bonaci	-	-	-	-	-	-	-	-
Mycteroperca tigris	-	-	-	-	-	-	-	-
Holanthias martinicensis	-	-	2.373	.163	6.027	12.595	26.327	12.717
Paranthias furcifer	5.210	.300	2.373	5.056	8.723	-	.383	-
Serranus phoebe	-	-	-	-	-	.957	1.278	.505
Family Serranidae (small,without bars)	-	.043	-	-	-	-	.256	-
Mycteroperca/Epinephelus spp.	-	.043	.297	-	-	-	-	-
Family Serranidae	-	.129	-	-	-	-	-	1.514
Family Serranidae (Pikea/Hemanthias)	-	.386	8.159	-	4.123	-	.128	.101
Mycteroperca spp.	.575	.943	1.335	.979	.952	.478	1.278	1.009
Priacanthus arenatus	-	.086	.148	.326	.159	.478	2.556	1.009
Malacanthus plumieri	.072	.129	-	-	-	-	-	-
Caranx hippos	.108	-	-	-	-	-	-	-
Caranx latus	-	-	-	-	-	-	-	-
Caranx lugubris	-	-	-	-	-	-	-	-
Caranx ruber	-	-	-	-	-	-	-	-
Elagatis bipennulata	-	-	-	-	-	-	-	-
Seriola dumerili	-	.257	1.335	-	.159	.478	.256	.303
Seriola rivoliana	.108	-	-	-	-	-	-	.101
Family Carangidae	.683	-	-	-	-	-	-	-
Lutjanus campechanus	.108	-	-	-	.159	-	1.278	.706
Lutjanus griseus	-	-	-	-	-	-	-	-
Rhomboplites aurorubens	-	-	2.670	-	.317	-	-	3.734
Haemulon melanurum	.108	-	-	-	-	-	-	-
Calamus nodosus	.287	.086	.297	.489	.159	.159	.256	-
Pargrus sedecim	-	-	-	-	-	-	1.789	.505
Calamus spp.	-	-	-	-	-	-	-	-
Equetus lanceolatus	-	-	-	-	-	-	-	.101
Mulloidichthys martinicus	-	-	-	-	-	-	-	-
Pseudupeneus maculatus	-	-	.148	-	-	-	-	-
Kyphosus spp.	.467	-	-	-	-	-	-	-
Centropyge argi	.108	.472	.593	-	-	-	-	-
Chaetodon ocellatus	-	-	-	-	-	-	-	-
Chaetodon sedentarius	.934	.814	.742	.326	2.220	1.275	1.278	1.009
Holacanthus tricolor	.144	-	.297	-	-	-	-	-
Pomacanthus paru	.144	.086	-	-	-	-	-	-
Holacanthus spp.	.287	.214	.148	-	-	-	.128	-
Chaetodon spp.	-	-	-	-	-	-	-	-
Chromis enchrysurus	12.683	12.217	22.696	2.610	4.282	5.421	1.278	.505
Pomacentrus partitus	.144	-	-	-	-	-	-	-
Chromis/Pomacentrus spp.	-	.214	-	-	-	-	-	-
Chromis spp.	-	-	-	-	-	-	-	-
Pomacentrus spp.	-	-	-	-	-	-	-	-
Bodianus pulchellus	.539	.343	.593	.163	.476	.638	.256	.101
Bodianus rufus	-	-	-	-	-	-	-	-
Clepticus parrai	.216	-	-	.326	-	-	-	-
Thalassoma bifasciatum	-	-	-	-	-	-	-	-
Family Labridae	.036	-	-	-	-	-	-	-
Scarus taeniopterus	-	-	-	-	-	-	-	-
Scarus vetula	-	-	-	-	-	-	-	-
Sparisoma aurofrenatum	-	-	-	-	-	-	-	-
Sparisoma viride	.180	-	-	-	-	-	-	-
Scarus/Sparisoma spp.	-	-	-	-	-	-	-	-
Sphyraena barracuda	-	.043	-	-	-	-	-	-
Family Gobiidae	-	-	-	-	-	-	-	-
Ioglossus spp.	-	-	-	-	-	-	-	-
Acanthurus coeruleus	-	-	-	-	-	-	-	-
Acanthurus spp.	-	-	-	-	-	-	-	-
Prionotus spp.	-	-	-	-	-	-	-	-
Family Bothidae	-	-	-	-	-	-	-	-
Aluterus scriptus	-	-	-	.163	-	-	-	-
Balistes capriscus	.287	.429	.148	-	.159	-	-	-
Balistes vetula	.467	.043	.148	-	-	-	-	-
Canthirhines macrocerus	-	-	-	-	-	-	-	-
Canthirdermis sufflamen	.575	-	-	-	-	-	-	-
Melichthys niger	-	-	-	-	-	-	-	-
Xanthichthys ringens	-	.086	-	-	-	-	-	-
Family Balistidae	.072	-	-	-	-	-	-	-
Lactophrys quadricornis	.036	-	-	-	-	-	.128	-
Lactophrys triqueter	-	-	-	-	-	-	-	-
Diodon holocanthus	-	-	-	.163	.159	-	-	-
Family Diodontidae	.036	-	-	-	-	-	-	-

Appendix 6-7 (cont'd)

Cruise: 5   Station: E

Species	Depth in Meters 90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129
Manta birostris	-	-	-	-	-	-	-	-
Gymnothorax spp.	-	-	-	-	-	-	-	-
Ophichthus rex	-	-	-	-	-	-	-	.399
Order Clupeiformes	-	-	-	-	-	-	-	-
Family Synodontidae	1.062	-	-	-	-	-	-	.399
Halieutichthys aculeatus	-	.329	-	-	-	-	-	.399
Family Ogcocephalidae	.177	-	-	2.001	-	-	.681	-
Holocentrus spp.	-	-	-	-	-	-	-	-
Aulostomus maculatus	-	-	-	-	-	-	-	-
Dermatolepis inermis	-	-	-	-	-	-	-	-
Epinephelus adscensionis	-	-	-	-	-	-	-	-
Epinephelus guttatus	-	-	-	-	-	-	-	-
Mycteroperca bonaci	-	-	-	-	-	-	-	-
Mycteroperca tigris	-	-	-	-	-	-	-	-
Holanthias martinicensis	5.840	9.859	26.765	-	-	-	-	-
Paranthias furcifer	-	-	-	-	-	-	-	-
Serranus phoebe	.708	.657	-	-	-	-	.681	.399
Family Serranidae (small,without bars)	.177	.329	-	2.001	2.310	-	1.362	1.595
Mycteroperca/Epinephelus spp.	-	-	-	-	-	-	-	-
Family Serranidae	3.717	.986	3.346	-	2.310	.895	6.810	5.581
Family Serranidae (Pikea/Hemanthias)	.885	-	2.230	-	-	-	-	-
Mycteroperca spp.	1.239	1.315	-	-	-	-	-	-
Priacanthus arenatus	2.301	.329	-	-	-	-	-	-
Malacanthus plumieri	-	-	-	-	-	-	-	-
Caranx hippos	-	-	-	-	-	-	-	-
Caranx latus	-	-	-	-	-	-	-	-
Caranx lugubris	-	-	-	-	-	-	-	-
Caranx ruber	-	-	-	-	-	-	-	-
Elagatis bipennulata	-	-	-	-	-	-	-	-
Seriola dumerili	-	-	-	-	-	-	-	-
Seriola rivoliana	-	-	-	-	-	-	-	-
Family Carangidae	-	-	-	-	-	-	-	-
Lutjanus campechanus	.531	-	-	-	-	-	-	-
Lutjanus griseus	-	-	-	-	-	-	-	-
Rhomboplites aurorubens	1.416	-	-	-	-	-	-	-
Haemulon melanurum	-	-	-	-	-	-	-	-
Calamus nodosus	-	-	-	-	-	-	-	-
Pargrus sedecim	-	-	-	-	-	-	-	-
Calamus spp.	-	-	-	-	-	-	-	-
Equetus lanceolatus	-	-	-	-	-	-	-	-
Mulloidichthys martinicus	-	-	-	-	-	-	-	-
Pseudupeneus maculatus	-	-	-	-	-	-	-	-
Kyphosus spp.	-	-	-	-	-	-	-	-
Centropyge argi	-	-	-	-	-	-	-	-
Chaetodon ocellatus	-	-	-	-	-	-	-	-
Chaetodon sedentarius	.531	-	-	-	-	-	-	-
Holacanthus tricolor	-	-	-	-	-	-	-	-
Pomacanthus paru	-	-	-	-	-	-	-	-
Holacanthus spp.	-	-	-	-	-	-	-	-
Chaetodon spp.	-	-	-	-	-	-	-	-
Chromis enchrysurus	.354	-	-	-	-	-	-	-
Pomacentrus partitus	-	-	-	-	-	-	-	-
Chromis/Pomacentrus spp.	-	-	-	-	-	-	-	-
Chromis spp.	-	-	-	-	-	-	-	-
Pomacentrus spp.	-	-	-	-	-	-	-	-
Bodianus pulchellus	-	-	-	-	-	-	-	-
Bodianus rufus	-	-	-	-	-	-	-	-
Clepticus parrai	-	-	-	-	-	-	-	-
Thalassoma bifasciatum	-	-	-	-	-	-	-	-
Family Labridae	-	-	-	-	-	-	-	-
Scarus taeniopterus	-	-	-	-	-	-	-	-
Scarus vetula	-	-	-	-	-	-	-	-
Sparisoma aurofrenatum	-	-	-	-	-	-	-	-
Sparisoma viride	-	-	-	-	-	-	-	-
Scarus/Sparisoma spp.	-	-	-	-	-	-	-	-
Sphyraena barracuda	-	-	-	-	-	-	-	-
Family Gobiidae	.177	-	-	-	-	-	-	-
Ioglossus spp.	.177	-	-	-	-	-	-	-
Acanthurus coeruleus	-	-	-	-	-	-	-	-
Acanthurus spp.	-	-	-	-	-	-	-	-
Prionotus spp.	-	-	-	-	2.310	.895	4.086	.797
Family Bothidae	-	-	1.115	2.001	-	-	-	.399
Aluterus scriptus	-	-	-	-	-	-	-	-
Balistes capriscus	-	-	-	-	-	-	-	-
Balistes vetula	-	-	-	-	-	-	-	-
Canthirhines macrocerus	-	-	-	-	-	-	-	-
Canthirdermis sufflamen	-	-	-	-	-	-	-	-
Melichthys niger	-	-	-	-	-	-	-	-
Xanthichthys ringens	-	-	-	-	-	-	-	-
Family Balistidae	-	-	-	-	-	-	-	-
Lactophrys quadricornis	-	-	-	-	-	-	-	-
Lactophrys triqueter	-	-	-	-	-	-	-	-
Diodon holocanthus	.177	-	-	-	-	-	-	-
Family Diodontidae	-	-	-	-	-	-	-	-

Cruise: 6 Station: E

Species	Depth in Meters 15-19	20-24	25-29	30-34	35-39	40-44	45-49
Ginglymostoma cirratum	-	.058	-	-	-	-	-
Dasyatis spp.	-	.038	-	-	-	-	-
Gymnothorax spp.	-	-	-	-	-	-	-
Synodus intermedius	-	-	-	-	-	-	.011
Synodus spp.	-	-	-	-	-	-	-
Family Ogcocephalidae	-	-	-	-	-	-	-
Family Gadidae	-	-	-	-	-	-	-
Holocentrus spp.	-	-	-	.060	.096	.046	.138
Cephalopholis fulva	-	-	-	-	-	-	-
Dermatolepis inermis	-	-	-	-	.048	-	-
Epinephelus adscensionis	-	-	.081	-	.048	-	.042
Liopropama eukrines	-	-	-	-	-	-	-
Holanthias martinicensis	-	-	-	-	-	-	-
Paranthias furcifer	83.628	76.021	260.107	108.739	67.286	31.812	15.415
Serranus phoebe	-	-	-	-	-	-	-
Family Serranidae (small,without bars)	-	-	-	-	-	-	-
Mycteroperca/Epinephelus spp.	-	.058	.081	-	.048	-	.011
Epinephelus spp.	-	-	-	-	-	.023	-
Family Serranidae (Barred)	-	-	-	-	-	-	.011
Family Serranidae (Pikea/Hemanthias)	-	-	-	-	-	-	-
Mycteroperca spp.	.255	.579	1.217	.241	.288	.456	.201
Priacanthus arenatus	-	-	-	-	-	-	.021
Malacanthus plumieri	-	-	-	-	-	.023	-
Family Branchiostegidae	-	-	-	-	-	-	-
Caranx hippos	1.400	4.462	-	-	-	-	-
Caranx lugubris	-	-	.162	-	-	-	-
Caranx ruber	-	2.028	-	-	-	-	-
Seriola dumerili	.636	.464	.162	.060	.096	.182	.085
Seriola rivoliana	-	-	-	.060	.048	.023	.053
Caranx spp.	-	-	-	-	-	.046	.021
Lutjanus campechanus	-	-	-	-	-	-	.201
Rhomboplites aurorubens	-	-	-	-	-	-	-
Haemulon melanurum	-	-	-	.121	17.085	.501	.339
Calamus nodosus	-	-	-	.060	.240	.205	.053
Pargrus sedecim	-	-	-	-	-	-	-
Equetus lanceolatus	-	-	-	.060	-	-	-
Equetus umbrosus	-	-	-	-	-	-	-
Mulloidichthys martinicus	1.146	2.549	3.406	-	15.166	.912	.307
Pseudupeneus maculatus	-	-	-	.060	2.304	.524	.233
Family Mullidae	-	-	.649	-	-	-	-
Kyphosus spp.	8.146	21.033	10.787	.181	.288	.023	-
Centropyge argi	-	-	-	.060	-	-	.021
Chaetodon aya	-	-	-	-	-	-	-
Chaetodon ocellatus	.255	-	.162	.121	.288	-	.011
Chaetodon sedentarius	.127	.406	1.217	1.750	1.200	1.504	.646
Chaetodon striatus	-	-	-	.121	-	-	.021
Holacanthus tricolor	-	-	.162	.543	.240	.160	.042
Pomacanthus paru	-	-	.406	.362	.144	.160	.170
Prognathodes aculeatus	-	-	.081	-	-	-	-
Holacanthus spp.	.127	-	.081	.241	.048	.114	.042
Chaetodon spp.	-	-	-	-	-	.046	.085
Chromis enchrysurus	.255	-	-	.241	.096	.114	2.373
Pomacentrus partitus	.382	.290	1.217	.181	.096	.091	.042
Chromis/Pomacentrus spp.	.636	.116	1.135	10.681	1.968	1.527	1.303
Chromis spp.	167.511	63.853	40.553	26.189	17.997	1.960	.201
Pomacentrus spp.	74.591	33.375	30.820	16.172	16.845	3.373	.222
Bodianus pulchellus	.127	.058	.162	10.198	.384	.570	.254
Bodianus rufus	-	.116	.649	.664	.096	.319	.042
Clepticus parrai	34.495	25.031	132.284	29.930	30.955	3.760	-
Halichoeres garnoti	-	.058	-	-	-	-	-
Lachnolamius maximus	.127	-	-	-	-	.023	.011
Thalassoma bifasciatum	3.819	4.056	6.975	2.233	.432	.387	.042
Family Labridae	-	.116	.649	.422	.192	.137	.138
Scarus taeniopterus	.255	.521	.487	.302	.048	.091	-
Scarus vetula	.764	1.159	.406	.181	.048	-	-
Sparisoma aurofrenatum	-	-	-	-	-	.046	-
Sparisoma viride	.382	.232	.162	.543	.192	.160	.117
Scarus/Sparisoma spp.	.764	.406	.324	.060	.336	.046	.032
Sphyraena barracuda	.127	.058	-	.060	-	-	.011
Ophioblennius atlanticus	-	-	-	.060	-	-	-
Family Gobiidae	-	-	-	-	-	-	-
Ioglossus spp.	-	-	-	-	-	-	-
Acanthurus coeruleus	-	-	-	.302	-	.023	.032
Acanthurus spp.	.509	.174	-	.422	.240	.137	.053
Family Scorpaenidae	-	-	-	-	-	-	-
Prionotus spp.	-	-	-	-	-	-	-
Family Bothidae	-	-	-	-	-	-	-
Aluterus scriptus	-	-	.081	.060	.048	-	-
Balistes capriscus	-	-	-	-	-	.023	.170
Balistes vetula	.127	.058	.081	-	-	-	.042
Canthirhines macrocerus	-	-	.081	-	-	-	.032
Canthidermis sufflamen	.636	1.043	.081	-	.048	-	.011
Melichthys niger	2.546	1.738	.324	.181	-	-	-
Xanthichthys ringens	-	-	-	-	-	-	-
Lactophrys quadricornis	-	-	-	-	-	-	.011
Lactophrys triqueter	.127	.058	-	.060	-	-	-
Canthigaster rostrata	-	-	-	-	-	-	.032
Family Tetraodontidae	-	-	-	-	-	-	-
Diodon holocanthus	-	-	-	-	-	-	.021
Diodon hystrix	.127	-	-	-	-	-	-

Cruise: 6 Station: E

Species	Depth in Meters 50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89
Ginglymostoma cirratum	-	-	-	-	-	-	-	-
Dasyatis spp.	-	-	-	-	-	-	-	-
Gymnothorax spp.	.015	-	-	-	-	-	-	-
Synodus intermedius	-	-	-	-	-	-	-	-
Synodus spp.	-	-	-	-	-	-	-	-
Family Ogcocephalidae	-	-	-	-	-	-	-	-
Family Gadidae	-	-	-	-	-	-	-	-
Holocentrus spp.	.279	.120	.739	.529	-	-	-	-
Cephalopholis fulva	.015	-	-	-	-	-	-	-
Dermatolepis inermis	-	.072	-	-	-	-	-	-
Epinephelus adscensionis	.029	.024	-	-	-	-	-	-
Liopropama eukrines	.015	-	-	-	-	.331	-	-
Holanthias martinicensis	-	-	7.942	15.858	6.376	77.989	141.109	11.202
Paranthias furcifer	2.968	.048	-	2.114	6.730	37.091	-	-
Serranus phoebe	.015	.024	.369	.264	.354	.331	.784	.442
Family Serranidae (small,without bars)	-	.024	-	-	-	-	-	-
Mycteroperca/Epinephelus spp.	.015	-	-	-	-	.331	-	-
Epinephelus spp.	-	.024	-	-	-	-	-	-
Family Serranidae (Barred)	-	-	-	-	-	-	.523	1.179
Family Serranidae (Pikea/Hemanthias)	1.102	2.725	151.074	5.022	-	120.047	66.112	2.064
Mycteroperca spp.	.250	.645	2.032	3.172	1.063	1.325	1.307	.737
Priacanthus arenatus	.044	.024	.185	.264	-	.662	.261	2.653
Malacanthus plumieri	.029	-	-	-	-	-	-	-
Family Branchiostegidae	-	-	-	-	-	-	-	-
Caranx hippos	1.396	-	-	-	-	-	-	20.636
Caranx lugubris	-	-	-	-	-	-	-	-
Caranx ruber	-	-	-	-	-	-	-	-
Seriola dumerili	.118	.120	.185	-	.354	-	.392	.442
Seriola rivoliana	-	-	-	-	-	-	-	-
Caranx spp.	-	-	-	-	-	-	-	-
Lutjanus campechanus	-	.120	.369	-	-	.662	1.045	.442
Rhomboplites aurorubens	-	-	-	-	-	-	-	.590
Haemulon melanurum	-	-	31.397	-	-	.331	-	-
Calamus nodosus	.015	.048	.369	-	.354	-	-	-
Pargrus sedecim	.029	.024	-	.529	.708	.662	.392	.295
Equetus lanceolatus	-	-	-	-	-	-	.131	-
Equetus umbrosus	-	-	-	-	-	-	.131	-
Mulloidichthys martinicus	-	-	-	-	-	-	-	-
Pseudupeneus maculatus	.191	.167	-	-	-	-	-	-
Family Mullidae	-	-	-	-	-	-	-	-
Kyphosus spp.	-	-	-	-	-	-	-	-
Centropyge argi	.132	.072	.739	.264	-	-	-	-
Chaetodon aya	-	.024	-	-	-	.497	.392	.147
Chaetodon ocellatus	-	-	-	-	-	-	-	-
Chaetodon sedentarius	.690	.789	2.770	1.322	2.125	.993	1.829	.442
Chaetodon striatus	-	-	-	-	-	-	-	-
Holacanthus tricolor	.044	.024	-	-	-	.331	-	-
Pomacanthus paru	.176	.048	-	-	-	-	-	-
Prognathodes aculeatus	-	-	-	-	-	-	-	-
Holacanthus spp.	.191	.239	-	-	-	-	.131	-
Chaetodon spp.	.029	-	-	.264	-	-	-	-
Chromis enchrysurus	8.139	12.165	22.347	7.400	.708	6.292	5.096	-
Pomacentrus partitus	.044	-	-	-	-	-	-	-
Chromis/Pomacentrus spp.	.206	.311	-	-	-	-	-	-
Chromis spp.	.015	-	-	-	-	-	-	-
Pomacentrus spp.	-	-	-	-	-	-	-	-
Bodianus pulchellus	.191	.574	1.293	-	.708	.497	.131	-
Bodianus rufus	.029	.072	-	-	-	-	-	-
Clepticus parrai	-	-	-	-	-	-	-	-
Halichoeres garnoti	-	-	-	-	-	-	-	-
Lachnolamius maximus	-	-	-	-	-	-	-	-
Thalassoma bifasciatum	.059	-	-	-	-	-	-	-
Family Labridae	.044	.072	-	.529	-	-	-	-
Scarus taeniopterus	-	-	-	-	-	-	-	-
Scarus vetula	-	-	-	-	-	-	-	-
Sparisoma aurofrenatum	-	.024	-	-	-	-	-	-
Sparisoma viride	.029	.024	-	-	-	-	-	-
Scarus/Sparisoma spp.	-	-	-	.264	-	-	-	-
Sphyraena barracuda	-	-	-	-	-	-	-	-
Ophioblennius atlanticus	-	-	-	-	-	-	-	-
Family Gobiidae	-	-	-	-	-	.166	-	-
Ioglossus spp.	-	-	-	-	-	-	.131	-
Acanthurus coeruleus	-	-	-	-	-	-	-	-
Acanthurus spp.	-	-	-	-	-	-	-	-
Family Scorpaenidae	.015	-	-	-	-	-	-	-
Prionotus spp.	-	-	-	-	-	-	-	-
Family Bothidae	-	-	-	-	-	-	-	-
Aluterus scriptus	-	-	-	-	-	-	-	-
Balistes capriscus	.044	-	-	-	-	-	-	-
Balistes vetula	.029	.024	-	.264	-	-	-	-
Canthirhines macrocerus	-	-	-	-	-	-	-	-
Canthidermis sufflamen	-	-	-	-	-	-	-	-
Melichthys niger	-	-	-	-	-	-	-	-
Xanthichthys ringens	.132	.024	-	-	-	-	-	-
Lactophrys quadricornis	.044	.024	-	-	-	-	-	-
Lactophrys triqueter	-	-	-	-	-	-	-	-
Canthigaster rostrata	.029	.024	-	-	-	-	-	-
Family Tetraodontidae	-	-	-	-	-	-	-	-
Diodon holocanthus	.015	-	-	-	-	-	-	-
Diodon hystrix	-	-	-	-	-	-	-	-

Cruise: 5 Station: E Species	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-12-
	Depth in Meters							
Ginglymostoma cirratum	-	-	-	-	-	-	-	-
Dasyatis spp.	-	-	-	-	-	-	-	-
Gymnothorax spp.	-	-	-	-	-	-	-	-
Synodus intermedius	-	-	-	-	-	-	-	-
Synodus spp.	-	.233	-	-	-	-	-	-
Family Ogcocephalidae	-	.233	-	.447	-	-	-	-
Family Gadidae	.115	-	-	.447	-	-	-	-
Holocentrus spp.	-	-	-	-	-	-	-	-
Cephalopholis fulva	-	-	-	-	-	-	-	-
Dermatolepis inermis	-	-	-	-	-	-	-	-
Epinephelus adscensionis	-	-	-	-	-	-	-	-
Liopropama eukrines	-	-	-	-	-	-	-	-
Holanthias martinicensis	29.296	16.064	-	-	-	-	-	-
Paranthias furcifer	-	-	-	-	-	-	-	-
Serranus phoebe	.346	.931	-	-	-	1.226	-	-
Family Serranidae (small,without bars)	.115	1.863	-	.447	-	-	-	-
Mycteroperca/Epinephelus spp.	-	-	-	-	-	-	1.066	-
Epinephelus spp.	-	-	-	-	-	-	-	-
Family Serranidae (Barred)	1.153	1.397	2.376	3.132	5.771	-	2.131	2.399
Family Serranidae (Pikea/Hemanthias)	5.190	1.863	-	-	-	-	-	-
Mycteroperca spp.	.807	2.328	-	4.027	-	-	-	-
Priacanthus arenatus	2.768	2.095	.396	-	-	-	-	-
Malacanthus plumieri	-	-	-	-	-	-	-	-
Family Branchiostegidae	.115	.233	-	-	-	-	-	-
Caranx hippos	-	-	-	-	-	-	-	-
Caranx lugubris	-	-	-	-	-	-	-	-
Caranx ruber	-	-	-	-	-	-	-	-
Seriola dumerili	1.038	1.164	-	.895	-	-	-	-
Seriola rivoliana	-	-	-	-	-	-	-	-
Caranx spp.	-	-	-	-	-	-	-	-
Lutjanus campechanus	5.652	1.630	-	-	-	-	-	-
Rhomboplites aurorubens	-	2.328	-	-	-	-	-	-
Haemulon melanurum	-	-	-	-	-	-	-	-
Calamus nodosus	-	-	-	-	-	-	-	-
Pargrus sedecim	.346	-	-	-	-	-	-	-
Equetus lanceolatus	-	-	-	-	-	-	-	-
Equetus umbrosus	-	-	-	-	-	-	-	-
Mulloidichthys martinicus	-	-	-	-	-	-	-	-
Pseudupeneus maculatus	-	-	-	-	-	-	-	-
Family Mullidae	-	-	-	-	-	-	-	-
Kyphosus spp.	-	-	-	-	-	-	-	-
Centropyge argi	-	-	-	-	-	-	-	-
Chaetodon aya	-	.233	-	-	-	-	-	-
Chaetodon ocellatus	-	-	-	-	-	-	-	-
Chaetodon sedentarius	.231	-	-	-	-	-	-	-
Chaetodon striatus	-	-	-	-	-	-	-	-
Holacanthus tricolor	-	-	-	-	-	-	-	-
Pomacanthus paru	-	-	-	-	-	-	-	-
Prognathodes aculeatus	-	-	-	-	-	-	-	-
Holacanthus spp.	-	-	-	-	-	-	-	-
Chaetodon spp.	-	-	-	-	-	-	-	-
Chromis enchrysurus	.115	-	-	-	-	-	-	-
Pomacentrus partitus	-	-	-	-	-	-	-	-
Chromis/Pomacentrus spp.	-	-	-	-	-	-	-	-
Chromis spp.	-	-	-	-	-	-	-	-
Pomacentrus spp.	-	-	-	-	-	-	-	-
Bodianus pulchellus	-	-	-	-	-	-	-	-
Bodianus rufus	-	-	-	-	-	-	-	-
Clepticus parrai	-	-	-	-	-	-	-	-
Halichoeres garnoti	-	-	-	-	-	-	-	-
Lachnolamius maximus	-	-	-	-	-	-	-	-
Thalassoma bifasciatum	-	-	-	-	-	-	-	-
Family Labridae	-	-	-	-	-	-	-	-
Scarus taeniopterus	-	-	-	-	-	-	-	-
Scarus vetula	-	-	-	-	-	-	-	-
Sparisoma aurofrenatum	-	-	-	-	-	-	-	-
Sparisoma viride	-	-	-	-	-	-	-	-
Scarus/Sparisoma spp.	-	-	-	-	-	-	-	-
Sphyraena barracuda	-	-	-	-	-	-	-	-
Ophioblennius atlanticus	-	-	-	-	-	-	-	-
Family Gobiidae	-	-	-	-	-	-	-	-
Ioglossus spp.	-	-	-	-	-	-	-	-
Acanthurus coeruleus	-	-	-	-	-	-	-	-
Acanthurus spp.	-	-	-	-	-	-	-	-
Family Scorpaenidae	-	-	-	-	-	-	-	-
Prionotus spp.	-	-	.396	-	-	-	-	-
Family Bothidae	-	-	-	-	1.154	-	1.066	-
Aluterus scriptus	-	-	-	-	-	-	-	-
Balistes capriscus	-	-	-	-	-	-	-	-
Balistes vetula	-	-	-	-	-	-	-	-
Canthirhines macrocerus	-	-	-	-	-	-	-	-
Canthidermis sufflamen	-	-	-	-	-	-	-	-
Melichthys niger	-	-	-	-	-	-	-	-
Xanthichthys ringens	-	-	-	-	-	-	-	-
Lactophrys quadricornis	-	-	-	-	-	-	-	-
Lactophrys triqueter	-	-	-	-	-	-	-	-
Canthigaster rostrata	-	-	-	-	-	-	-	-
Family Tetraodontidae	.115	-	-	-	-	-	-	-
Diodon holocanthus	-	-	-	-	-	-	-	-
Diodon hystrix	-	-	-	-	-	-	-	-

Cruise: 7 Station: E

Species	Depth in Meters 15-19	20-24	25-29	30-34	35-39	40-44	45-49
Carcharhinus spp.	-	-	-	-	-	-	-
Manta birostris	.183	-	-	-	.101	.058	-
Gymnothorax spp.	-	-	-	-	-	-	-
Synodus spp.	-	-	-	-	-	-	-
Family Ogcocephalidae	-	-	-	-	-	-	-
Family Gadidae	-	-	-	-	-	-	-
Holocentrus spp.	-	-	-	-	.203	.292	.043
Aulostomus maculatus	-	-	-	-	-	.058	-
Dermatolepis inermis	-	-	-	.148	-	.058	-
Epinephelus adscensionis	-	.062	-	-	-	.234	.022
Liopropama eukrines	-	-	-	-	-	-	-
Mycteroperca bonaci	-	-	-	-	-	-	.022
Mycteroperca tigris	-	-	.106	.148	-	-	-
Holanthias martinicensis	-	-	-	-	-	-	-
Paranthias furcifer	68.560	97.715	146.216	144.901	105.610	51.954	23.620
Serranus phoebe	-	-	-	-	-	-	-
Family Serranidae (small,without bars)	-	-	-	-	-	-	-
Mycteroperca/Epinephelus spp.	-	-	.424	-	.101	-	.086
Family Serranidae (Barred)	-	-	-	-	-	-	-
Family Serranidae (Pikea/Hemanthias)	-	-	-	-	-	-	4.862
Mycteroperca spp.	.367	.312	.529	.890	.304	.642	.409
Priacanthus arenatus	-	-	-	-	.203	.117	.022
Malacanthus plumieri	-	-	-	-	-	.058	.108
Family Branchiostegidae	-	-	-	-	-	-	-
Caranx crysos	-	-	-	-	-	-	-
Caranx latus	-	16.432	-	-	-	-	-
Caranx lugubris	-	-	.106	.148	.304	-	-
Caranx ruber	2.566	25.616	27.422	-	1.013	-	-
Seriola dumerili	.367	.125	.106	.148	1.215	.292	.108
Seriola rivoliana	-	-	-	-	1.215	.175	.065
Caranx spp.	-	.562	-	-	-	-	-
Lutjanus campechanus	-	-	-	-	-	.117	-
Lutjanus griseus	-	.187	.212	-	.101	-	-
Lutjanus jocu	-	-	-	-	.101	-	-
Rhomboplites aurorubens	-	-	-	-	-	-	-
Haemulon melanurum	-	-	-	.297	1.519	.058	2.474
Calamus nodosus	-	-	.106	-	.911	.525	.366
Pargrus sedecim	-	-	-	-	-	-	-
Equetus lanceolatus	-	-	-	-	-	-	-
Equetus umbrosus	-	-	-	-	-	-	-
Mulloidichthys martinicus	2.933	4.311	.635	1.928	3.645	9.048	.774
Pseudupeneus maculatus	-	-	.318	.445	2.025	.234	.237
Kyphosus spp.	24.198	11.433	9.000	3.263	-	.175	.387
Centropyge argi	-	.187	-	-	-	.350	.473
Chaetodon aya	-	-	-	-	-	-	-
Chaetodon ocellatus	-	.187	-	-	.506	-	-
Chaetodon sedentarius	1.833	1.125	1.694	2.225	6.177	3.386	1.785
Holacanthus tricolor	.183	.125	.212	.148	.911	.350	.129
Pomacanthus paru	-	.187	.424	.593	-	.642	.344
Prognathodes aculeatus	-	-	.106	-	-	.058	.022
Holacanthus spp.	-	-	.212	.148	.203	.409	.409
Chaetodon spp.	-	.125	.212	-	.304	.350	.065
Chromis enchrysurus	-	.187	.212	.445	4.556	3.561	11.229
Pomacentrus partitus	.917	2.437	4.023	3.856	1.013	.292	.258
Chromis/Pomacentrus spp.	.550	1.000	9.317	12.458	10.429	7.530	1.398
Chromis spp.	166.267	105.900	24.140	.445	21.770	8.173	.301
Pomacentrus spp.	50.778	76.160	22.340	2.966	31.288	9.165	.452
Bodianus pulchellus	-	.187	.212	1.038	3.038	1.459	.753
Bodianus rufus	.183	.187	1.800	4.004	.506	.467	.258
Clepticus parrai	19.798	15.994	43.409	162.846	49.008	6.947	1.269
Decodon puellaris	-	-	-	-	-	-	-
Halichoeres garnoti	-	-	.106	-	-	.058	.043
Halichoeres radiatus	-	-	-	-	-	-	-
Thalassoma bifasciatum	9.166	5.373	15.034	14.535	5.063	.409	.323
Family Labridae	.733	.062	1.376	6.822	.304	.292	.108
Scarus taeniopterus	1.467	.625	.424	.148	1.114	.876	.301
Scarus vetula	2.750	2.749	.318	-	.608	.409	-
Sparisoma aurofrenatum	-	-	.318	.593	.405	.234	.043
Sparisoma viride	-	.187	.424	.445	.304	.584	.667
Scarus/Sparisoma spp.	.367	.250	.847	.445	.101	.234	.065
Sphyraena barracuda	.550	.375	-	-	.101	-	-
Bembrops spp.	-	-	-	-	-	-	-
Ioglossus spp.	-	-	-	-	-	-	-
Acanthurus coeruleus	.183	.062	.635	.297	.101	-	.194
Acanthurus spp.	.183	.625	.424	.445	1.721	.467	.086
Scomberomorus cavalla	-	-	-	-	-	-	-
Prionotus spp.	-	-	-	-	-	-	-
Family Bothidae	-	-	-	-	-	-	-
Aluterus scriptus	-	.062	-	-	-	-	-
Balistes capriscus	-	-	-	-	-	-	.065
Balistes vetula	.183	.062	-	.148	.304	.234	.129
Cantherhines macrocerus	-	-	-	-	.203	-	.043
Canthidermis sufflamen	6.783	6.623	3.917	.742	-	.525	.151
Melichthys niger	2.200	2.124	.635	.297	-	.058	-
Xanthichthys ringens	-	-	-	-	-	-	.022
Lactophrys quadricornis	-	.062	-	-	-	-	.022
Lactophrys triqueter	-	.125	-	-	.203	.117	-
Family Ostraciidae	-	.062	.106	-	-	-	-
Canthigaster rostrata	.183	-	-	.148	.405	.117	.022
Family Tetraodontidae	-	-	-	-	-	-	-
Diodon holocanthus	-	-	.106	-	-	.058	.043
Family Diodontidae	-	-	-	-	-	-	-
Fistulara tabacaria	-	-	-	-	-	-	-

Cruise: 7 Station: E

Species	Depth in Meters 50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89
Carcharhinus spp.	-	-	-	-	-	-	-	.240
Manta birostris	-	-	-	-	-	-	-	-
Gymnothorax spp.	-	-	-	-	-	-	.120	-
Synodus spp.	-	-	-	-	-	-	-	-
Family Ogcocephalidae	-	-	-	-	-	-	-	-
Family Gadidae	-	-	-	-	-	-	-	-
Holocentrus spp.	.261	.030	.093	-	-	-	-	-
Aulostomus maculatus	-	-	-	-	-	-	-	-
Dermatolepis inermis	-	.060	-	-	.250	-	-	-
Epinephelus adscensionis	.025	-	-	-	-	-	-	-
Liopropama eukrines	.012	.060	.093	-	-	-	.241	.240
Mycteroperca bonaci	-	-	-	-	-	-	-	-
Mycteroperca tigris	-	-	-	-	-	-	-	-
Holanthias martinicensis	-	1.790	2.048	13.473	12.734	24.798	32.511	14.889
Paranthias furcifer	5.819	5.846	8.379	23.821	7.740	-	-	-
Serranus phoebe	-	-	.093	-	.250	1.231	.602	1.681
Family Serranidae (small,without bars)	-	-	-	-	-	-	.120	-
Mycteroperca/Epinephelus spp.	.025	.030	-	-	-	.176	-	.240
Family Serranidae (Barred)	-	-	.093	-	-	-	1.445	3.362
Family Serranidae (Pikea/Hemanthias)	17.086	6.353	6.051	39.637	37.203	19.346	16.015	-
Mycteroperca spp.	.248	.686	1.210	2.343	.499	.176	.843	.720
Priacanthus arenatus	.037	-	.186	-	.499	.703	1.686	4.323
Malacanthus plumieri	.037	.030	.186	-	-	-	-	-
Family Branchiostegidae	-	-	-	-	-	-	-	-
Caranx crysos	-	-	-	-	-	-	-	-
Caranx latus	-	-	-	-	-	-	-	-
Caranx lugubris	-	-	-	-	-	-	-	-
Caranx ruber	-	-	-	-	-	-	-	-
Seriola dumerili	.112	.119	.093	.195	-	.176	-	.240
Seriola rivoliana	-	-	-	-	-	-	.120	-
Caranx spp.	.298	-	-	-	-	-	-	-
Lutjanus campechanus	-	.537	3.445	4.296	-	-	.602	2.882
Lutjanus griseus	-	-	-	-	-	-	-	-
Lutjanus jocu	-	-	-	-	-	-	-	-
Rhomboplites aurorubens	-	-	.279	2.148	-	-	-	-
Haemulon melanurum	-	.060	-	-	14.482	-	-	-
Calamus nodosus	.211	.119	.186	-	.499	-	-	-
Pargrus sedecim	.012	-	-	.976	.250	1.231	-	-
Equetus lanceolatus	-	-	-	-	-	-	.120	.240
Equetus umbrosus	-	-	-	-	-	-	.120	-
Mulloidichthys martinicus	-	-	-	-	-	-	-	-
Pseudupeneus maculatus	.136	.089	-	1.562	-	-	-	-
Kyphosus spp.	.012	-	-	-	-	-	-	-
Centropyge argi	.124	.447	.186	.195	.250	-	-	-
Chaetodon aya	-	-	-	-	-	-	-	-
Chaetodon ocellatus	.025	-	-	.391	-	-	-	-
Chaetodon sedentarius	.943	1.402	4.189	2.343	.499	.528	.963	1.201
Holacanthus tricolor	.050	.089	.186	.195	-	-	-	-
Pomacanthus paru	.124	.030	.465	-	-	-	-	-
Prognathodes aculeatus	-	-	-	-	-	-	-	-
Holacanthus spp.	.223	.239	-	-	-	-	.120	-
Chaetodon spp.	-	-	-	-	-	-	-	-
Chromis enchrysurus	12.594	20.939	23.274	13.277	3.995	1.583	3.974	.240
Pomacentrus partitus	.074	-	-	-	-	-	-	-
Chromis/Pomacentrus spp.	.099	.119	.186	-	-	-	-	-
Chromis spp.	.025	.060	.372	1.562	-	-	-	-
Pomacentrus spp.	.050	-	-	-	-	-	-	-
Bodianus pulchellus	.546	.597	3.258	.781	.999	.352	.120	-
Bodianus rufus	.186	.149	.093	.195	-	-	-	-
Clepticus parrai	.112	.030	-	-	-	-	-	-
Decodon puellaris	-	-	-	-	-	-	.241	-
Halichoeres garnoti	-	-	-	-	-	-	-	-
Halichoeres radiatus	.012	-	-	-	-	-	-	-
Thalassoma bifasciatum	-	-	-	-	-	-	-	-
Family Labridae	.099	.030	.186	-	-	-	-	.240
Scarus taeniopterus	-	-	-	-	-	-	-	-
Scarus vetula	-	-	-	-	-	-	-	-
Sparisoma aurofrenatum	-	-	-	-	-	-	-	-
Sparisoma viride	.136	.119	.093	-	-	-	-	-
Scarus/Sparisoma spp.	.012	-	-	-	-	-	-	-
Sphyraena barracuda	-	-	-	-	-	-	-	-
Bembrops spp.	-	-	-	-	-	-	-	-
Ioglossus spp.	-	-	-	-	-	-	-	.720
Acanthurus coeruleus	-	-	-	-	-	-	-	-
Acanthurus spp.	.012	-	-	-	-	-	-	-
Scomberomorus cavalla	.012	-	-	-	-	-	-	-
Prionotus spp.	-	-	-	-	-	-	-	-
Family Bothidae	-	-	-	-	-	-	-	-
Aluterus scriptus	.012	-	-	-	-	.176	-	-
Balistes capriscus	.186	-	-	.586	-	-	-	-
Balistes vetula	.025	-	-	-	-	-	-	-
Canthirhines macrocerus	-	-	-	-	-	-	-	-
Canthidermis sufflamen	.012	-	-	-	-	-	-	-
Melichthys niger	-	-	-	-	-	-	-	-
Xanthichthys ringens	.248	.477	.372	-	-	-	-	-
Lactophrys quadricornis	.037	-	-	-	-	-	-	-
Lactophrys triqueter	-	-	-	-	-	-	-	-
Family Ostraciidae	-	-	-	-	-	-	-	-
Canthigaster rostrata	.012	-	-	-	-	-	-	-
Family Tetraodontidae	.012	-	-	-	-	-	-	-
Diodon holocanthus	.025	.030	-	-	-	.352	-	-
Family Diodontidae	.012	-	-	-	-	-	-	-
Fistulara tabacaria	-	-	-	-	-	-	[illegible]	

Cruise: 7 Station: E

Species	Depth in Meters							
	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129
Carcharhinus spp.	-	-	-	-	-	-	-	-
Manta birostris	-	-	-	-	-	-	-	-
Gymnothorax spp.	-	-	-	-	-	-	-	-
Synodus spp.	-	-	-	.639	-	-	-	-
Family Ogcocephalidae	.232	.599	-	1.278	3.078	-	-	-
Family Gadidae	-	.599	-	-	-	-	-	-
Holocentrus spp.	-	-	-	-	-	-	-	-
Aulostomus maculatus	-	-	-	-	-	-	-	-
Dermatolepis inermis	-	-	-	-	-	-	-	-
Epinephelus adscensionis	-	-	-	-	-	-	-	-
Liopropama eukrines	-	-	-	-	-	-	-	-
Mycteroperca bonaci	-	-	-	-	-	-	-	-
Mycteroperca tigris	-	-	-	-	-	-	-	-
Holanthias martinicensis	18.562	15.864	11.910	-	-	-	-	-
Paranthias furcifer	-	-	-	-	-	-	-	-
Serranus phoebe	.464	2.095	-	-	4.618	-	-	-
Family Serranidae (small,without bars)	.928	1.497	-	-	1.539	-	-	-
Mycteroperca/Epinephelus spp.	-	.299	.627	-	-	-	-	-
Family Serranidae (Barred)	.696	1.497	3.134	7.027	1.539	12.174	-	-
Family Serranidae (Pikea/Hemanthias)	-	.898	-	-	-	-	-	-
Mycteroperca spp.	.232	1.197	-	-	-	-	-	-
Priacanthus arenatus	3.016	1.197	-	-	-	-	-	-
Malacanthus plumieri	-	-	-	-	-	-	-	-
Family Branchiostegidae	.232	-	-	-	-	-	-	-
Caranx crysos	5.337	-	-	-	-	-	-	-
Caranx latus	-	-	-	-	-	-	-	-
Caranx lugubris	-	-	-	-	-	-	-	-
Caranx ruber	-	-	-	-	-	-	-	-
Seriola dumerili	-	-	-	-	-	-	-	-
Seriola rivoliana	-	-	-	-	-	-	-	-
Caranx spp.	-	-	-	-	-	-	-	-
Lutjanus campechanus	-	1.197	-	-	-	-	-	-
Lutjanus griseus	-	-	-	-	-	-	-	-
Lutjanus jocu	-	-	-	-	-	-	-	-
Rhomboplites aurorubens	-	-	-	-	-	-	-	-
Haemulon melanurum	-	-	-	-	-	-	-	-
Calamus nodosus	-	-	-	-	-	-	-	-
Pargrus sedecim	-	-	-	-	-	-	-	-
Equetus lanceolatus	-	-	-	-	-	-	-	-
Equetus umbrosus	-	-	5.015	-	-	-	-	-
Mulloidichthys martinicus	-	-	-	-	-	-	-	-
Pseudupeneus maculatus	-	-	-	-	-	-	-	-
Kyphosus spp.	-	-	-	-	-	-	-	-
Centropyge argi	-	-	-	-	-	-	-	-
Chaetodon aya	-	.898	-	-	-	-	-	-
Chaetodon ocellatus	-	-	-	-	-	-	-	-
Chaetodon sedentarius	-	-	-	-	-	-	-	-
Holacanthus tricolor	-	-	-	-	-	-	-	-
Pomacanthus paru	-	-	-	-	-	-	-	-
Prognathodes aculeatus	-	-	-	-	-	-	-	-
Holacanthus spp.	-	-	-	-	-	-	-	-
Chaetodon spp.	-	-	-	-	-	-	-	-
Chromis enchrysurus	-	-	-	-	-	-	-	-
Pomacentrus partitus	-	-	-	-	-	-	-	-
Chromis/Pomacentrus spp.	-	-	-	-	-	-	-	-
Chromis spp.	-	-	-	-	-	-	-	-
Pomacentrus spp.	-	-	-	-	-	-	-	-
Bodianus pulchellus	-	-	-	-	-	-	-	-
Bodianus rufus	-	-	-	-	-	-	-	-
Clepticus parrai	-	-	-	-	-	-	-	-
Decodon puellaris	-	-	-	-	-	-	-	-
Halichoeres garnoti	-	-	-	-	-	-	-	-
Halichoeres radiatus	-	-	-	-	-	-	-	-
Thalassoma bifasciatum	-	-	-	-	-	-	-	-
Family Labridae	-	-	-	-	-	-	-	-
Scarus taeniopterus	-	-	-	-	-	-	-	-
Scarus vetula	-	-	-	-	-	-	-	-
Sparisoma aurofrenatum	-	-	-	-	-	-	-	-
Sparisoma viride	-	-	-	-	-	-	-	-
Scarus/Sparisoma spp.	-	-	-	-	-	-	-	-
Sphyraena barracuda	-	-	-	-	-	-	-	-
Bembrops spp.	-	-	-	-	-	-	16.667	-
Ioglossus spp.	.928	-	.627	.639	-	-	-	-
Acanthurus coeruleus	-	-	-	-	-	-	-	-
Acanthurus spp.	-	-	-	-	-	-	-	-
Scomberomorus cavalla	-	-	-	-	-	-	-	-
Prionotus spp.	-	-	.627	-	-	2.435	-	-
Family Bothidae	-	-	.627	.639	3.078	-	-	-
Aluterus scriptus	-	-	-	-	-	-	-	-
Balistes capriscus	-	-	-	-	-	-	-	-
Balistes vetula	-	-	-	-	-	-	-	-
Canthirhines macrocerus	-	-	-	-	-	-	-	-
Canthidermis sufflamen	-	-	-	-	-	-	-	-
Melichthys niger	-	-	-	-	-	-	-	-
Xanthichthys ringens	-	-	-	-	-	-	-	-
Lactophrys quadricornis	-	-	-	-	-	-	-	-
Lactophrys triqueter	-	-	-	-	-	-	-	-
Family Ostraciidae	-	-	-	-	-	-	-	-
Canthigaster rostrata	-	-	-	-	-	-	-	-
Family Tetraodontidae	-	-	-	-	-	-	-	-
Diodon holocanthus	-	-	-	-	-	-	-	-
Family Diodontidae	-	-	-	-	-	-	-	-
Fistulara tabacaria	-	-	-	-	-	-	-	-

Appendix 6-7 (cont'd)

Cruise: 3 Station: 6	Depth in Meters						
Species	15-19	20-24	25-29	30-34	35-39	40-44	45-49
Ginglymostoma cirratum	-	-	-	-	-	-	.023
Carcharhinus spp.	-	-	-	-	-	-	.023
Gymnothorax spp.	-	-	-	-	-	-	-
Ophichthus spp.	-	-	-	-	-	-	-
Family Synodontidae	-	-	-	-	-	-	-
Synodus spp.	-	-	-	-	-	-	.023
Family Ogcocephalidae	-	-	-	-	-	-	-
Holocentrus spp.	-	.151	.116	-	.407	.500	.747
Aulostomus maculatus	.140	.151	-	-	-	-	-
Epinephelus adscensionis	-	-	-	-	-	.100	.045
Epinephelus nigritus	-	-	-	-	-	-	-
Liopropama eukrines	-	-	-	-	-	-	.023
Holanthias martinicensis	-	-	-	-	-	-	-
Paranthias furcifer	98.443	121.525	219.673	384.319	125.879	60.902	52.848
Serranus phoebe	-	-	-	-	-	-	-
Serranus spp. small sea bass	-	-	-	-	-	.050	-
Mycteroperca/Epinephelus spp.	-	-	-	-	-	.050	.091
Epinephelus spp.	-	-	-	-	-	-	.068
Family Serranidae (Barred)	-	-	-	-	-	-	-
Family Serranidae (Pikea/Hemanthias)	-	-	-	-	-	-	-
Mycteroperca spp.	.838	.452	1.395	1.495	.407	.950	.747
Priacanthus arenatus	-	-	-	-	-	.050	.023
Malacanthus plumieri	-	-	-	-	-	.050	.158
Caranx crysos	-	-	-	-	-	-	.136
Caranx lugubris	-	-	-	-	-	.050	-
Caranx ruber	2.095	-	.116	1.495	-	.150	-
Elagatis bipinnulata	-	-	-	-	-	-	.906
Seriola dumerili	.140	-	1.279	-	-	.150	.136
Seriola rivoliana	-	-	-	-	-	-	.023
Lutjanus campechanus	-	-	-	-	-	-	.045
Lutjanus griseus	-	-	.232	.187	-	-	-
Pristipomoides aquilonari	-	-	-	-	-	-	-
Haemulon melanurum	-	-	.116	-	.204	.100	-
Calamus nodosus	-	.151	-	.374	.407	.750	.362
Calamus spp.	-	-	-	-	-	-	-
Equetus lanceolatus	-	-	-	-	-	-	-
Equetus umbrosus	-	-	-	-	-	-	-
Mulloidichthys martinicus	-	.151	2.790	2.989	10.184	8.650	-
Pseudupeneus maculatus	-	-	.232	.374	.407	.400	.408
Kyphosus spp.	.140	21.561	14.529	2.242	12.832	2.300	-
Centropyge argi	-	-	.349	.187	-	1.300	.928
Chaetodon ocellatus	.559	.905	.349	-	-	.100	.068
Chaetodon sedentarius	1.117	1.659	3.836	5.605	3.055	3.900	1.947
Chaetodon striatus	.279	-	-	-	-	-	-
Holacanthus tricolor	.279	.151	.349	-	.407	.350	.113
Pomacanthus paru	.140	.151	.581	1.495	.407	.650	.408
Prognathodes aculeatus	-	-	-	-	-	-	.023
Holacanthus spp.	-	.151	-	.561	.611	.600	.430
Chaetodon spp.	.140	.302	.116	.187	-	.100	-
Chromis enchrysurus	.977	.302	.465	1.868	1.630	9.500	15.080
Pomacentrus partitus	1.117	1.055	2.208	2.989	1.222	1.550	.928
Chromis/Pomacentrus spp.	.140	2.262	7.439	8.781	6.518	7.550	1.042
Chromis spp.	342.106	75.237	36.845	52.687	13.036	1.500	2.151
Pomacentrus spp.	52.782	51.113	33.590	25.223	22.609	2.600	2.196
Bodianus pulchellus	.140	.754	1.279	2.242	1.018	1.900	.815
Bodianus rufus	.698	.603	1.162	2.055	.815	.850	.453
Clepticus parrai	9.216	155.299	73.922	40.356	16.499	8.500	.747
Decodon puellaris	-	-	-	-	-	-	.023
Halichoeres garnoti	-	-	.116	-	-	.050	-
Halichoeres radiatus	-	.151	-	-	.204	-	-
Lachnolaimus maximus	-	-	-	-	-	-	-
Thalassoma bifasciatum	6.563	9.348	5.811	10.836	.407	.300	.045
Family Labridae	.140	-	.814	.561	.204	.150	.113
Scarus taeniopterus	1.536	.452	.814	.561	1.426	.950	.113
Scarus vetula	3.910	1.055	.581	.374	-	-	.045
Sparisoma aurofrenatum	-	-	.581	.374	.407	.150	.113
Sparisoma viride	1.815	.302	1.162	.187	1.222	.900	.408
Scarus/Sparisoma spp.	1.257	.302	-	.747	.407	.400	.045
Sphyraena barracuda	.419	.151	.232	-	.204	-	.023
Family Gobiidae	-	-	-	-	-	-	.158
Ioglossus spp.	-	-	-	-	-	.150	-
Acanthurus coeruleus	-	-	.232	.561	.204	-	.045
Acanthurus spp.	.559	-	1.162	.561	1.018	1.950	.226
Balistes capriscus	-	-	.116	-	-	-	1.291
Balistes vetula	.279	.452	-	-	.204	.200	.181
Canthirhines macrocerus	-	-	-	-	-	.200	.158
Canthidermis sufflamen	.140	-	-	-	-	.100	.068
Melichthys niger	6.842	.603	2.790	.374	.204	-	-
Xanthichthys ringens	-	-	-	-	-	-	.045
Lactophrys quadricornis	-	-	-	-	-	.050	.045
Lactophrys triqueter	.140	-	-	.187	-	.050	.023
Canthigaster rostrata	.140	-	-	-	.204	.050	-
Diodon holocanthus	-	-	-	-	-	-	.068

Appendix 6-7 (cont'd)

Cruise: 8 Station: E

Species	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89
	Depth in Meters							
Ginglymostoma cirratum	-	-	-	-	-	-	-	-
Carcharhinus spp.	-	-	-	-	-	-	-	-
Gymnothorax spp.	.031	.057	-	-	-	-	-	-
Ophichthus spp.	-	-	-	-	-	-	-	-
Family Synodontidae	-	-	-	-	-	-	-	-
Synodus spp.	-	-	-	-	-	-	-	.228
Family Ogcocephalidae	-	-	-	-	-	-	-	-
Holocentrus spp.	.345	.458	.177	-	-	-	-	-
Aulostomus maculatus	-	-	-	-	-	-	-	-
Epinephelus adscensionis	-	.057	.177	-	-	-	-	-
Epinephelus nigritus	-	-	-	-	-	-	-	.456
Liopropama eukrines	.063	.114	.355	-	-	-	-	-
Holanthias martinicensis	-	.972	.887	15.397	29.315	71.851	27.274	34.195
Paranthias furcifer	25.387	21.162	.710	-	-	-	-	-
Serranus phoebe	.031	-	-	-	.497	1.899	1.678	1.368
Serranus spp. small sea bass	-	.114	-	-	-	-	-	-
Mycteroperca/Epinephelus spp.	.031	-	-	-	-	-	-	-
Epinephelus spp.	-	-	-	-	-	-	-	-
Family Serranidae (Barred)	-	-	-	-	-	-	.839	3.192
Family Serranidae (Pikea/Hemanthias)	18.986	95.001	9.051	22.207	8.198	1.266	40.282	2.736
Mycteroperca spp.	1.098	1.258	2.485	1.480	.745	6.647	1.049	.456
Priacanthus arenatus	.031	-	-	-	-	2.532	.420	1.140
Malacanthus plumieri	-	.057	-	-	-	-	-	-
Caranx crysos	.063	-	-	-	-	-	-	4.559
Caranx lugubris	.063	-	-	-	-	-	-	-
Caranx ruber	-	-	-	-	-	-	-	-
Elagatis bipinnulata	-	-	-	-	-	-	-	-
Seriola dumerili	.063	.458	-	-	-	1.266	-	.228
Seriola rivoliana	.031	.057	-	-	-	-	-	-
Lutjanus campechanus	.094	.972	1.597	.296	-	-	-	-
Lutjanus griseus	.031	-	-	-	-	-	-	-
Pristipomoides aquilonari	-	-	-	-	-	-	-	.228
Haemulon melanurum	.031	-	-	-	-	.317	-	-
Calamus nodosus	.282	.343	-	-	-	.317	-	-
Calamus spp.	-	-	-	-	-	-	-	.228
Equetus lanceolatus	.031	-	-	-	-	-	-	-
Equetus umbrosus	.063	-	-	-	-	-	-	-
Mulloidichthys martinicus	-	-	-	-	-	-	-	-
Pseudupeneus maculatus	.157	-	-	-	-	-	-	-
Kyphosus spp.	-	-	-	-	-	-	-	-
Centropyge argi	1.224	2.059	.710	.592	-	-	-	-
Chaetodon ocellatus	.063	-	-	-	-	-	-	-
Chaetodon sedentarius	2.542	3.775	4.437	1.184	1.739	2.532	.420	.684
Chaetodon striatus	-	-	-	-	-	-	-	-
Holacanthus tricolor	.282	.057	.177	-	-	-	-	-
Pomacanthus paru	.188	.114	-	-	-	-	-	-
Prognathodes aculeatus	-	-	-	-	-	-	-	-
Holacanthus spp.	.439	.114	-	-	-	-	-	-
Chaetodon spp.	-	-	-	-	-	-	-	-
Chromis enchrysurus	32.354	48.273	21.473	5.034	5.962	6.014	1.259	.228
Pomacentrus partitus	.157	-	-	-	-	-	-	-
Chromis/Pomacentrus spp.	.377	.114	-	-	-	-	-	-
Chromis spp.	-	-	-	-	-	-	-	-
Pomacentrus spp.	.188	-	-	-	-	-	-	-
Bodianus pulchellus	1.632	1.887	2.307	.296	1.739	.317	-	-
Bodianus rufus	.157	.114	-	.296	-	-	-	-
Clepticus parrai	-	-	-	-	-	-	-	-
Decodon puellaris	-	-	-	.296	.248	-	-	-
Halichoeres garnoti	-	-	-	-	-	-	-	-
Halichoeres radiatus	-	-	-	-	-	-	-	-
Lachnolamius maximus	-	-	-	-	-	.633	-	-
Thalassoma bifasciatum	-	.057	-	-	-	-	-	-
Family Labridae	.031	.286	.177	-	-	-	-	-
Scarus taeniopterus	.031	-	-	-	-	-	-	-
Scarus vetula	-	-	-	-	-	-	-	-
Sparisoma aurofrenatum	.031	-	-	-	-	-	-	-
Sparisoma viride	.063	.057	-	-	-	-	-	-
Scarus/Sparisoma spp.	-	-	-	-	-	-	-	-
Sphyraena barracuda	-	-	-	-	-	-	-	-
Family Gobiidae	-	-	-	-	-	-	.420	-
Ioglossus spp.	-	-	-	-	-	-	.210	.228
Acanthurus coeruleus	-	-	-	-	-	-	-	-
Acanthurus spp.	.063	-	-	-	-	-	-	-
Balistes capriscus	.439	-	.177	-	-	-	-	-
Balistes vetula	.157	.229	-	-	-	-	-	-
Canthirhines macrocerus	-	-	-	-	-	-	-	-
Canthidermis sufflamen	.126	-	-	-	-	-	-	-
Melichthys niger	-	-	-	-	-	-	-	-
Xanthichthys ringens	.439	.286	-	-	-	-	-	-
Lactophrys quadricornis	.031	.057	-	-	.248	-	.210	-
Lactophrys triqueter	-	-	-	-	-	-	-	-
Canthigaster rostrata	.031	-	-	-	-	-	-	-
Diodon holocanthus	.031	-	-	-	-	-	-	.228

Appendix 6-7 (cont'd)

Cruise: 8 Station: E

Species	Depth in Meters							
	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129
Ginglymostoma cirratum	-	-	-	-	-	-	-	-
Carcharhinus spp.	-	-	-	-	-	-	-	-
Gymnothorax spp.	-	-	-	-	-	-	-	-
Ophichthus spp.	-	-	-	-	-	2.697	-	-
Family Synodontidae	-	-	-	1.498	-	-	-	-
Synodus spp.	-	.728	-	1.498	-	-	-	-
Family Ogcocephalidae	.762	-	-	2.997	-	5.395	6.061	-
Holocentrus spp.	-	-	-	-	-	-	-	-
Aulostomus maculatus	-	-	-	-	-	-	-	-
Epinephelus adscensionis	-	-	-	-	-	-	-	-
Epinephelus nigritus	-	-	-	-	-	-	-	-
Liopropama eukrines	.381	-	-	-	-	-	-	-
Holanthias martinicensis	30.497	-	-	-	-	-	-	-
Paranthias furcifer	-	-	-	-	-	-	-	-
Serranus phoebe	.381	.728	-	-	-	-	-	-
Serranus spp. small sea bass	-	-	-	-	-	-	-	-
Mycteroperca/Epinephelus spp.	-	-	-	-	-	-	-	-
Epinephelus spp.	-	-	-	-	-	-	-	-
Family Serranidae (Barred)	1.906	6.549	8.174	5.994	15.027	2.697	6.061	-
Family Serranidae (Pikea/Hemanthias)	-	-	-	-	-	-	-	-
Mycteroperca spp.	.762	-	-	-	-	-	-	-
Priacanthus arenatus	6.862	.728	-	-	-	-	-	-
Malacanthus plumieri	-	-	-	-	-	-	-	-
Caranx crysos	-	-	-	-	-	-	-	-
Caranx lugubris	-	-	-	-	-	-	-	-
Caranx ruber	-	-	-	-	-	-	-	-
Elagatis bipinnulata	-	-	-	-	-	-	-	-
Seriola dumerili	1.144	-	-	-	-	-	-	-
Seriola rivoliana	-	-	-	-	-	-	-	-
Lutjanus campechanus	.762	-	-	-	-	2.697	-	-
Lutjanus griseus	-	-	-	-	-	-	-	-
Pristipomoides aquilonari	-	-	-	-	-	-	-	-
Haemulon melanurum	-	-	-	-	-	-	-	-
Calamus nodosus	-	-	-	-	-	-	-	-
Calamus spp.	-	-	-	-	-	-	-	-
Equetus lanceolatus	-	-	-	-	-	-	-	-
Equetus umbrosus	-	-	-	-	-	-	-	-
Mulloidichthys martinicus	-	-	-	-	-	-	-	-
Pseudupeneus maculatus	-	-	-	-	-	-	-	-
Kyphosus spp.	-	-	-	-	-	-	-	-
Centropyge argi	-	-	-	-	-	-	-	-
Chaetodon ocellatus	-	-	-	-	-	-	-	-
Chaetodon sedentarius	1.144	-	-	-	-	-	-	-
Chaetodon striatus	-	-	-	-	-	-	-	-
Holacanthus tricolor	-	-	-	-	-	-	-	-
Pomacanthus paru	-	-	-	-	-	-	-	-
Prognathodes aculeatus	-	-	-	-	-	-	-	-
Holacanthus spp.	-	-	-	-	-	-	-	-
Chaetodon spp.	-	-	-	-	-	-	-	-
Chromis enchrysurus	-	-	-	-	-	-	-	-
Pomacentrus partitus	-	-	-	-	-	-	-	-
Chromis/Pomacentrus spp.	-	-	-	-	-	-	-	-
Chromis spp.	-	-	-	-	-	-	-	-
Pomacentrus spp.	-	-	-	-	-	-	-	-
Bodianus pulchellus	-	-	-	-	-	-	-	-
Bodianus rufus	-	-	-	-	-	-	-	-
Clepticus parrai	-	-	-	-	-	-	-	-
Decodon puellaris	.381	-	-	-	-	-	-	-
Halichoeres garnoti	-	-	-	-	-	-	-	-
Halichoeres radiatus	-	-	-	-	-	-	-	-
Lachnolamius maximus	-	-	-	-	-	-	-	-
Thalassoma bifasciatum	-	-	-	-	-	-	-	-
Family Labridae	.762	-	-	-	-	-	-	-
Scarus taeniopterus	-	-	-	-	-	-	-	-
Scarus vetula	-	-	-	-	-	-	-	-
Sparisoma aurofrenatum	-	-	-	-	-	-	-	-
Sparisoma viride	-	-	-	-	-	-	-	-
Scarus/Sparisoma spp.	-	-	-	-	-	-	-	-
Sphyraena barracuda	-	-	-	-	-	-	-	-
Family Gobiidae	-	-	-	-	-	-	-	-
Ioglossus spp.	-	-	-	-	-	-	-	-
Acanthurus coeruleus	-	-	-	-	-	-	-	-
Acanthurus spp.	-	-	-	-	-	-	-	-
Balistes capriscus	-	-	-	-	-	-	-	-
Balistes vetula	-	-	-	-	-	-	-	-
Canthirhines macrocerus	-	-	-	-	-	-	-	-
Canthidermis sufflamen	-	-	-	-	-	-	-	-
Melichthys niger	-	-	-	-	-	-	-	-
Xanthichthys ringens	-	-	-	-	-	-	-	-
Lactophrys quadricornis	-	-	-	-	-	-	-	-
Lactophrys triqueter	-	-	-	-	-	-	-	-
Canthigaster rostrata	-	-	-	-	-	-	-	-
Diodon holocanthus	-	-	-	-	-	-	-	-

APPENDIX 6-8

Maximum Likelihood Estimates of Population Size for Selected Species by Major Habitat Type

Coral Reef Bank	Table 1 Figures 1-10
Algal-Nodule Zones	Table 2 Figures 11-14
Shallow Drowned Reef	Table 3 Figures 15-27
Deep Drowned Reef	Table 4 Figures 28-35

Table 1. Distribution types and maximum likelihood population size estimates with 95% confidence bands for selected species, Coral Reef Habitat, cruises 5-8, East Flower Garden Bank.

		Coral Reef Bank		
Species	Cruise	Distribution Type	Population Size Estimate	95% Confidence Band
Paranthias furcifer	5	NB(RR)	416280	± 129258
	6	NB(RR)	481441	± 150509
	7	NB(RR)	479696	± 112814
	8	NB(RR)	777928	± 188848
Mycteroperca	5	NB(RR)	5143	± 3912
	6	NB(RR)	3982	± 1925
	7	NB(RR)	3751	± 2684
	8	NB(RR)	6892	± 3791
Chromis spp.	5	NB(RR)	72551	± 42841
	6	NB(C)	152589	± 23489
	7	NB(C)	222953	± 37337
	8	NB(RR)	357736	± 206151
Clepticus parrai	5	NB(RR)	81380	± 66090
	6	NB(RR)	136930	± 100047
	7	NB(RR)	141410	± 82256
	8	NB(RR)	226081	± 145592
Haemulon melanurum	5	NB(RR)	293	± 1014
	6	P	141	± 113
	7	NB(RR)	6233	± 19740
	8	P	251	± 246
Bodianus pulchellus	5	NB(RR)	5957	± 4445
	6	NB(RR)	8399	± 6157
	7	NB(RR)	7660	± 3565
	8	NB(RR)	11019	± 5130
Chaetodon sedentarius	5	NB(C)	10481	± 4501
	6	NB(C)	8091	± 1862
	7	NB(RR)	18076	± 6417
	8	NB(RR)	23717	± 6958
Calamus nodosus	5	P	1347	± 440
	6	NB(RR)	1007	± 941
	7	NB(RR)	2957	± 2373
	8	NB(RR)	2646	± 2463
Pomacanthus paru	5	NB(RR)	1613	± 2316
	6	P	847	± 277
	7	NB(RR)	2202	± 2312
	8	P	2883	± 833
Holocentrus spp.	5	NB(RR)	527	± 1222
	6	P	329	± 172
	7	NB(RR)	731	± 1552
	8	NB(RR)	1550	± 2698

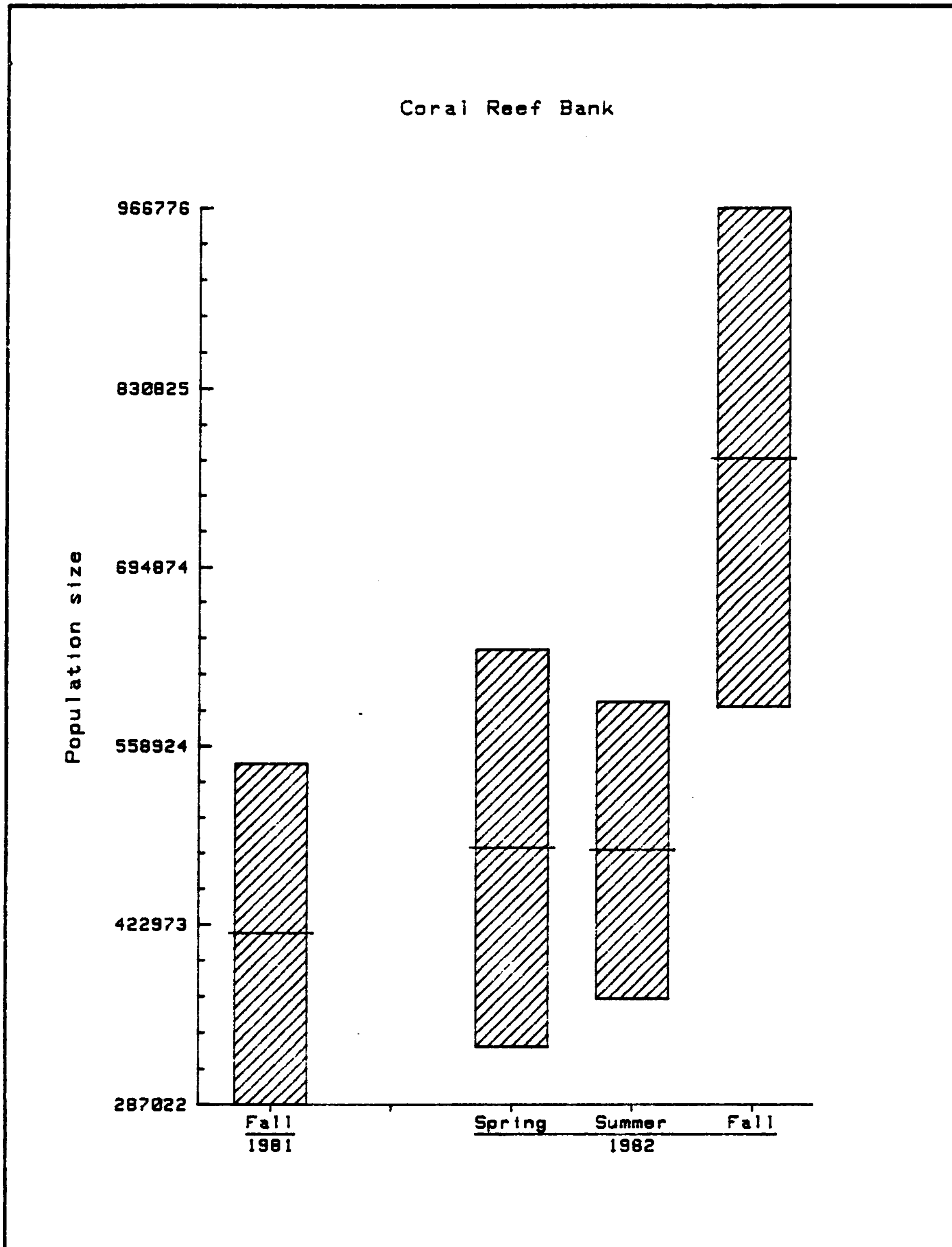


Fig. 1. Maximum likelihood estimates of population size for creolefish, <u>Paranthias furcifer</u>, coral reef bank, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

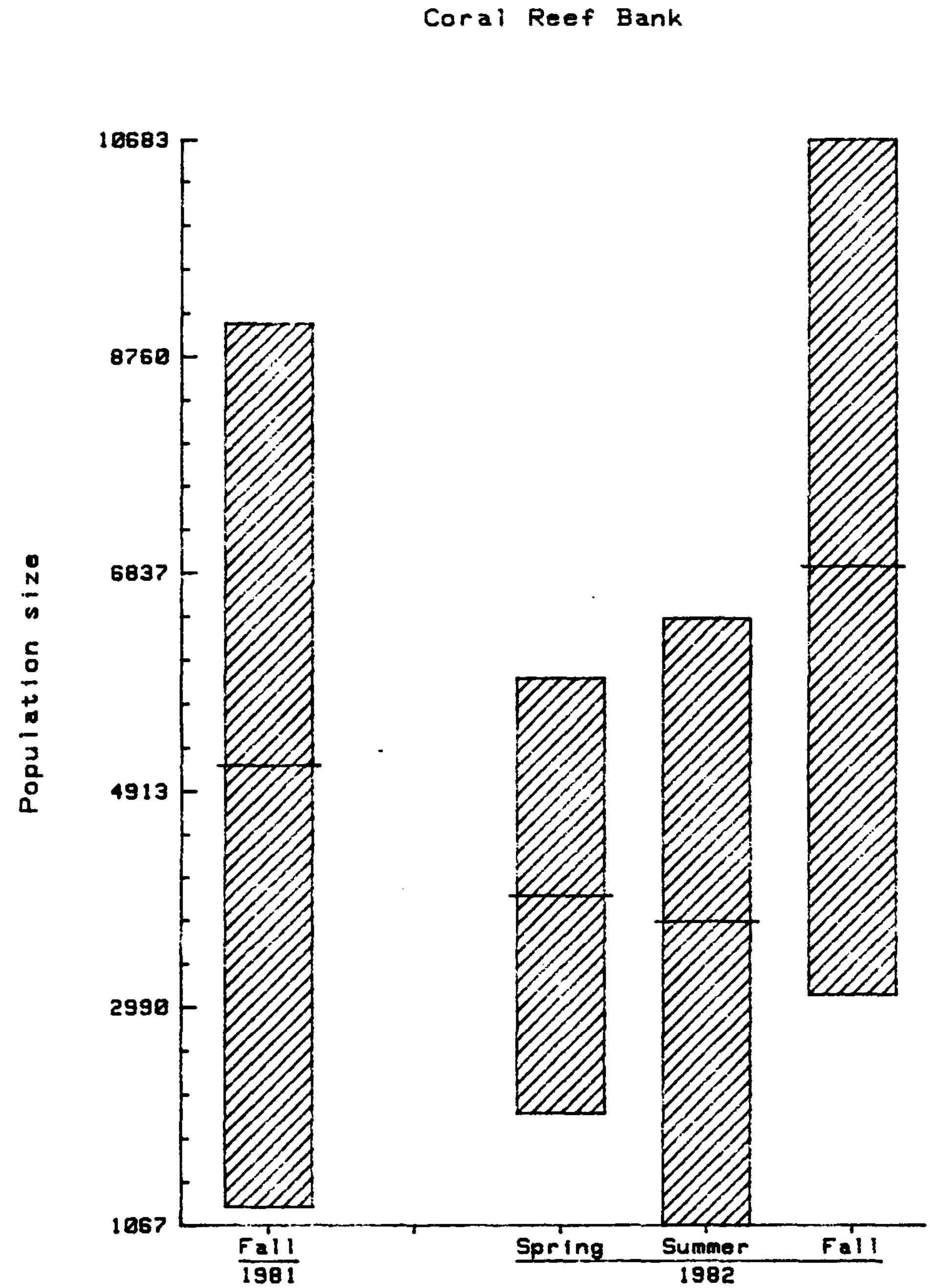


Fig. 2. Maximum likelihood estimates of population size for groupers, *Mycteroperca* spp., coral reef bank, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

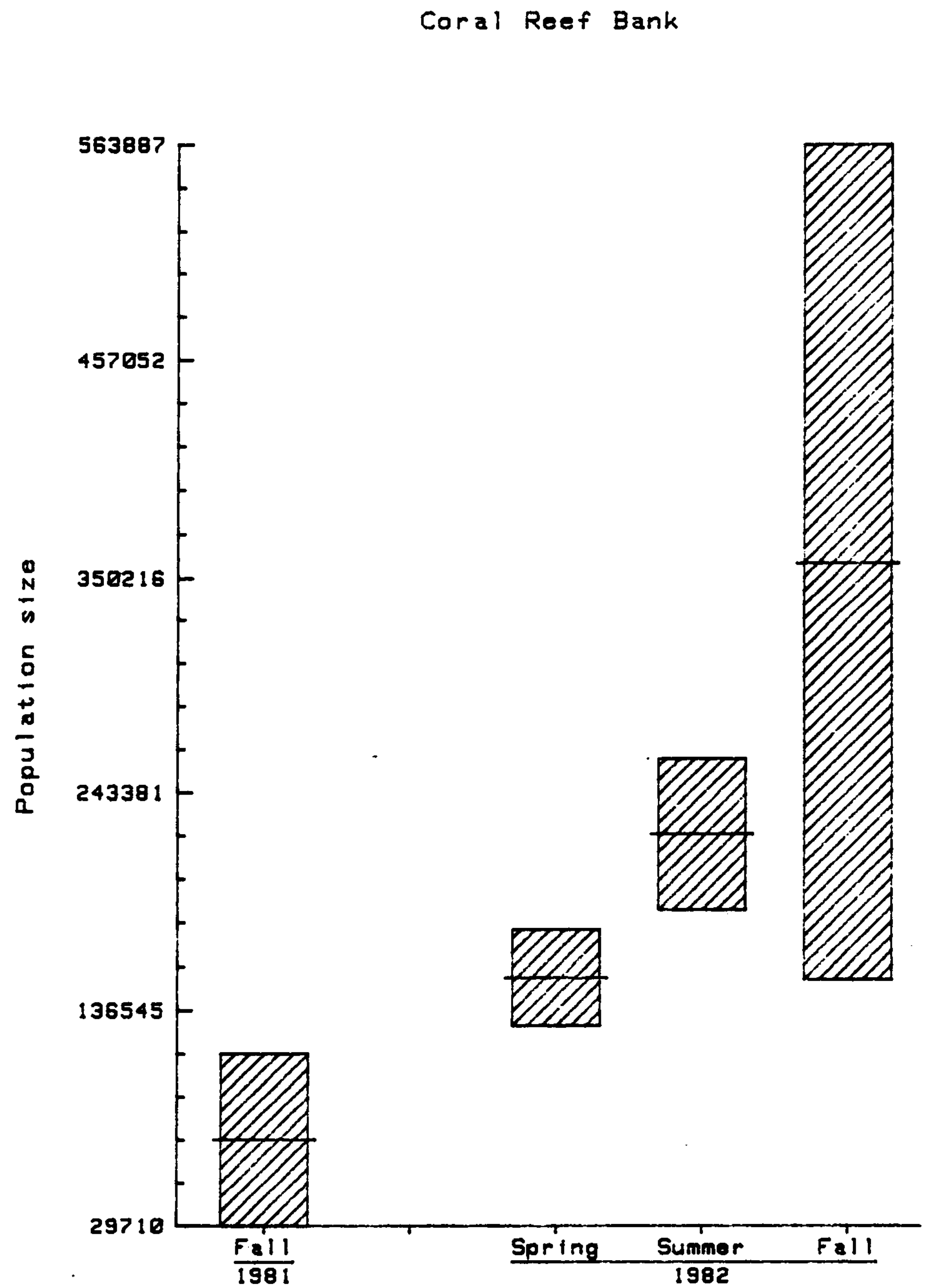


Fig. 3. Maximum likelihood estimates of population size for brown and blue chromis, *Chromis* spp., coral reef bank, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

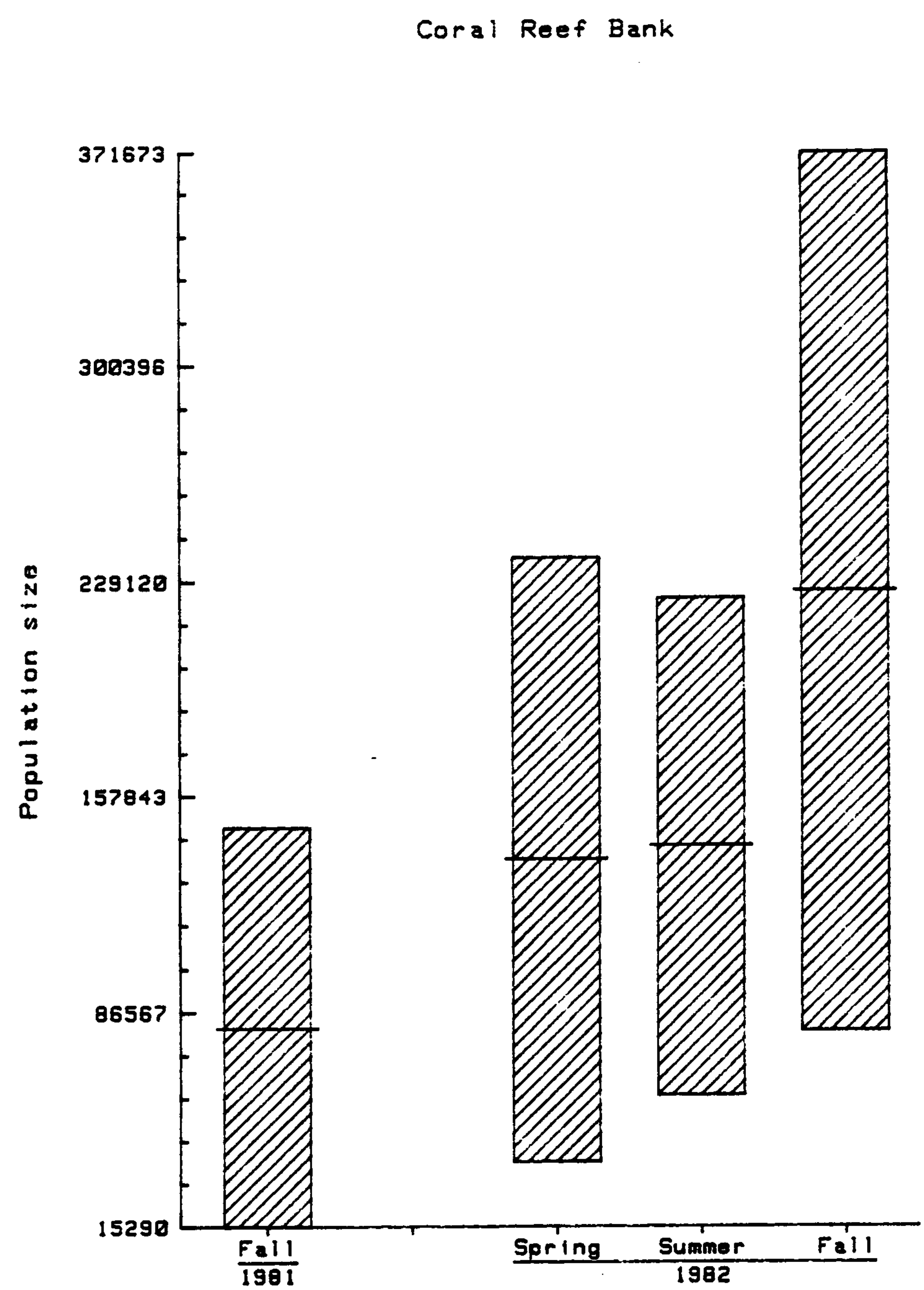


Fig. 4. Maximum likelihood estimates of population size for creole wrasse, *Clepticus parrai*, coral reef bank, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

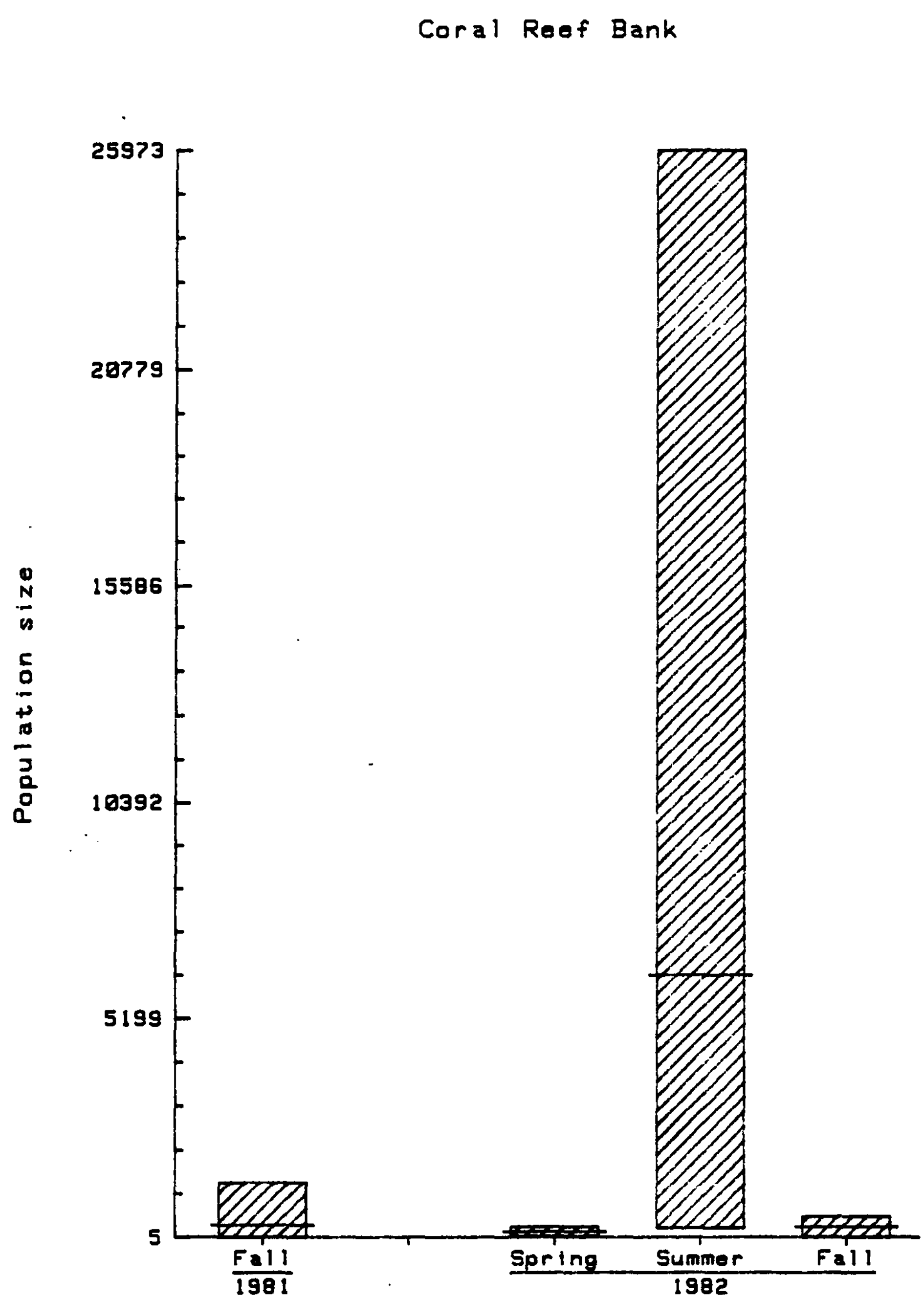


Fig. 5. Maximum likelihood estimates of population size for cottonwick, Haemulon melanurum, coral reef bank, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

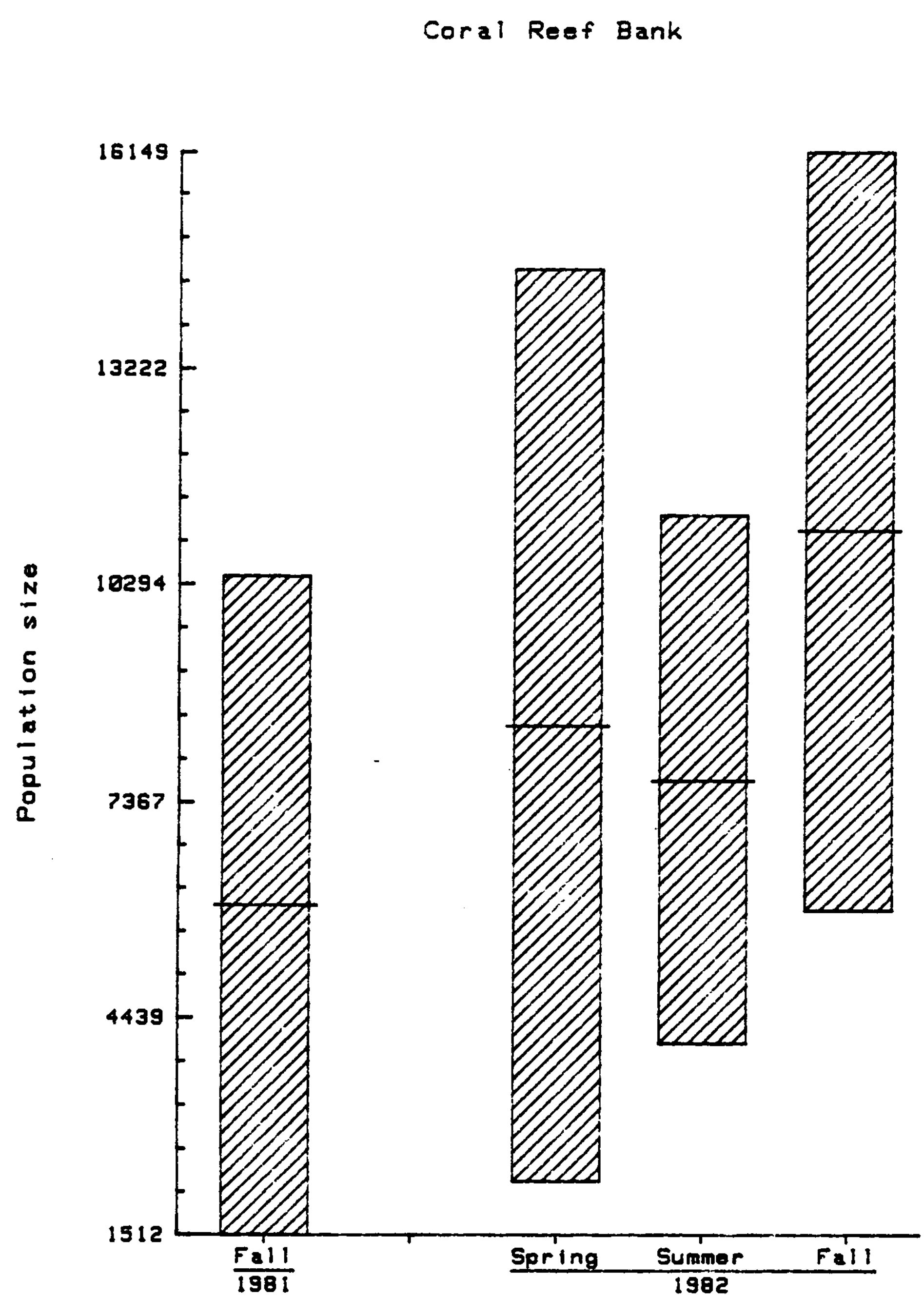


Fig. 6. Maximum likelihood estimates of population size for spotfin hogfish, Bodianus pulchellus, coral reef bank, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

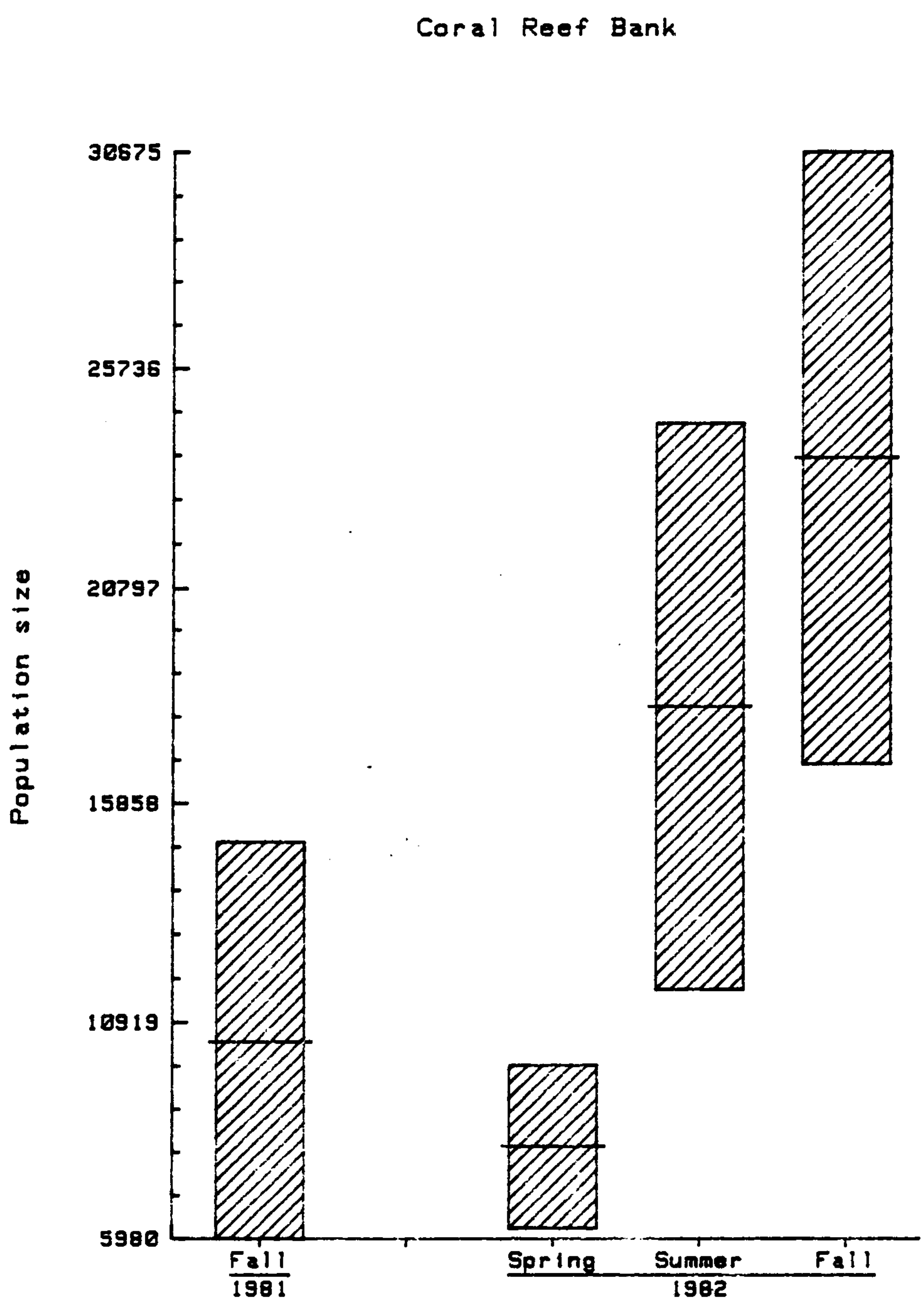


Fig. 7. Maximum likelihood estimates of population size for reef butterflyfish, Chaetodon sedentarius, coral reef bank, with 95% confidence bands on individual estimates only. Cruises 5-8. East Flower Garden Bank.

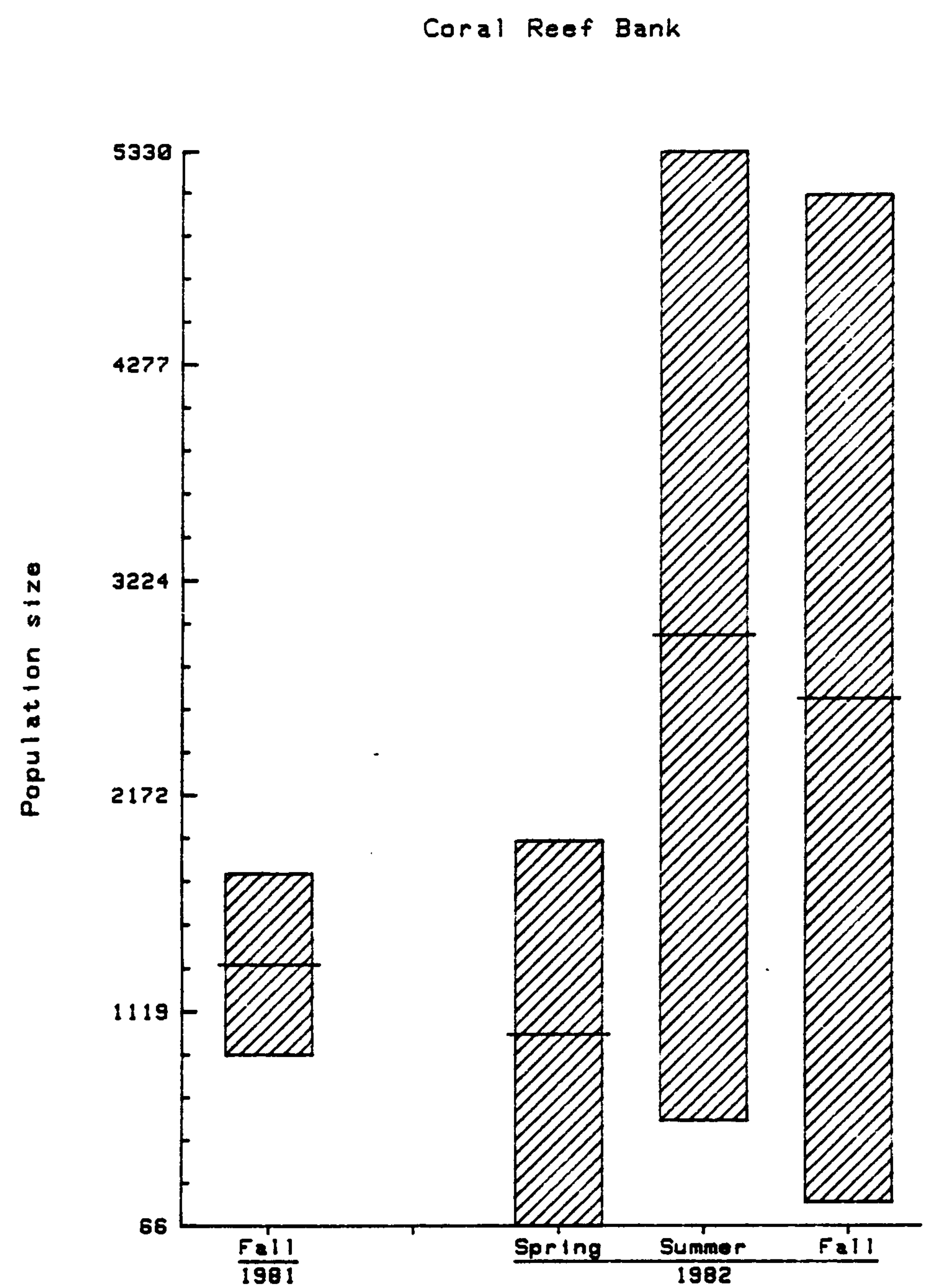


Fig. 8. Maximum likelihood estimates of population size for knobbed porgy, Calamus nodosus, coral reef bank, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

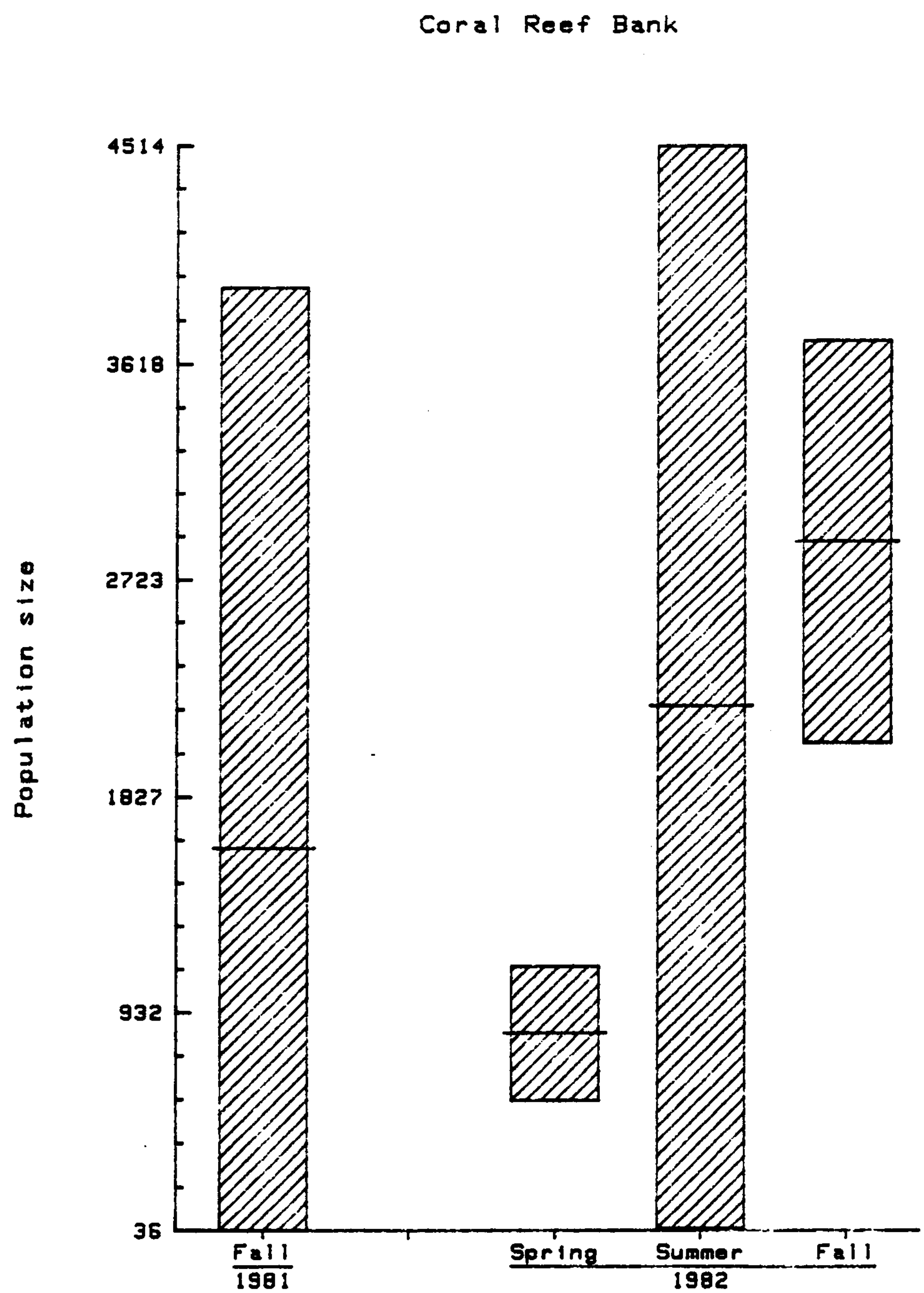


Fig. 9. Maximum likelihood estimates of population size for French angelfish, Pomacanthus paru, coral reef bank, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

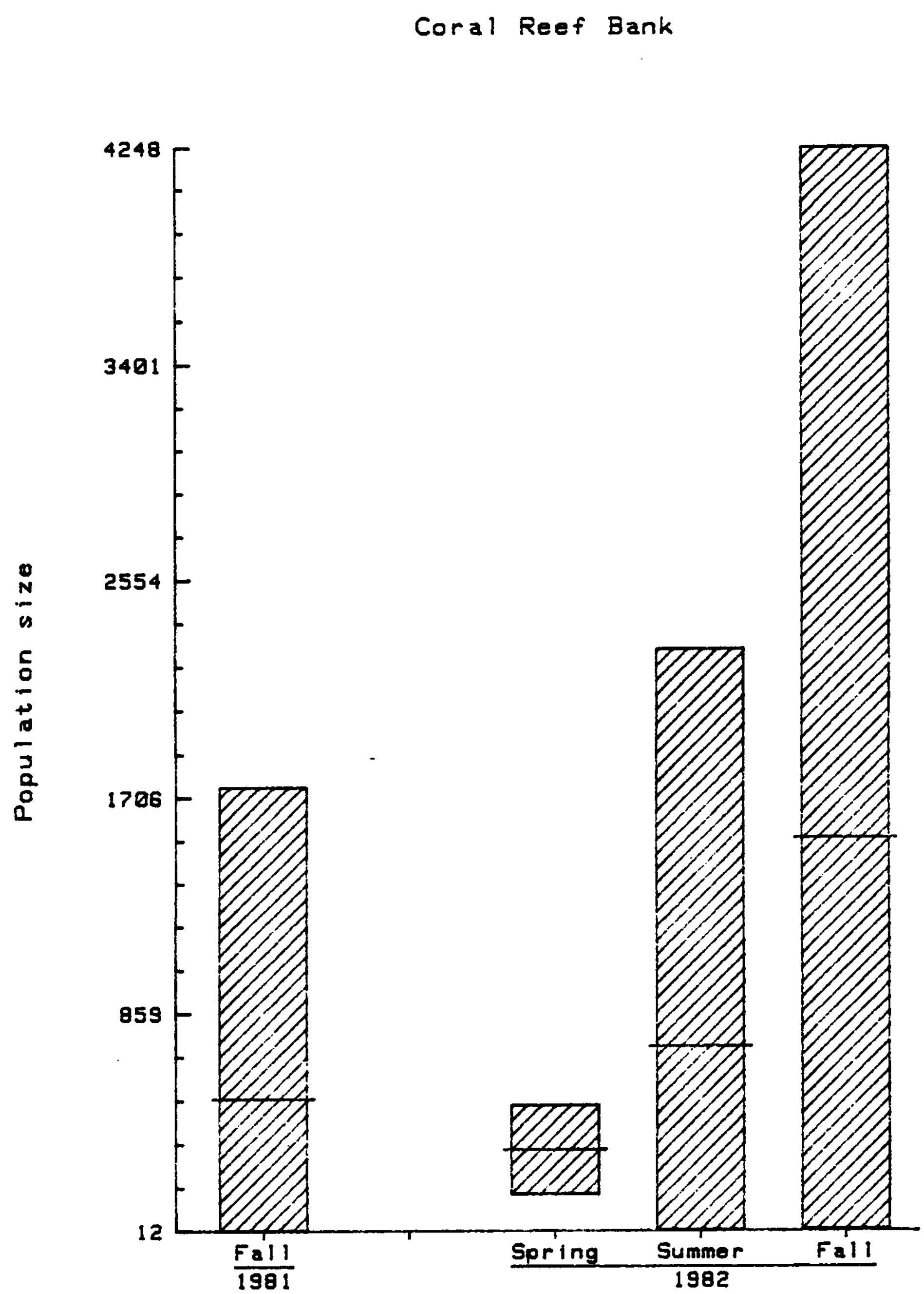


Fig. 10. Maximum likelihood estimates of population size for squirrelfish, Holocentrus spp., coral reef bank, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

Table 2. Distribution types and maximum likelihood population size estimates with 95% confidence bands for selected species, Algal-Nodule Zones, Cruises 5-8, East Flower Garden Bank.

		Algal Nodule Zone		
Species	Cruise	Distribution Type	Population Size Estimate	95% Confidence Band
Chromis enchrysurus	5	NB(RR)	152108	± 110619
	6	NB(RR)	16754	± 23164
	7	NB(RR)	98734	± 54823
	8	NB(RR)	204834	± 134677
Bodianus pulchellus	5	P	541	± 750
	6	P	1178	± 816
	7	P	827	± 810
	8	P	3144	± 1948
Chaetodon sedentarius	5	P	6497	± 2599
	6	NB(RR)	3389	± 6469
	7	NB(RR)	29107	± 25480
	8	NB(RR)	24086	± 21342
Pomacanthus paru	5	P	7579	± 2807
	6	P	3533	± 1413
	7	P	6202	± 2219
	8	P	12574	± 3897

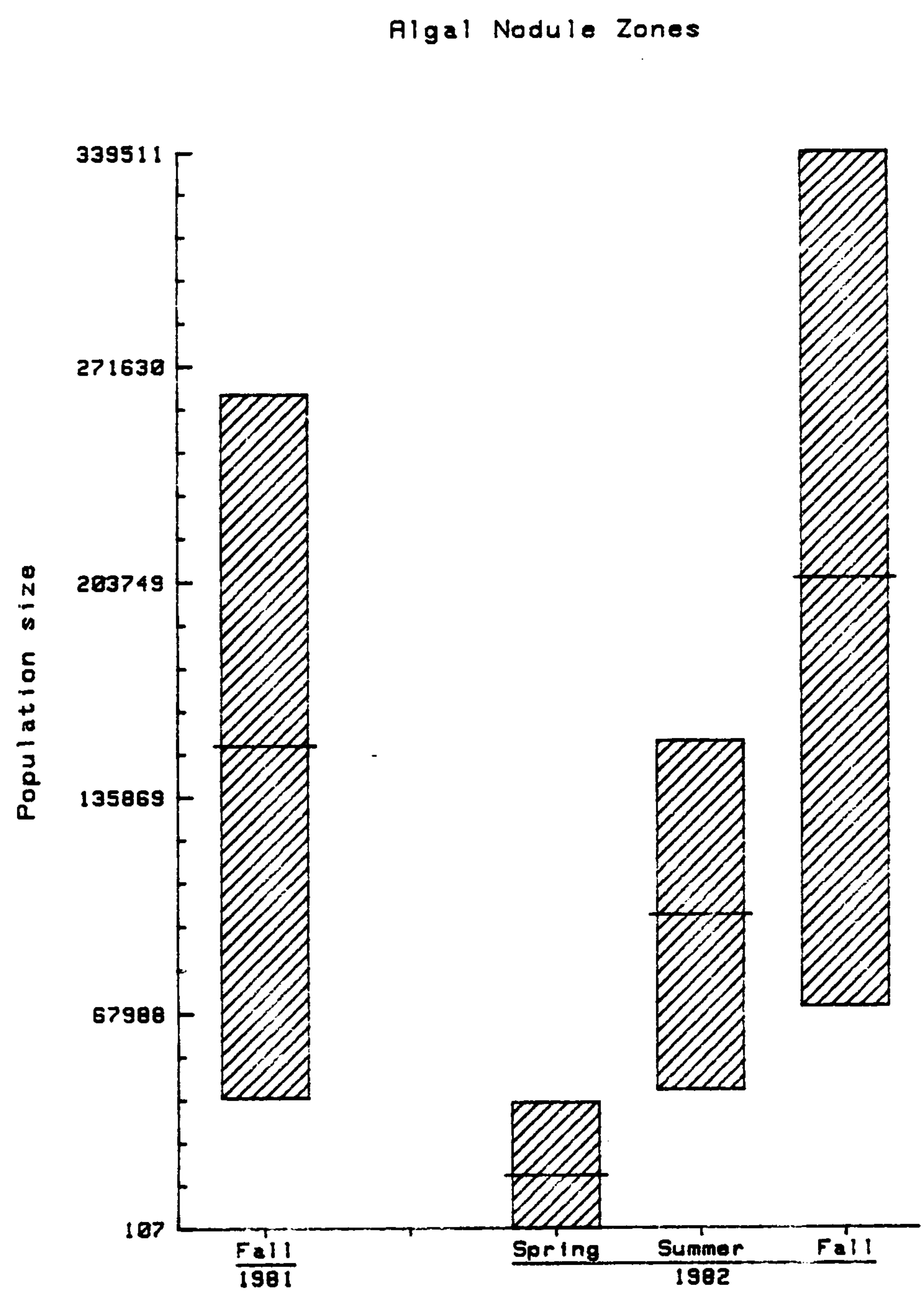


Fig. 11. Maximum likelihood estimates of population size for yellowtail reeffish, Chromis enchrysurus, algal nodule zones, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

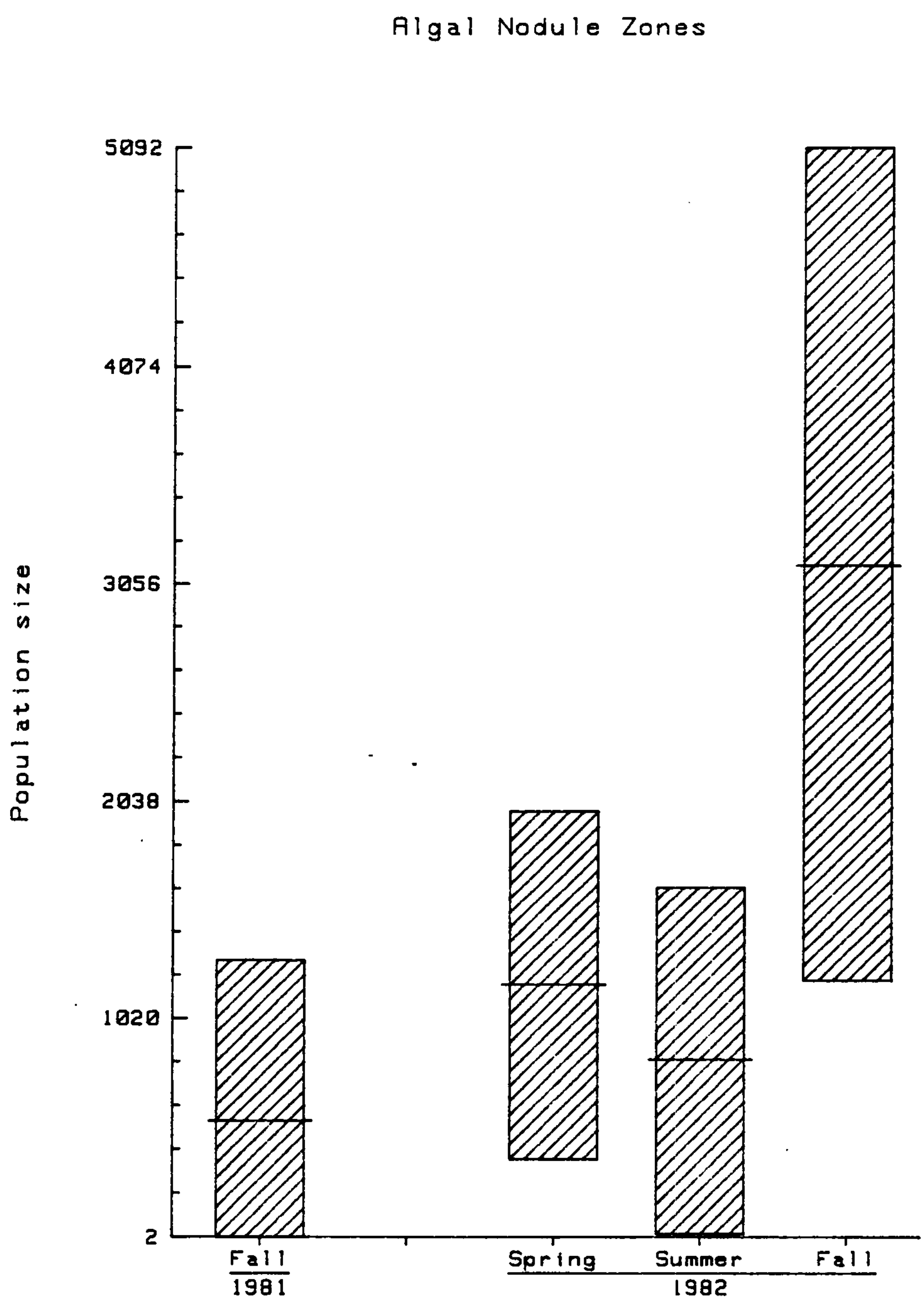


Fig. 12. Maximum likelihood estimates of population size for spotfin hogfish, Bodianus pulchellus, algal nodule zones, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

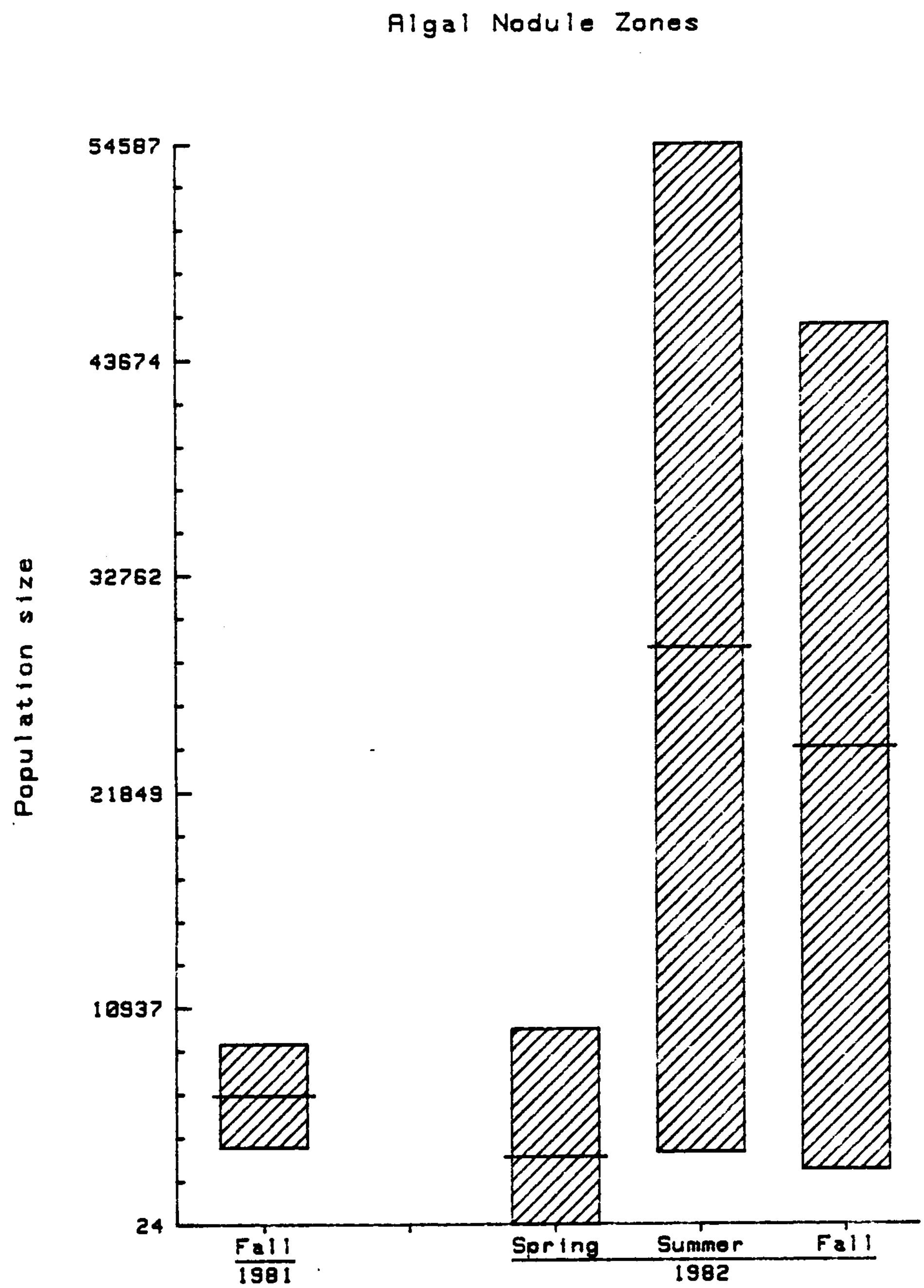


Fig. 13. Maximum likelihood estimates of population size for reef butterflyfish, Chaetodon sedentarius, algal nodule zones, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Banks.

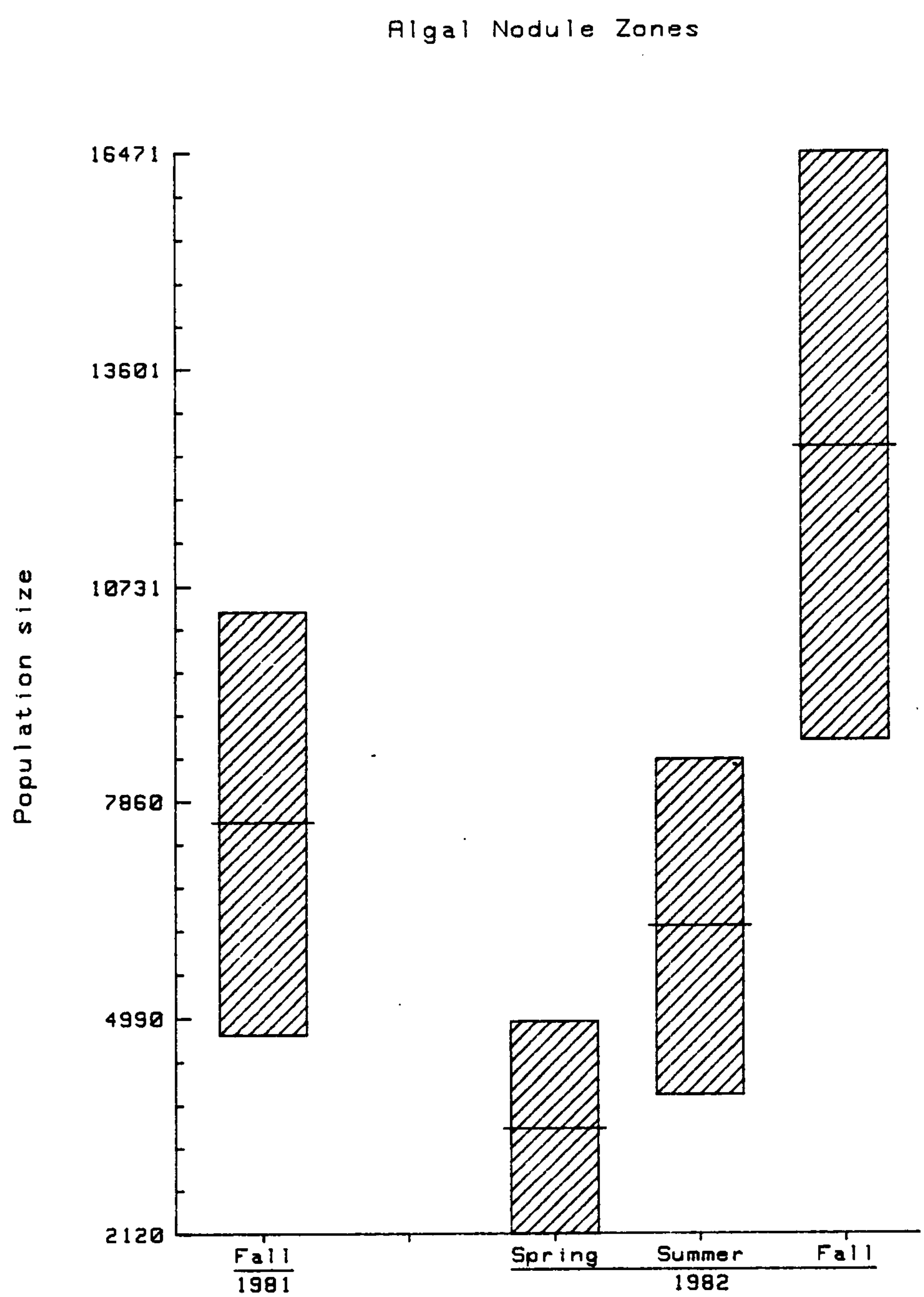


Fig. 14. Maximum likelihood estimates of population size for French angelfish, Pomacanthus paru, algal nodule zones, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

Table 3. Distribution types and maximum likelihood population size estimates with 95% confidence bands for selected species, Shallow Drowned Reef, Cruises 5-8, East Flower Garden Bank.

		Shallow Drowned Reef		
Species	Cruise	Distribution Type	Population Size Estimate	95% Confidence Band
Paranthias furcifer	5	NB(RR)	26161	± 50621
	6	NB(RR)	36045	± 116886
	7	NB(RR)	52268	± 56884
	8	NB(RR)	216020	± 128166
Mycteroperca	5	NB(C)	7651	± 1147
	6	NB(RR)	4974	± 2292
	7	NB(RR)	5898	± 2904
	8	NB(RR)	9938	± 4719
Family Serranidae (barred)	5	NB(RR)	224	± 1843
	6	P	179	± 143
	7	-	-	-
	8	-	-	-
Haemulon melanurum	5	NB(RR)	318	± 1047
	6	NB(RR)	9777	± 154136
	7	-	-	-
	8	P	100	± 138
Chromis enchrysurus	5	NB(RR)	130216	± 52442
	6	NB(RR)	76082	± 22080
	7	NB(RR)	127866	± 30020
	8	NB(RR)	228106	± 51043
Bodianus pulchellus	5	NB(RR)	6572	± 5295
	6	NB(RR)	3522	± 2272
	7	NB(C)	6784	± 711
	8	NB(RR)	10401	± 4325
Lutjanus campechanus	5	NB(RR)	1655	± 4548
	6	NB(RR)	1964	± 3696
	7	NB(C)	4177	± 437
	8	NB(RR)	2667	± 3830
Priacanthus arenatus	5	P	1058	± 442
	6	P	835	± 309
	7	P	436	± 228
	8	P	299	± 239
Chaetodon sedentarius	5	NB(RR)	9781	± 5975
	6	NB(RR)	8178	± 4327
	7	NB(RR)	13650	± 5140
	8	NB(C)	22398	± 4530
Pagrus sedecium	5	P	1155	± 462
	6	NB(RR)	694	± 1176
	7	NB(RR)	1629	± 4777
	8	-	-	-
Calamus nodosus	5	P	770	± 377
	6	NB(RR)	477	± 400
	7	P	1650	± 444
	8	NB(RR)	3214	± 2367
Pomacanthus paru	5	NB(RR)	1329	± 2071
	6	NB(RR)	972	± 1345
	7	P	1059	± 356
	8	NB(RR)	2416	± 4940
Holocentrus spp.	5	NB(RR)	2250	± 2175
	6	NB(RR)	2291	± 1833
	7	P	1526	± 427
	8	NB(RR)	5620	± 4257

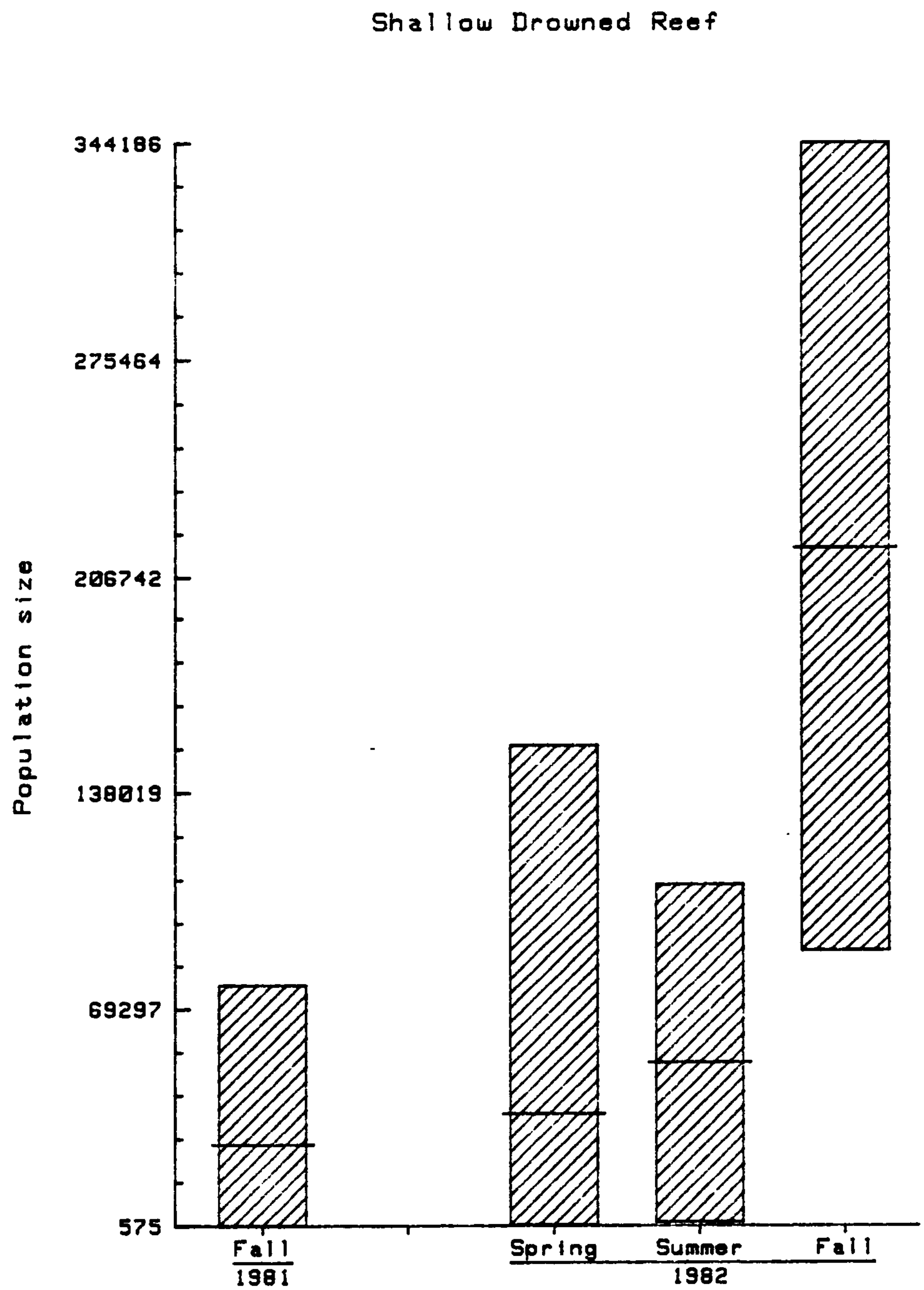


Fig. 15. Maximum likelihood estimates of population size for creole-fish, Paranthias furcifer, shallow drowned reef, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

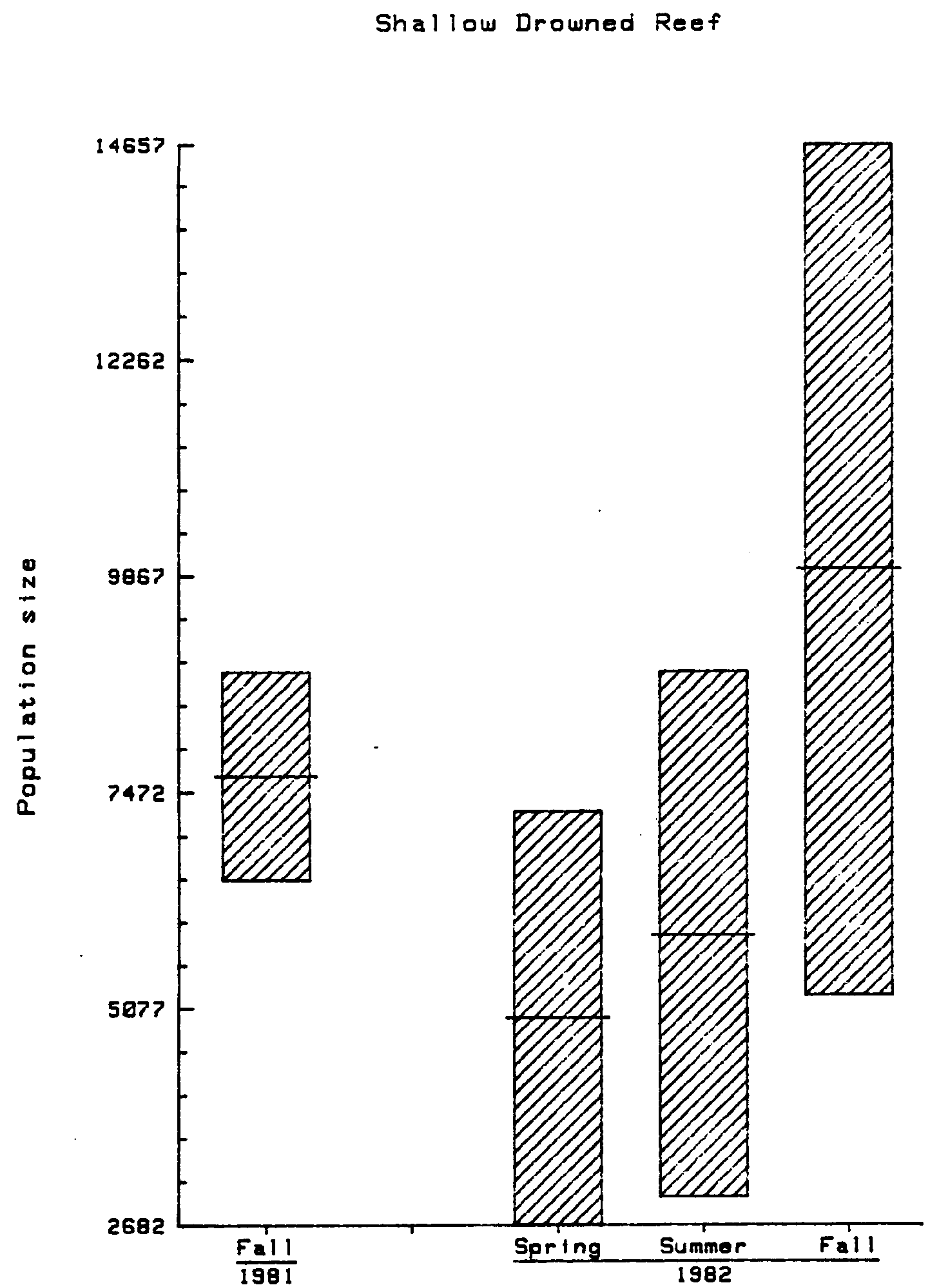


Fig. 16. Maximum likelihood estimates of population size for groupers, *Mycteroperca* spp., shallow drowned reef, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

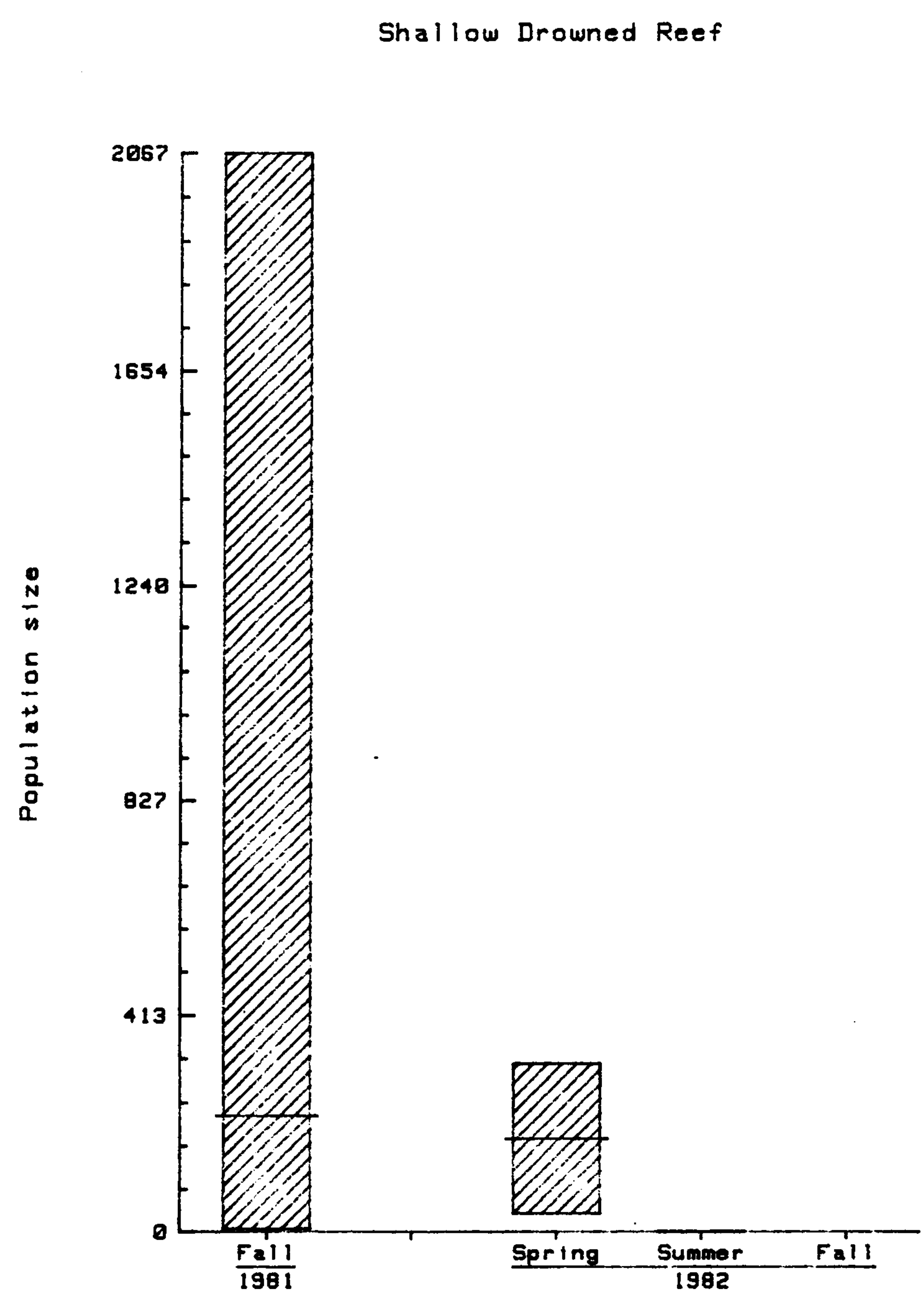


Fig. 17. Maximum likelihood estimates of population size for barred seabasses, Family Serranidae, shallow drowned reef with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

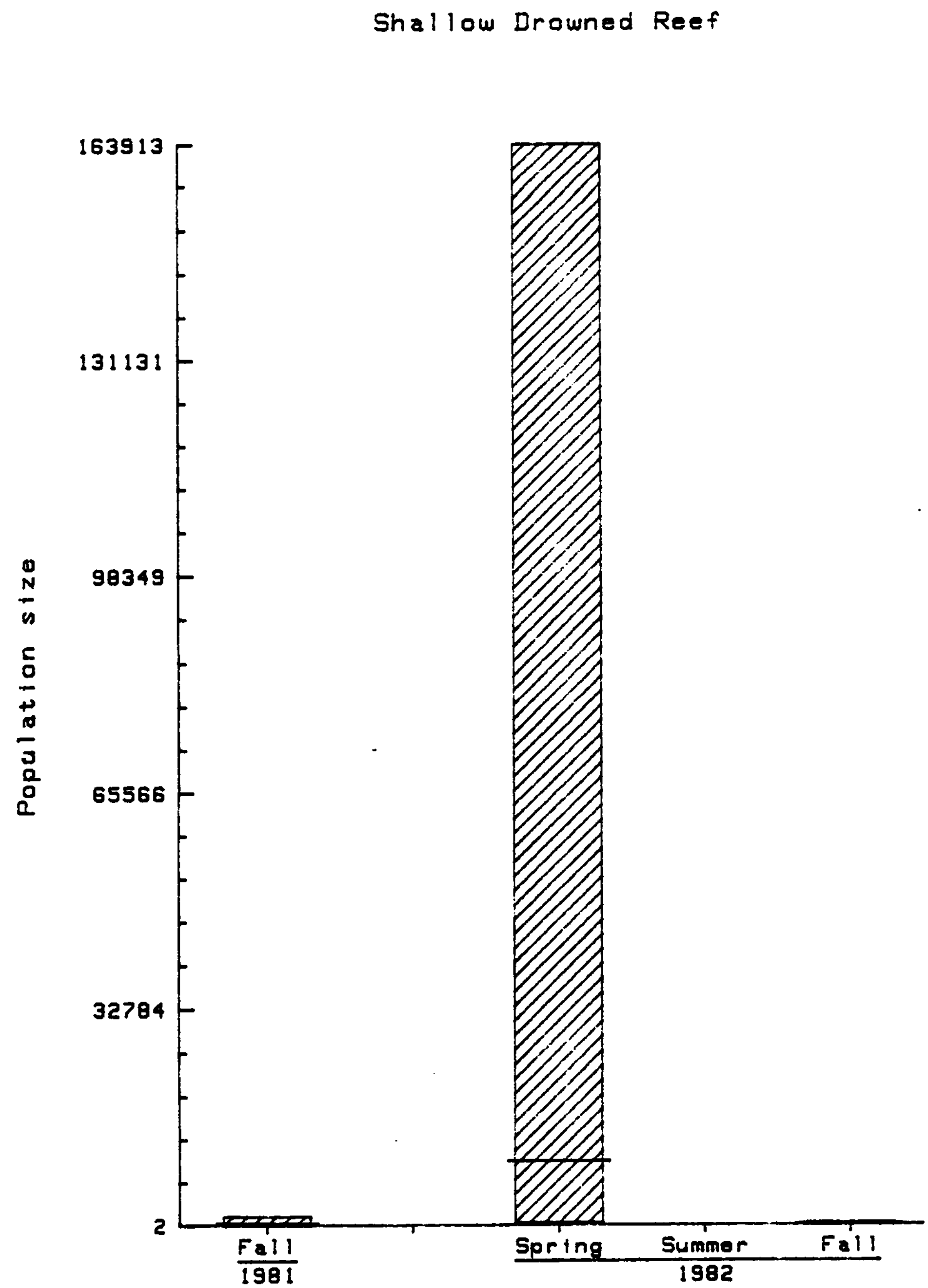


Fig. 18. Maximum likelihood estimates of population size for cotton-wick, Haemulon melanurum, shallow drowned reef, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

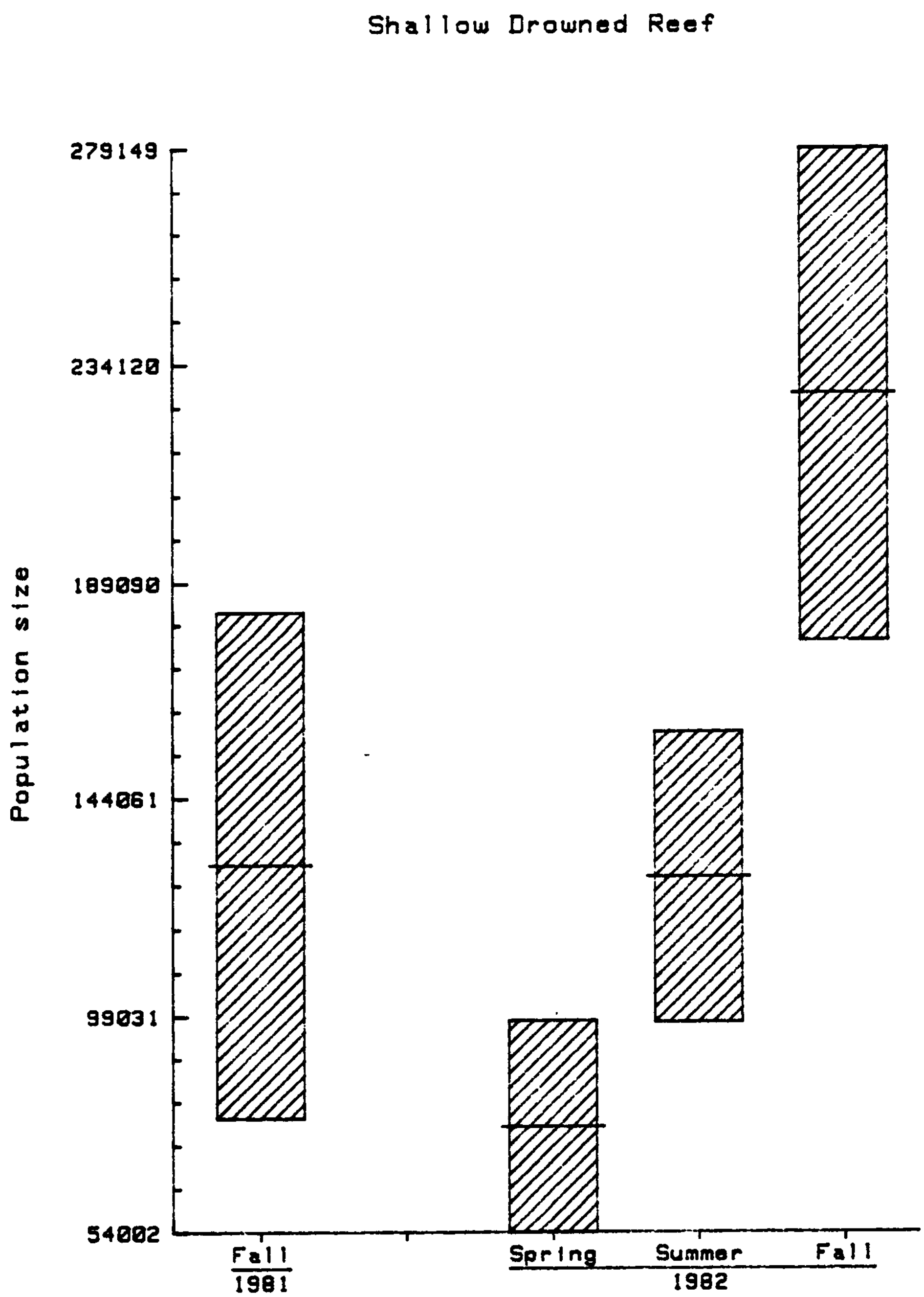


Fig. 19. Maximum likelihood estimates of population size for yellowtail reeffish, Chromis enchrysurus, shallow drowned reef, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

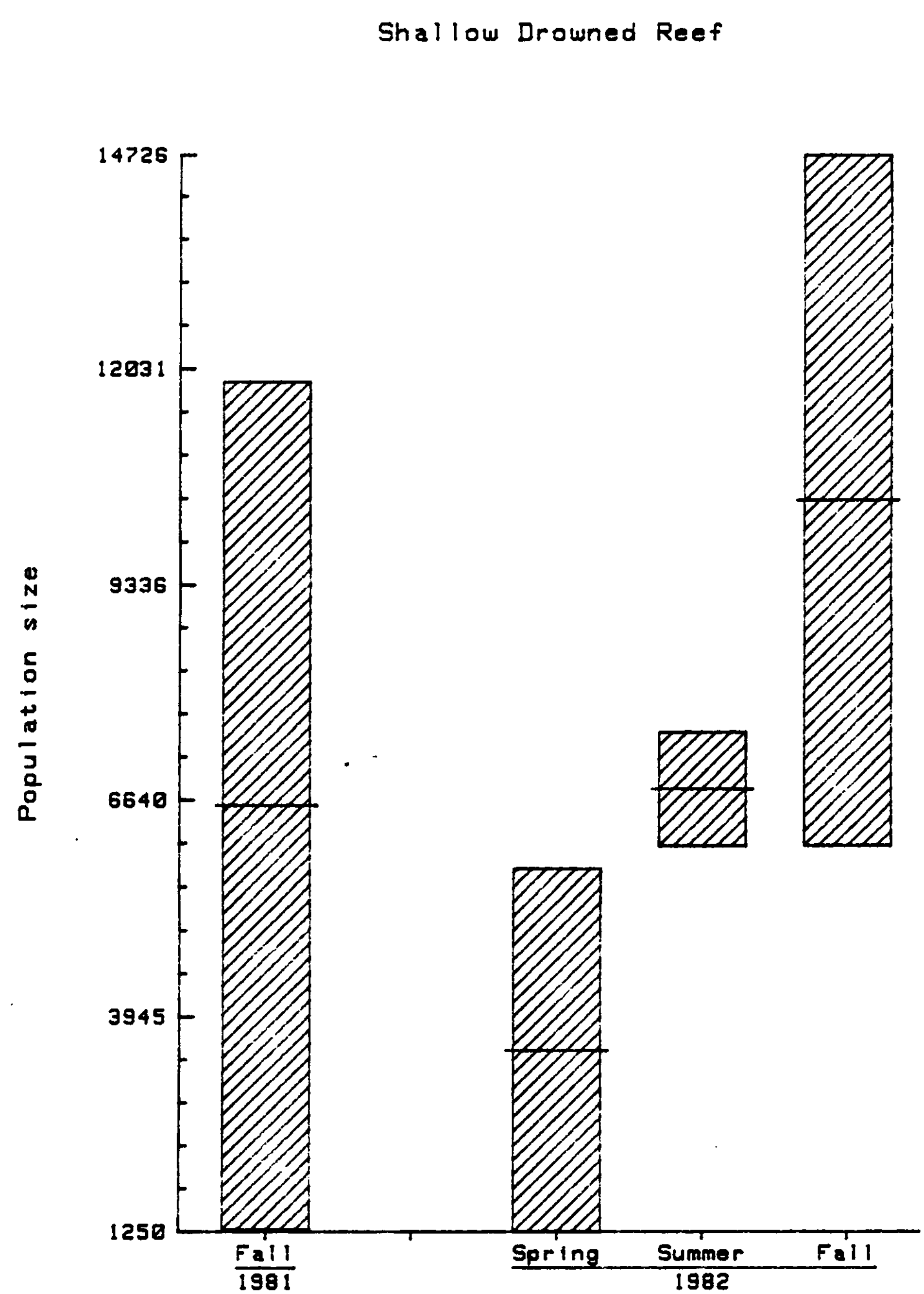


Fig. 20. Maximum likelihood estimates of population size for spotfin hogfish, Bodianus pulchellus, shallow drowned reef, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

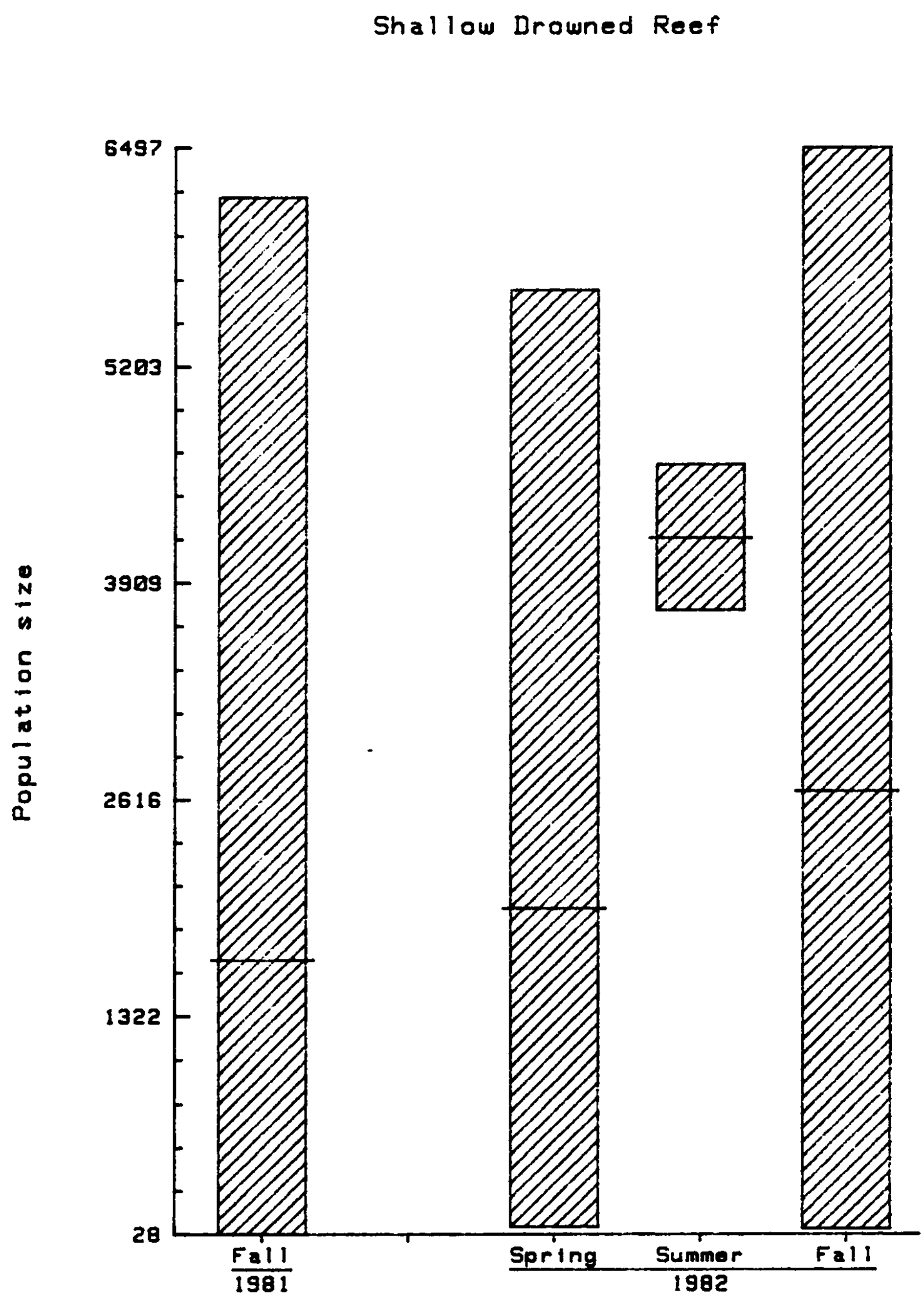


Fig. 21. Maximum likelihood estimates of population size for red snapper, Lutjanus campechanus, shallow drowned reef, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

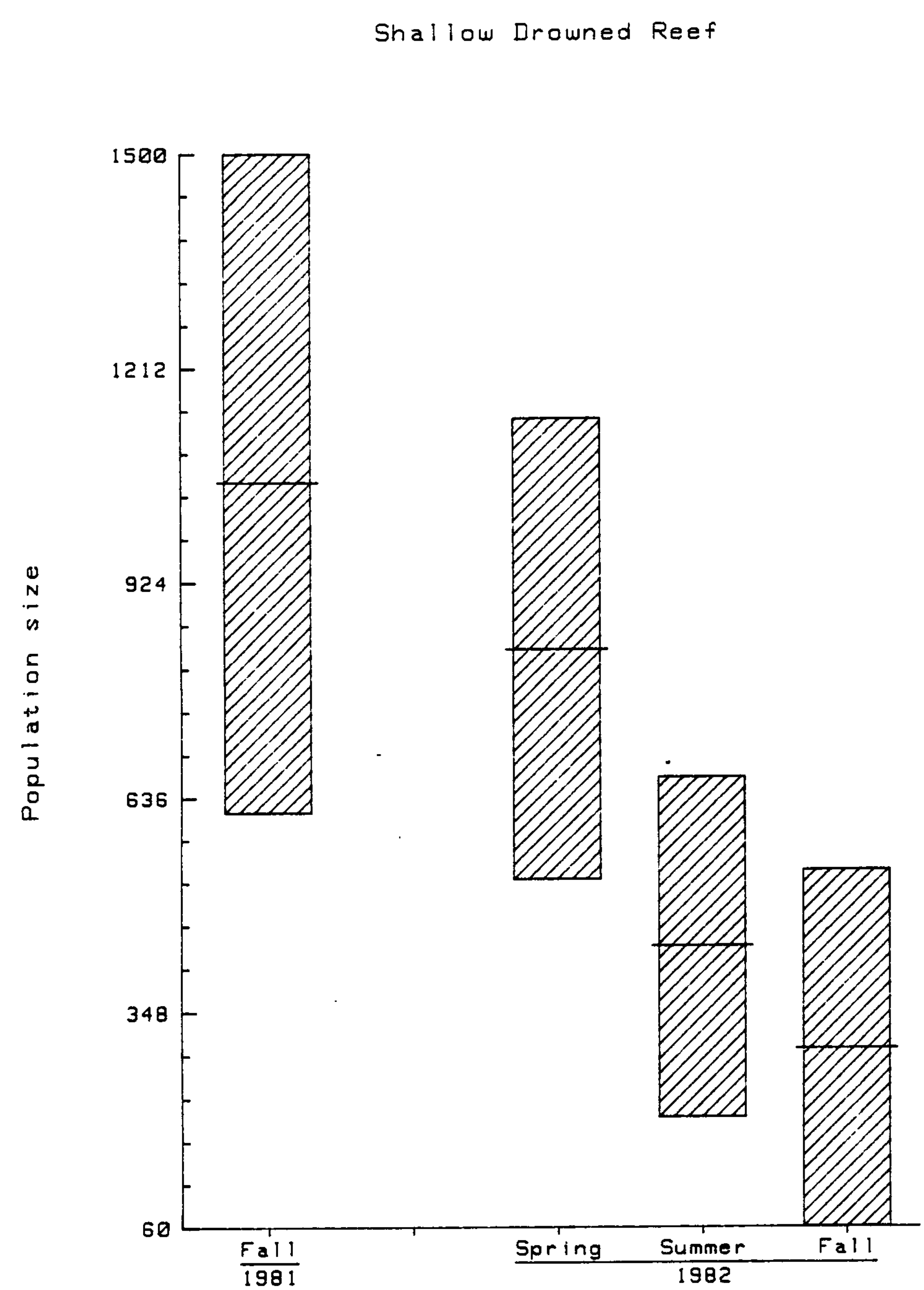


Fig. 22. Maximum likelihood estimates of population size of bigeye, *Priacanthus arenatus*, shallow drowned reef, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

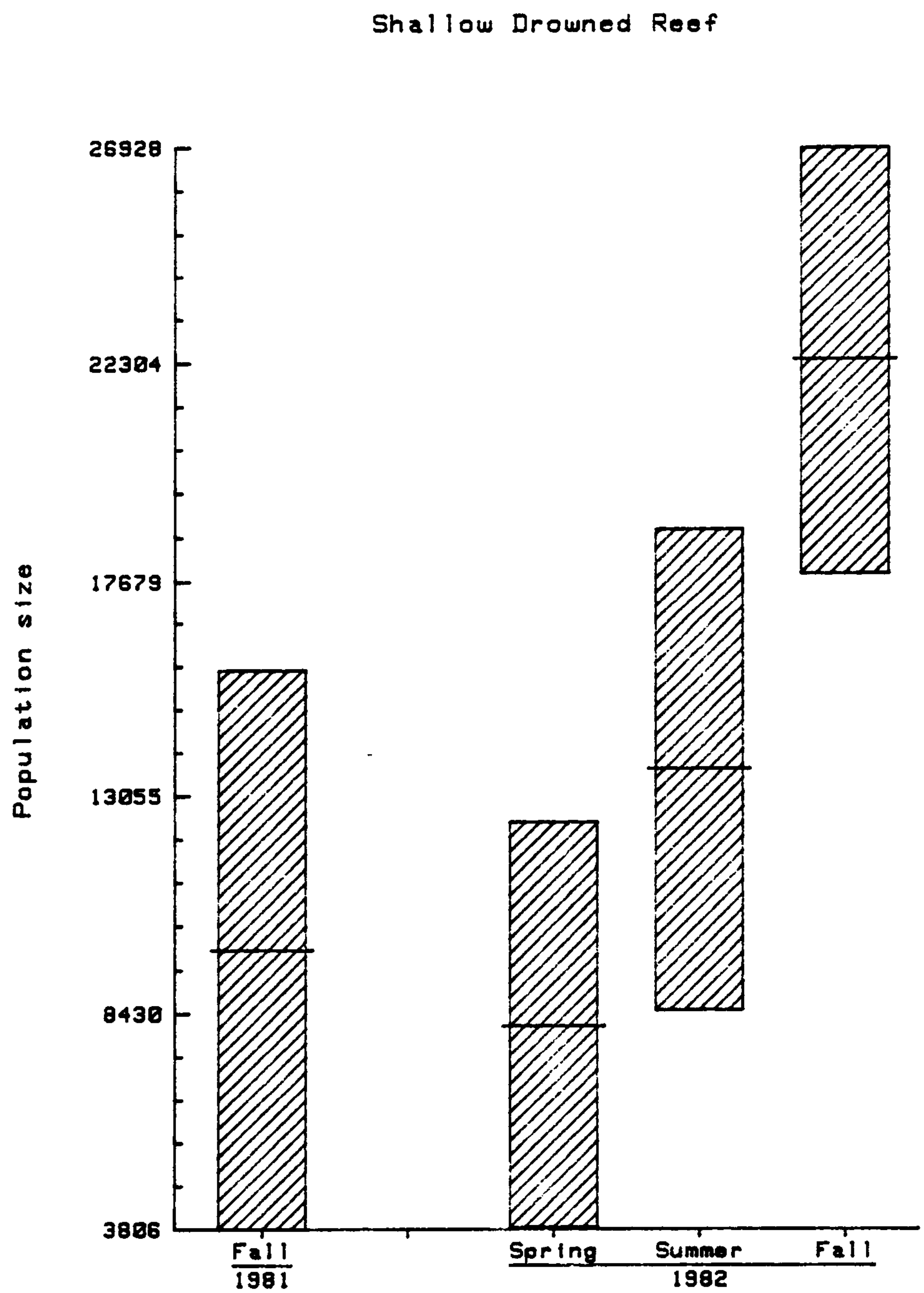


Fig. 23. Maximum likelihood estimates of population size of reef butterflyfish, Chaetodon sedentarius, shallow drowned reef, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

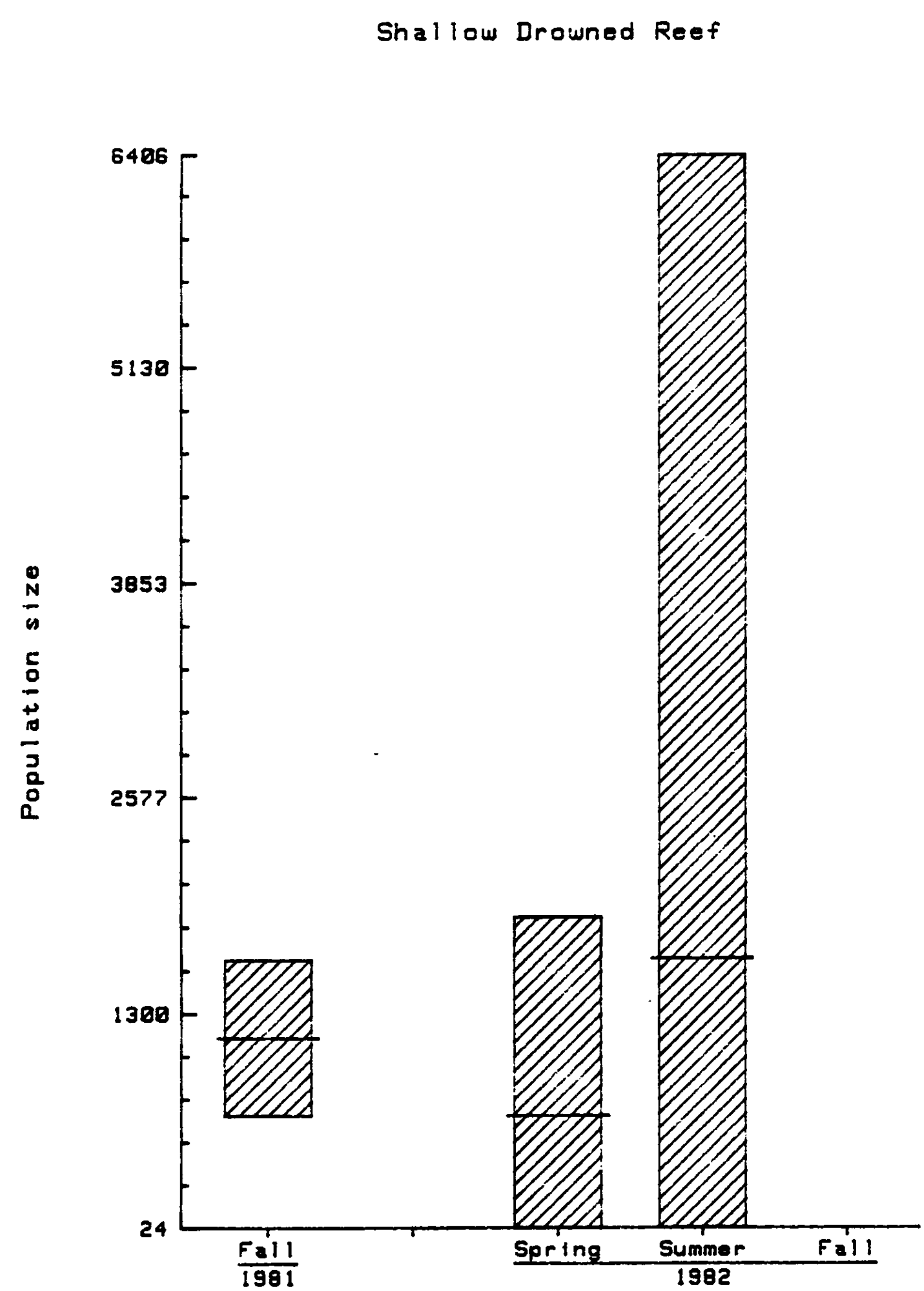


Fig. 24. Maximum likelihood estimates of population size for red porgy, Pagrus sedecim, shallow drowned reef, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

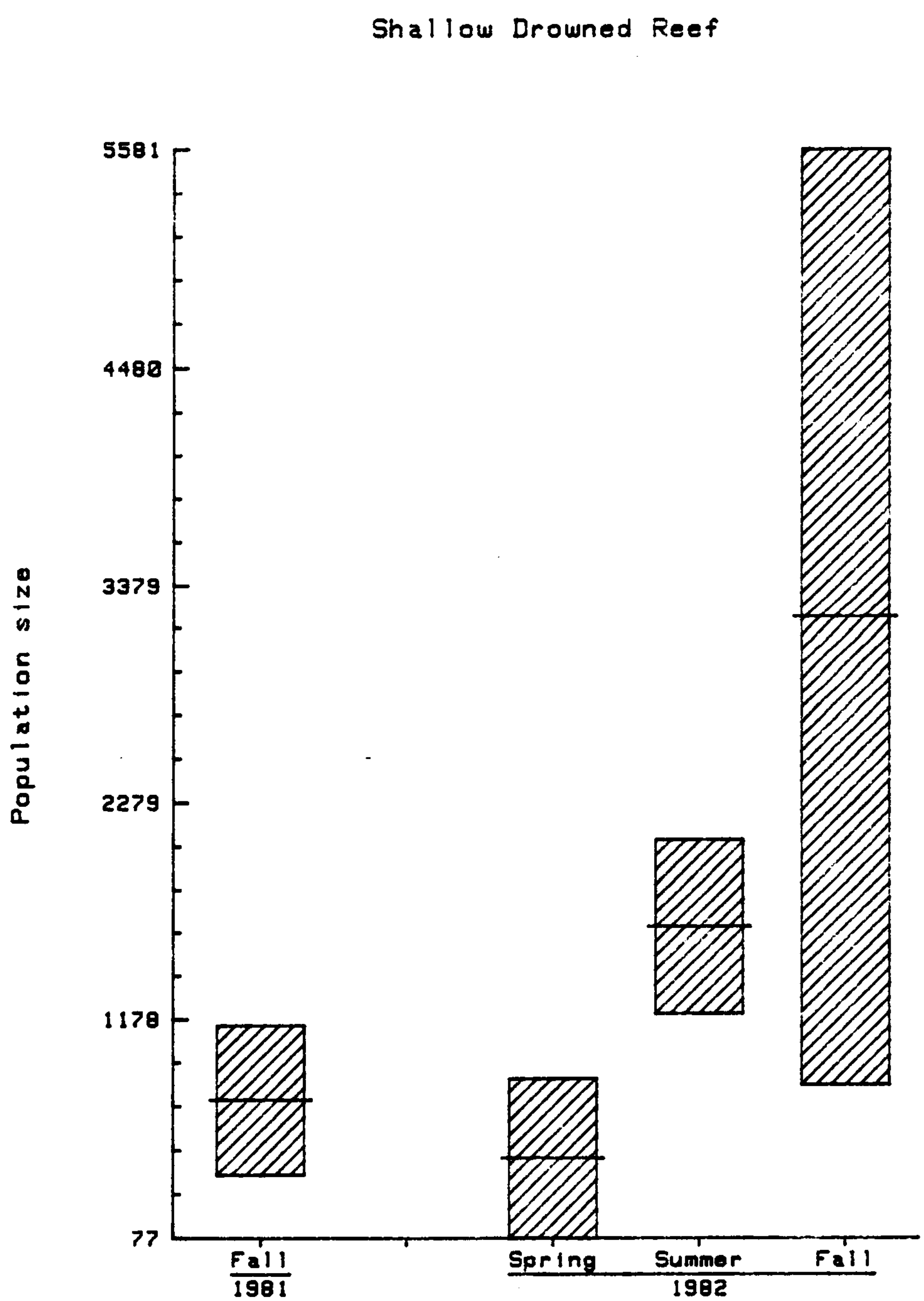


Fig. 25. Maximum likelihood estimates of population size for knobbed porgy, Calamus nodosus, shallow drowned reef, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

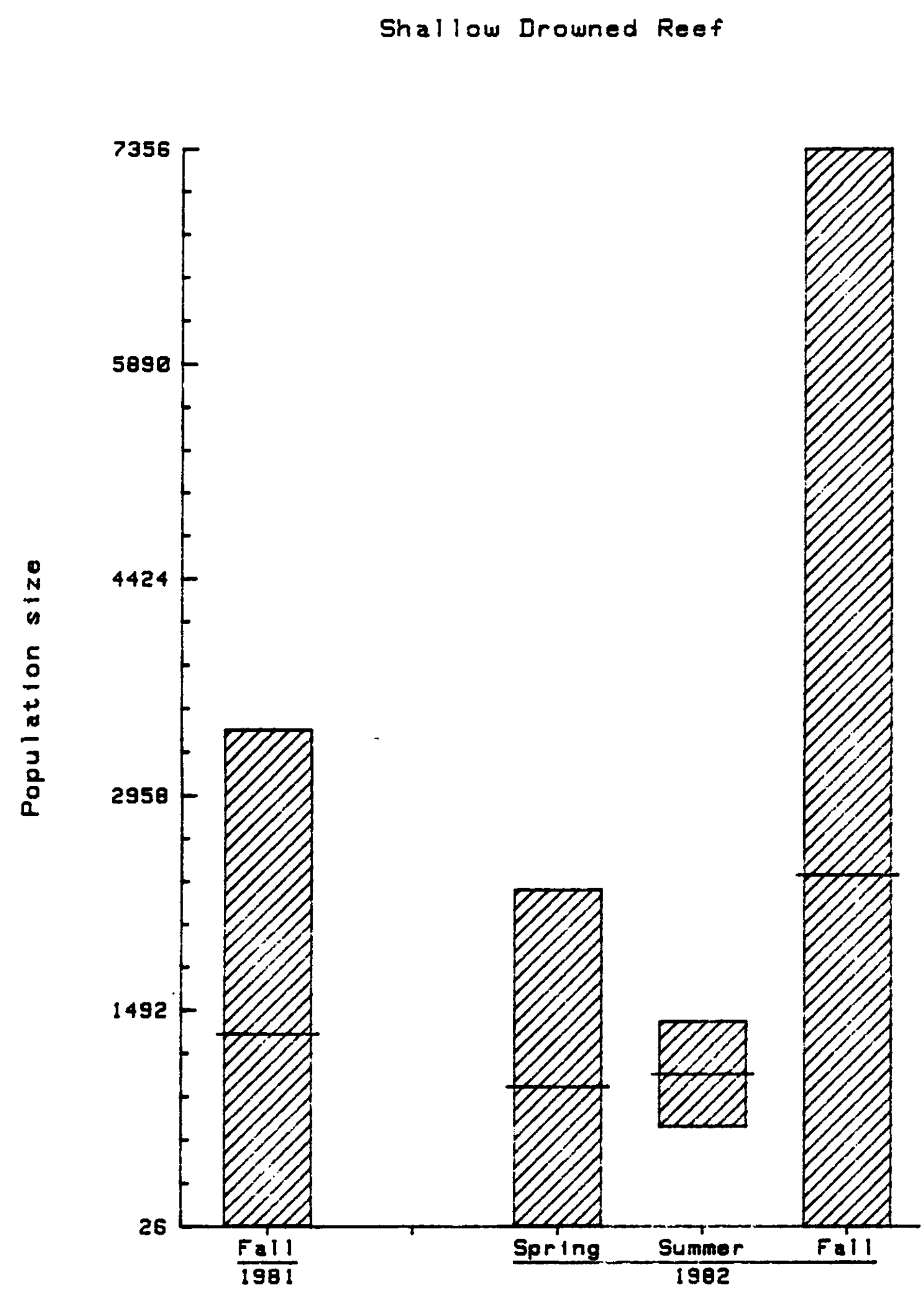


Fig. 26. Maximum likelihood estimates of population size for French angelfish, Pomacanthus paru, shallow drowned reef, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

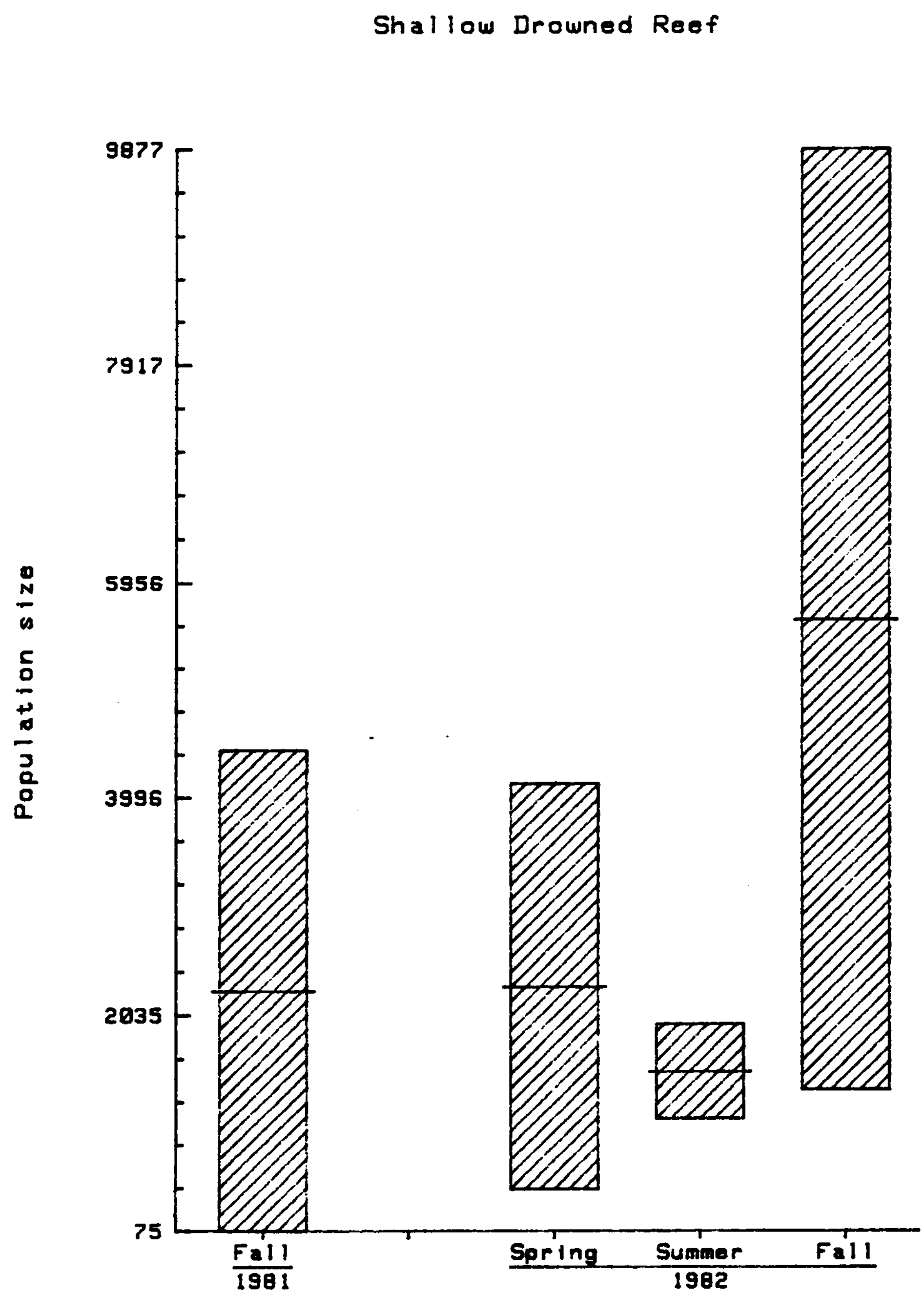


Fig. 27. Maximum likelihood estimates of population size for squirrel-fish, Holocentrus spp., shallow drowned reef, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

Table 4. Distribution types and maximum likelihood population size estimates with 95% confidence bands for selected species, Deep Drowned Reef, Cruises 5-8, East Flower Garden Bank.

		Deep Drowned Reef		
Species	Cruise	Distribution Type	Population Size Estimate	95% Confidence Band
Mycteroperca	5	NB(RR)	23711	± 20945
	6	NB(RR)	21078	± 13469
	7	P	13621	± 4874
	8	NB(RR)	30216	± 29376
Holanthias martinicensis	5	NB(RR)	434292	± 306579
	6	NB(C)	710658	± 305142
	7	NB(RR)	540760	± 299032
	8	NB(RR)	588396	± 273114
Family Serranidae (barred)	5	P	606	± 840
	6	P	1932	± 1339
	7	P	4994	± 2951
	8	-	-	-
Bodianus pulchellus	5	P	1212	± 1188
	6	NB(RR)	790	± 3576
	7	P	2724	± 2180
	8	P	1163	± 1611
Lutjanus campechanus	5	NB(RR)	11278	± 23545
	6	NB(RR)	18658	± 22556
	7	NB(RR)	15128	± 43371
	8	P	2325	± 2279
Priacanthus arenatus	5	NB(RR)	34480	± 24284
	6	NB(RR)	24747	± 21317
	7	NB(RR)	55561	± 32006
	8	P	34877	± 8825
Chaetodon sedentarius	5	NB(RR)	20449	± 28285
	6	NB(C)	9654	± 3238
	7	P	9081	± 3980
	8	P	13951	± 5581
Pagrus sedecium	5	P	4241	± 2222
	6	NB(RR)	3627	± 9581
	7	-	-	-
	8	-	-	-

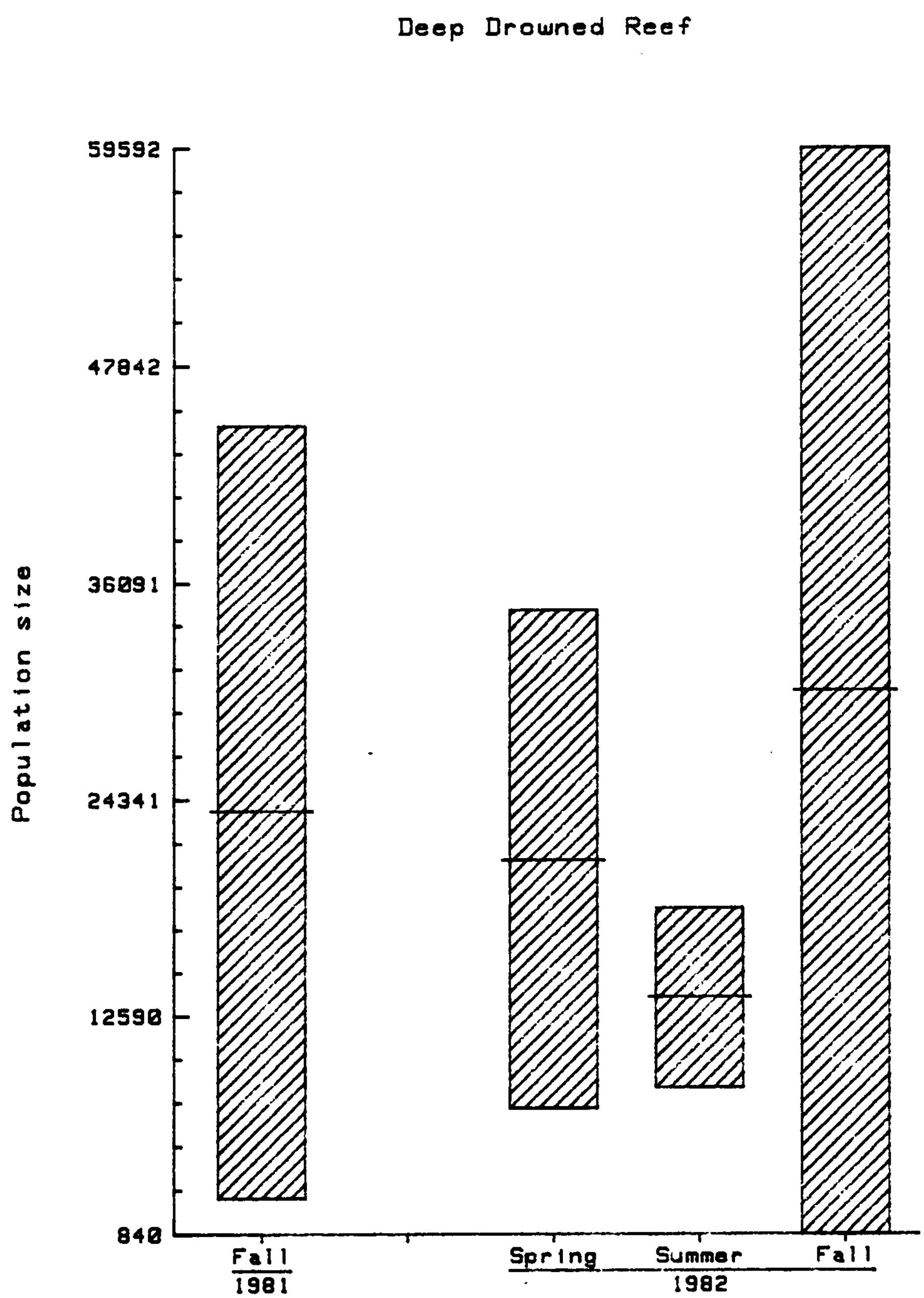


Fig. 28. Maximum likelihood estimates of population size for groupers, Mycteroperca spp., deep drowned reef, with 95% confidence bands on individual estimates only. Cruises 5-8, East

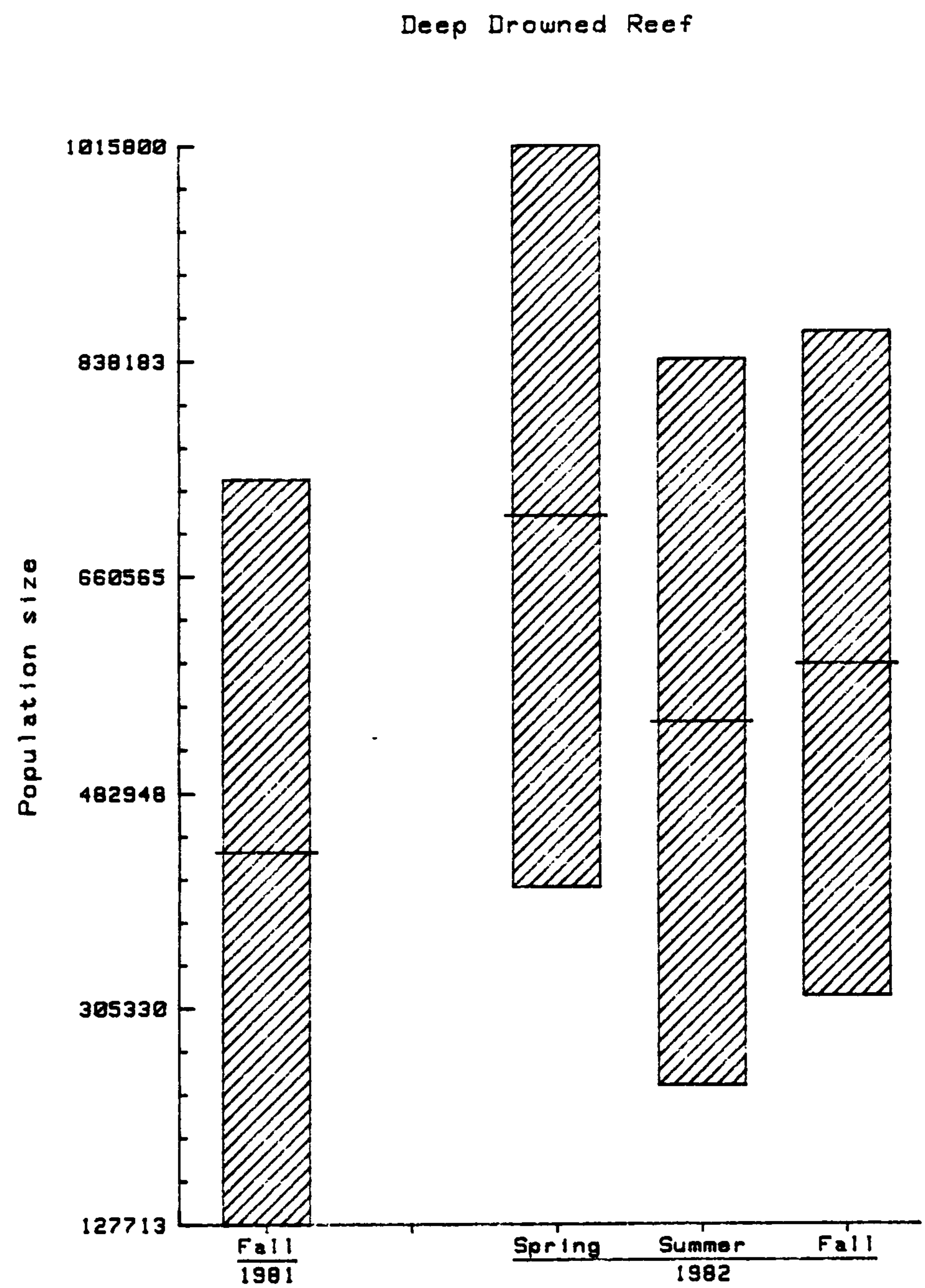


Fig. 29. Maximum likelihood estimates of population size for rough-tongue bass, Holanthias martinicensis, deep drowned reef, with 95% confidence bands on individual estimates only. Cruises 5-8. East Flower Garden Bank.

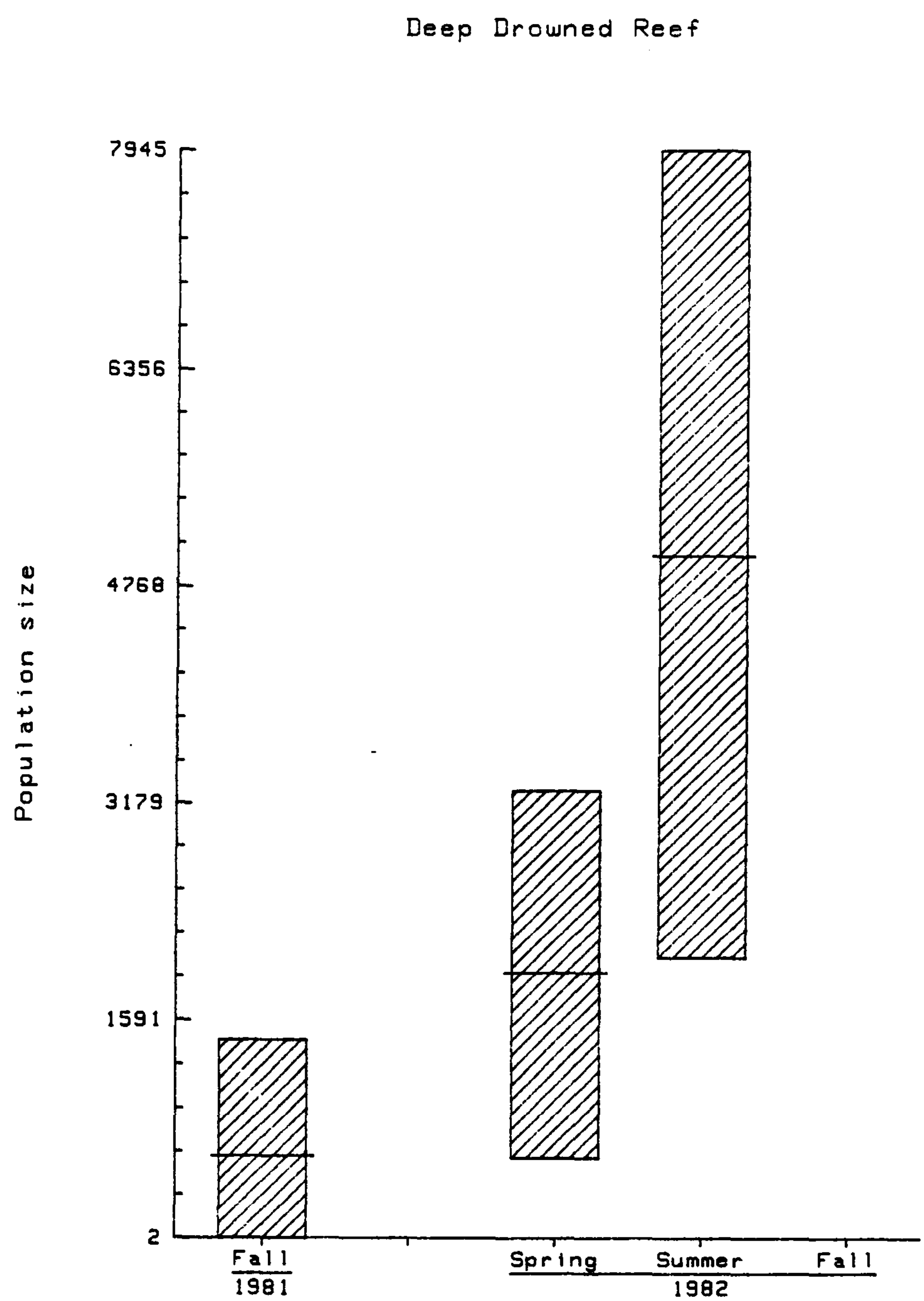


Fig. 30. Maximum likelihood estimates of population size for barred sea basses, Family Serranidae, deep drowned reef, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

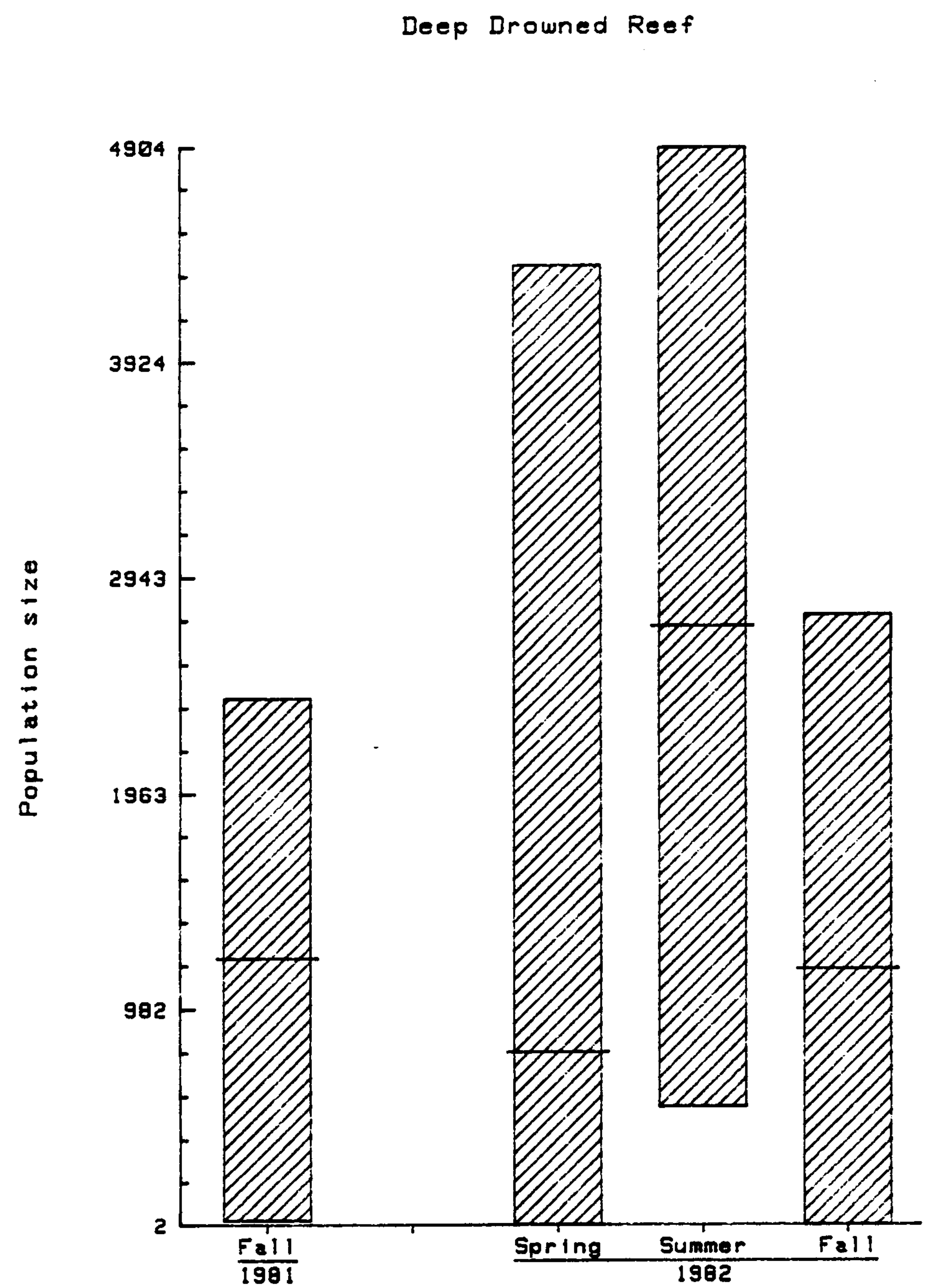


Fig. 31. Maximum likelihood estimates of population size for spotfin hogfish, Bodianus pulchellus, deep drowned reef, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

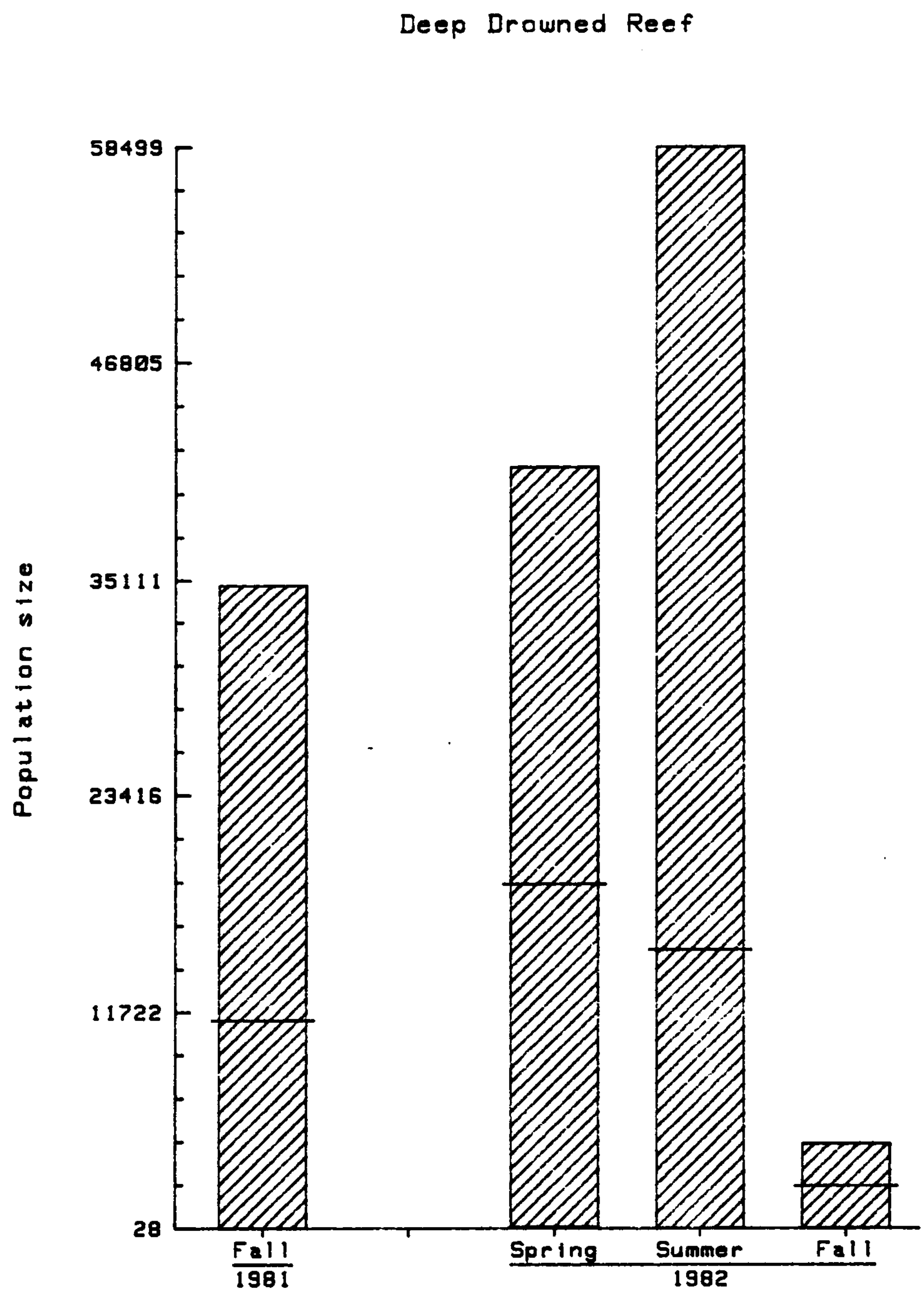


Fig. 32. Maximum likelihood estimates of population size for red snapper, *Lutjanus campechanus*, deep drowned reef, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

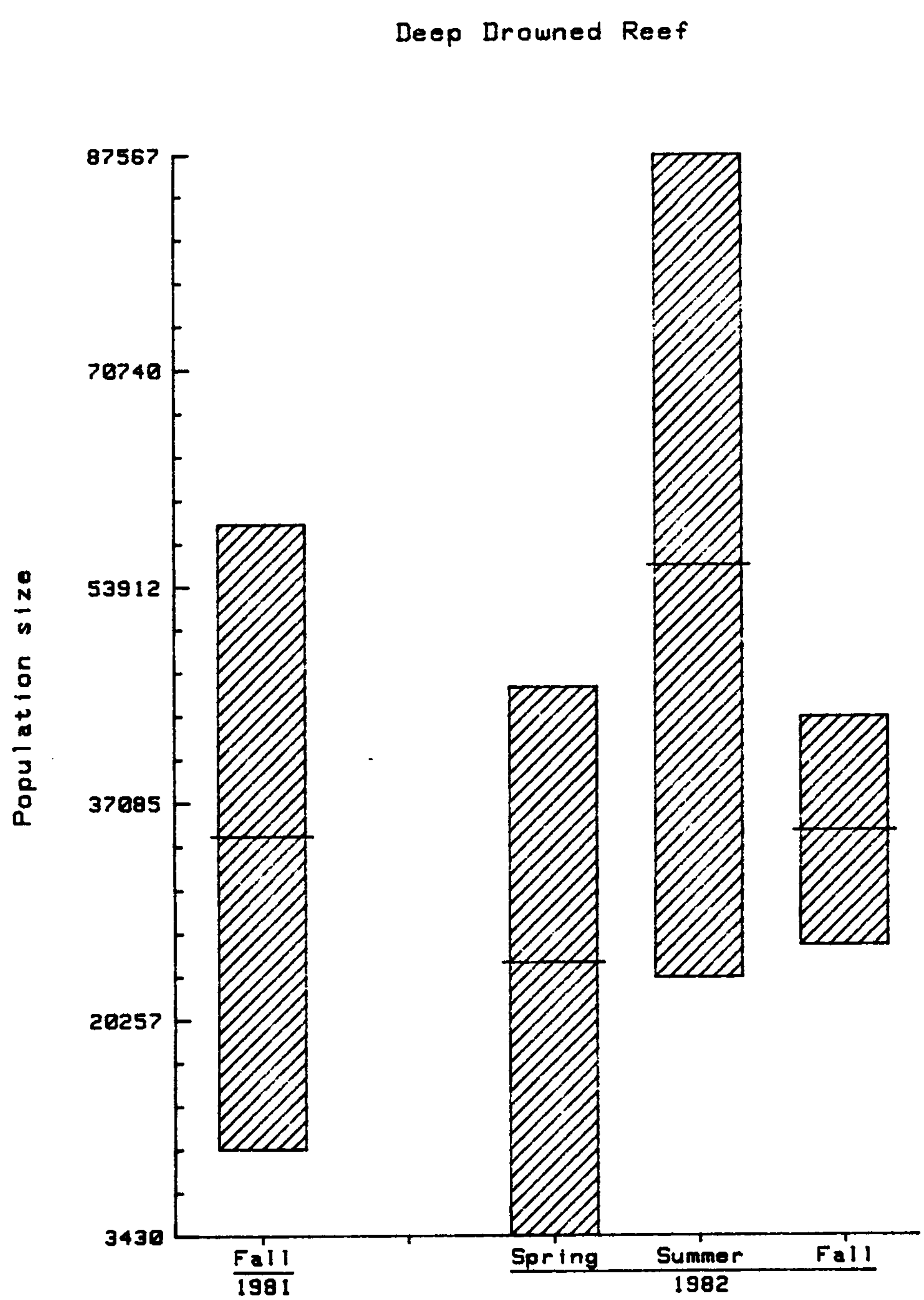


Fig. 33. Maximum likelihood estimates of population size of bigeye, *Priacanthus arenatus*, deep drowned reef, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

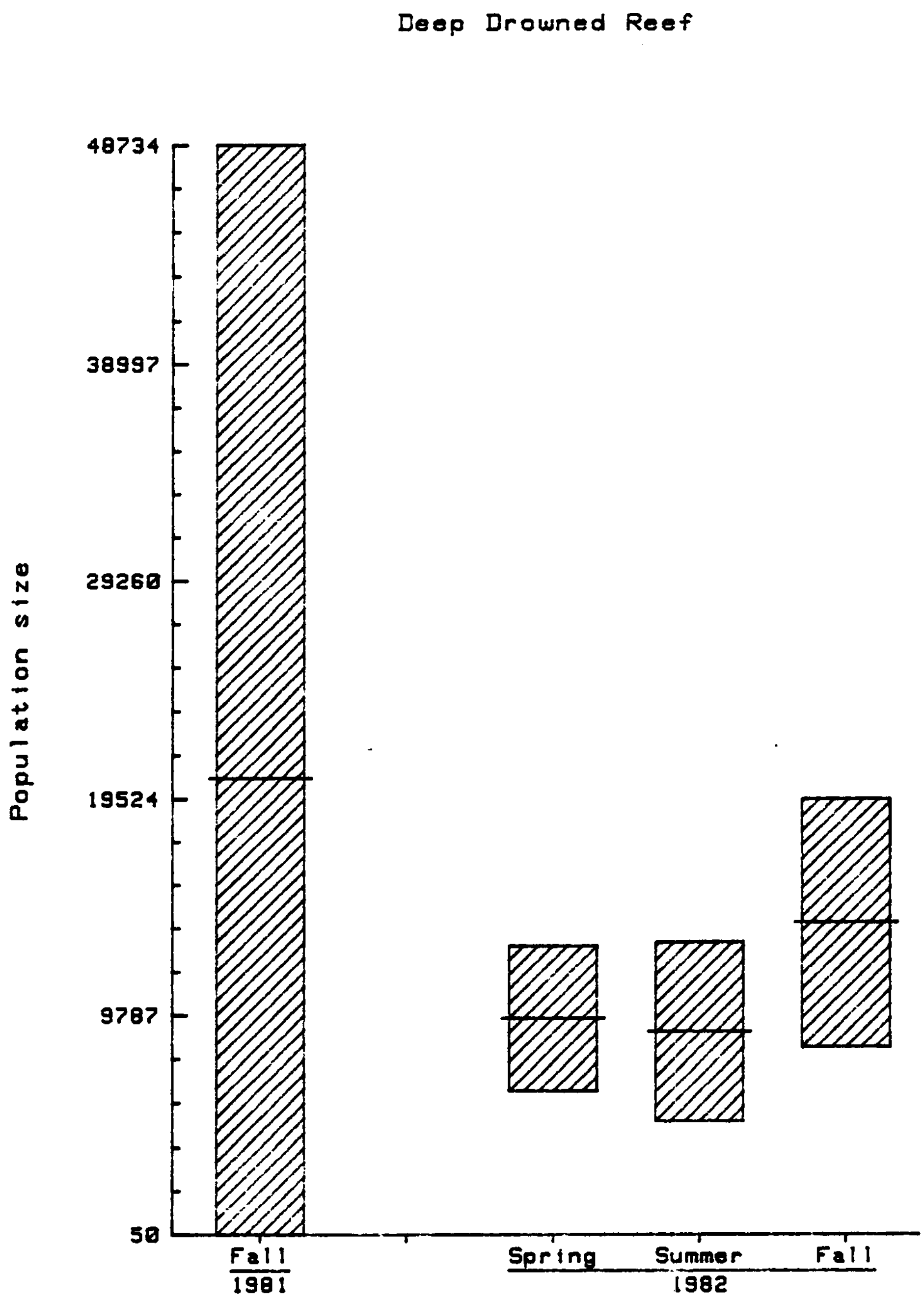


Fig. 34. Maximum likelihood estimates of population size for reef butterflyfish, Chaetodon sedentarius, deep drowned reef, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

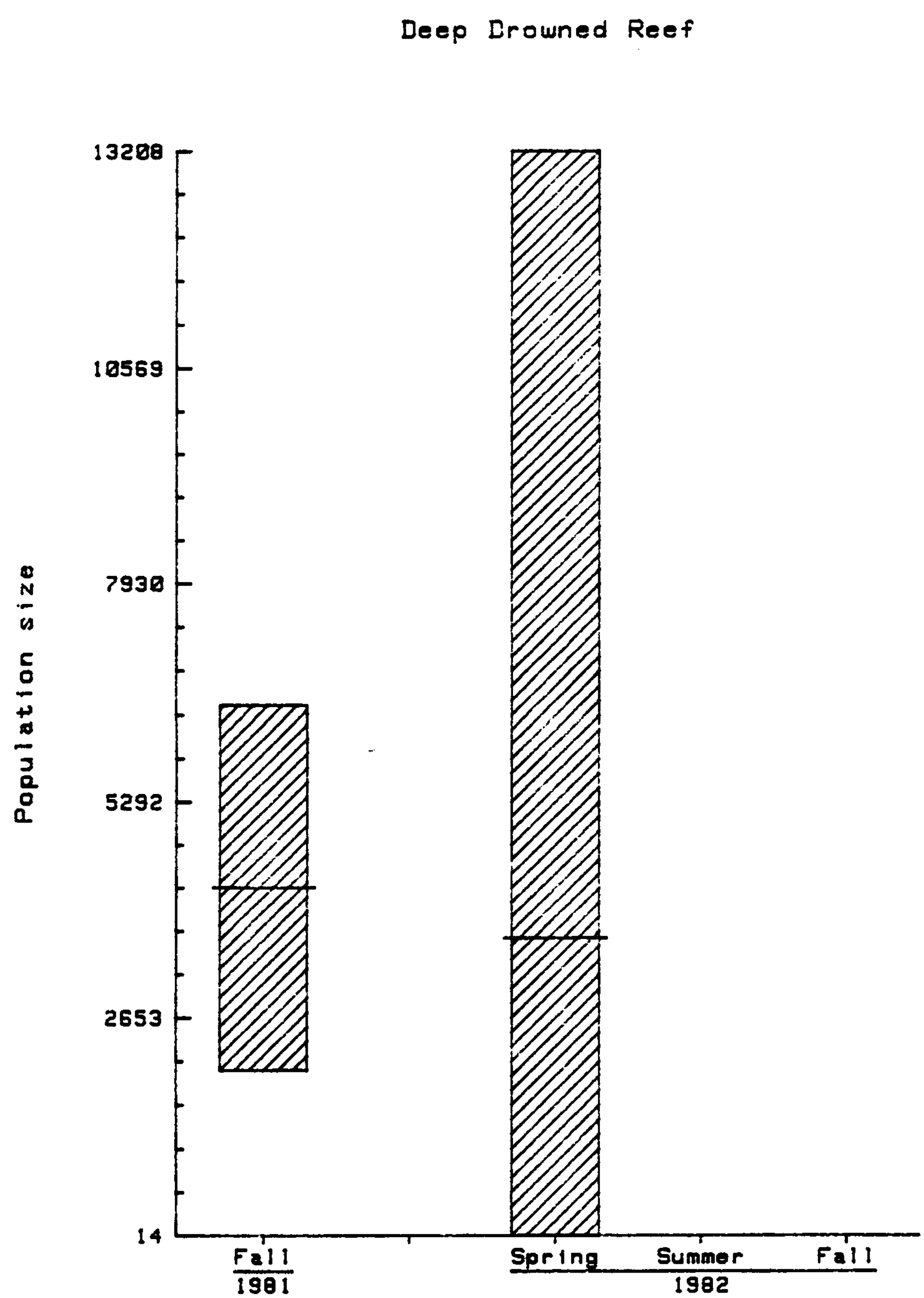


Fig. 35. Maximum likelihood estimates of population size for red porgy, Pagrus sedecim, deep drowned reef, with 95% confidence bands on individual estimates only. Cruises 5-8, East Flower Garden Bank.

APPENDIX 6-9

ANOVA RESULTS

GENERAL RESULTS FROM ANALYSIS OF VARIANCE

APPENDIX 6-9

GENERAL RESULTS FROM ANALYSIS OF VARIANCE

Initially for each species a two-way habitat by cruise analysis of variance was performed. In the majority of cases (approximately 90%) the interaction between habitat and cruise was highly significant. Analysis of variance was then performed on each habitat type individually. This was not a significant drawback due to the strong habitat preferences and differences in habitat utilization exhibited by most all selected taxa.

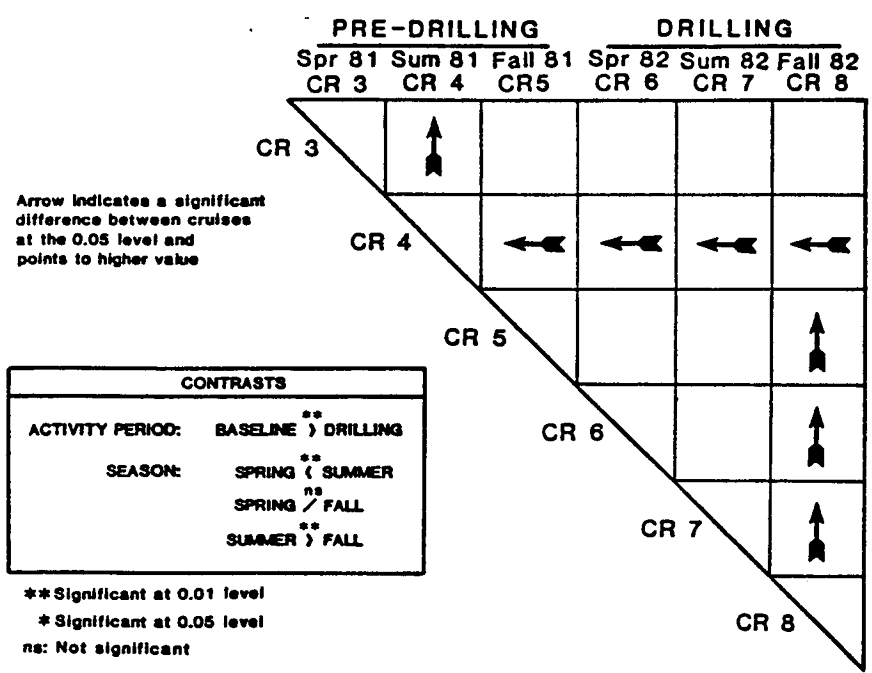
Because of missing data for Cruise 4 in the deeper habitats (Shallow and Deep Drowned Reefs) it was decided to use cruises as the main effect. Testing for impact of drilling and seasonal differences was then performed using contrasts of the appropriate available cruises. Additionally, on those species habitat combinations that showed significant differences between cruises, a Duncan's mean separation was performed. This was in an effort to explain observed differences in cruises not accounted for with the planned contrasts.

Creole-fish (<u>Paranthias furcifer</u>)
Habitat Type 1 - Upper Coral Reef

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	5	8.1790	1.6358	17.7700	.0001
Error	793	73.0056	.0920		
Total	798	81.1855			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	.2185	3.1000	.0020
Spring-Summer	-.3045	-4.9900	.0001
Spring-Fall	-.0674	-1.2000	.2290
Summer-Fall	.2371	4.2500	.0001

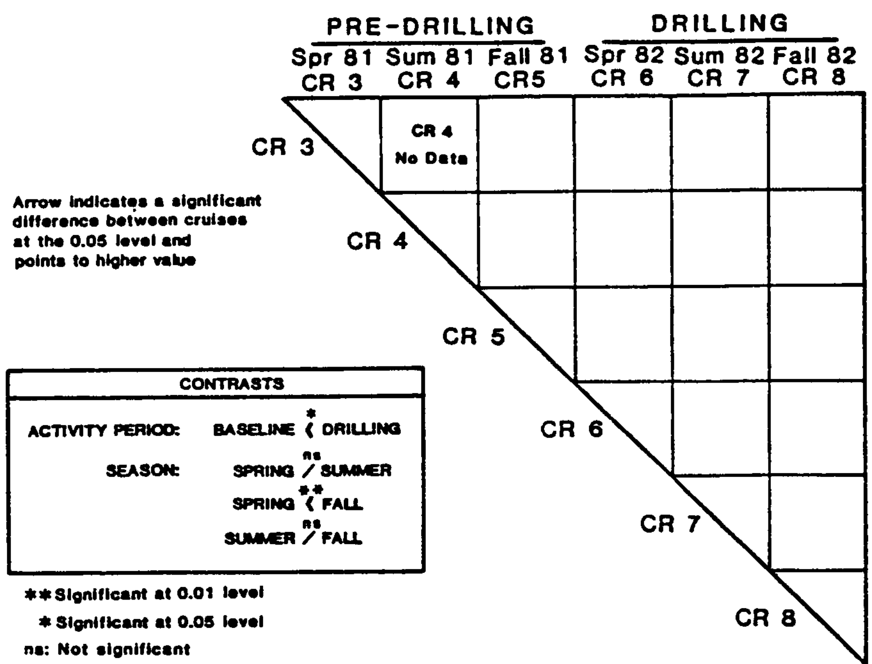


Creole-fish (<u>Paranthias furcifer</u>)
Habitat Type 72 - Shallow Drowned Reef

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	3	.4365	.1455	11.6100	.0001
Error	731	9.1624	.0125		
Total	734	9.5990			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	-.0229	-2.2200	.0268
Spring-Summer	-.0123	-1.0900	.2769
Spring-Fall	-.0300	-2.8700	.0043
Summer-Fall	-.0177	-1.8200	.0695



Creole-fish (*Paranthias furcifer*)
Habitat Type 7 - Deep Drowned Reef

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	3	.0110	.0036	.8400	.4759
Error	141	.6193	.0043		
Total	144	.6304			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	-.0049	-.4100	.6836
Spring-Summer	.0203	1.3200	.1890
Spring-Fall	.0194	1.4600	.1455
Summer-Fall	-.0009	-.0700	.9472

No significant differences at $\alpha = 0.05$

Grouper (<u>Mycteroperca</u> spp.)
Habitat Type 1 - Upper Coral Reef

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	5	.0709	.0141	1.9400	.0845
Error	793	5.7970	.0073		
Total	798	5.8679			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	-.0059	- .3000	.7637
Spring-Summer	.0435	2.5300	.0115
Spring-Fall	.0026	.1700	.8647
Summer-Fall	-.0408	-2.6000	.0095

CONTRASTS	
ACTIVITY PERIOD:	BASELINE / DRILLING (ns)
SEASON:	SPRING > SUMMER (*)
	SPRING / FALL (ns)
	SUMMER < FALL (**)

** Significant at 0.01 level
* Significant at 0.05 level
ns: Not significant

Grouper (*Mycteroperca* spp.)
Habitat Type 72 - Shallow Drowned Reef

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	3	.0699	.0233	1.9100	.1248
Error	731	8.9219	.0122		
Total	734	8.9918			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	-.0007	- .0800	.9394
Spring-Summer	.0010	.1000	.9228
Spring-Fall	-.0144	-1.3900	.1638
Summer-Fall	-.0155	-1.6200	.1062

No significant differences at $\alpha = 0.05$

Grouper (*Mycteroperca* spp.)
Habitat Type 7 - Deep Drowned Reef

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	3	.0673	.0224	.7800	.5098
Error	141	4.0589	.0287		
Total	144	4.1263			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	.0096	.3100	.7573
Spring-Summer	.0548	1.3900	.1673
Spring-Fall	.0076	.2300	.8217
Summer-Fall	-.0471	-1.3400	.1831

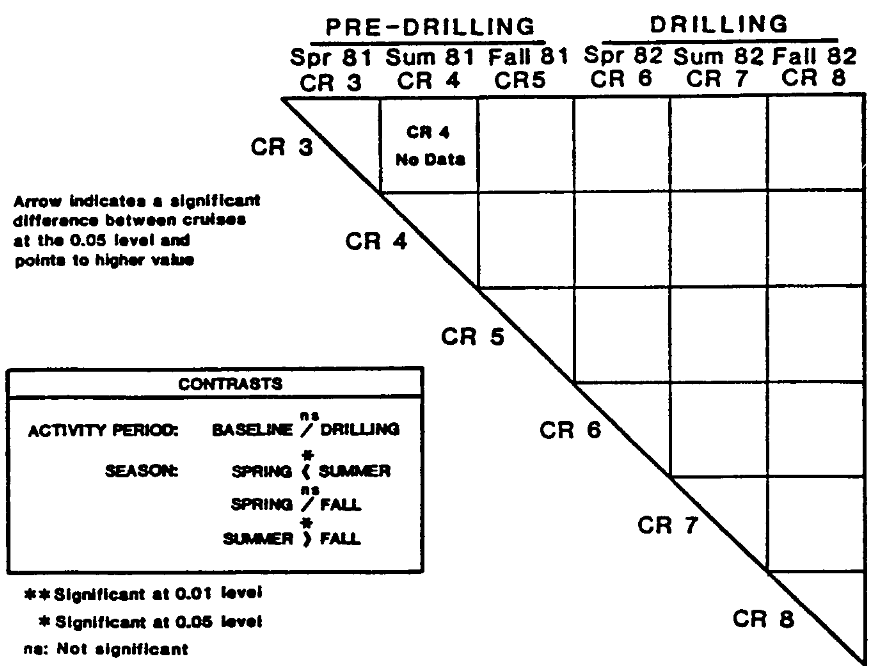
No significant differences at $\alpha = 0.05$

Barred seabasses (Family Serranidae)
Habitat Type 7 - Deep Drowned Reef

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	3	.0545	.0181	3.0200	.0314
Error	141	.8474	.0060		
Total	144	.9020			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	.0007	.0500	.9604
Spring-Summer	-.0464	-2.5700	.0111
Spring-Fall	-.0050	-.3200	.7464
Summer-Fall	.0414	2.5700	.0111

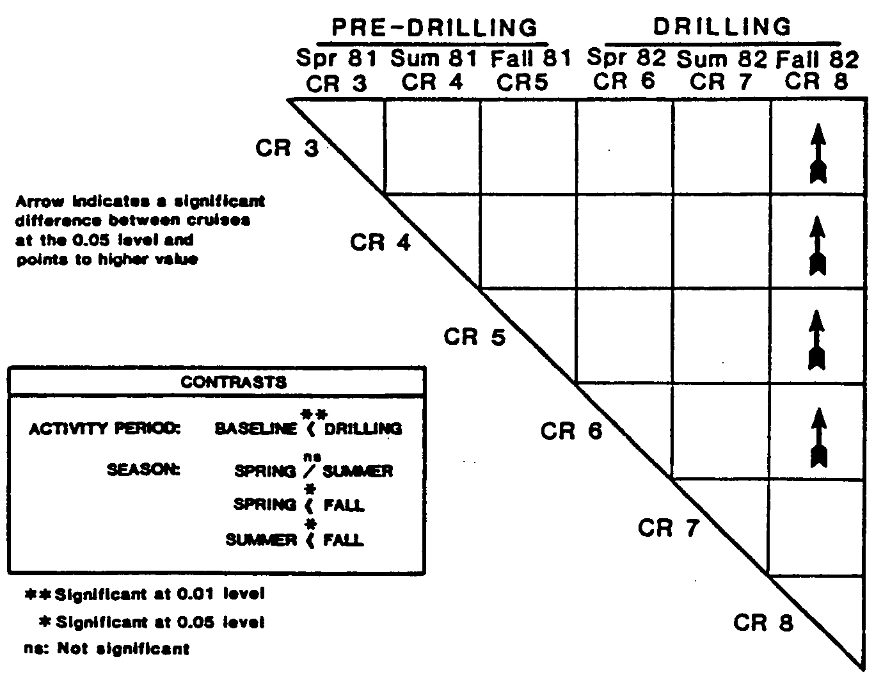


Barred seabasses (Family Serranidae)
Habitat Type 6 - Soft Bottom

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	5	.3097	.0619	2.7300	.0193
Error	435	9.8833	.0227		
Total	440	10.1931			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	-.1883	-2.9400	.0035
Spring-Summer	-.0450	-.7500	.4558
Spring-Fall	-.1329	-2.5400	.0116
Summer-Fall	-.0879	-2.0500	.0405



Roughtongue bass (*Holanthias martinicensis*)
Habitat Type 72 - Shallow Drowned Reef

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	3	.0046	.0015	.5500	.6519
Error	731	2.0374	.0027		
Total	734	2.0420			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	-.0037	-.7700	.4440
Spring-Summer	.0056	1.0500	.2926
Spring-Fall	.0053	1.0900	.2752
Summer-Fall	-.0002	-.0500	.9563

No significant differences at $\alpha = 0.05$

Roughtongue bass (*Holanthias martinicensis*)
Habitat Type 7 - Deep Drowned Reef

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	3	.3547	.1182	1.1400	.3347
Error	141	14.6050	.1035		
Total	144	14.9598			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	-.0896	-1.5200	.1314
Spring-Summer	-.0505	-.6700	.5014
Spring-Fall	-.0235	-.3600	.7161
Summer-Fall	.0269	.4000	.6870

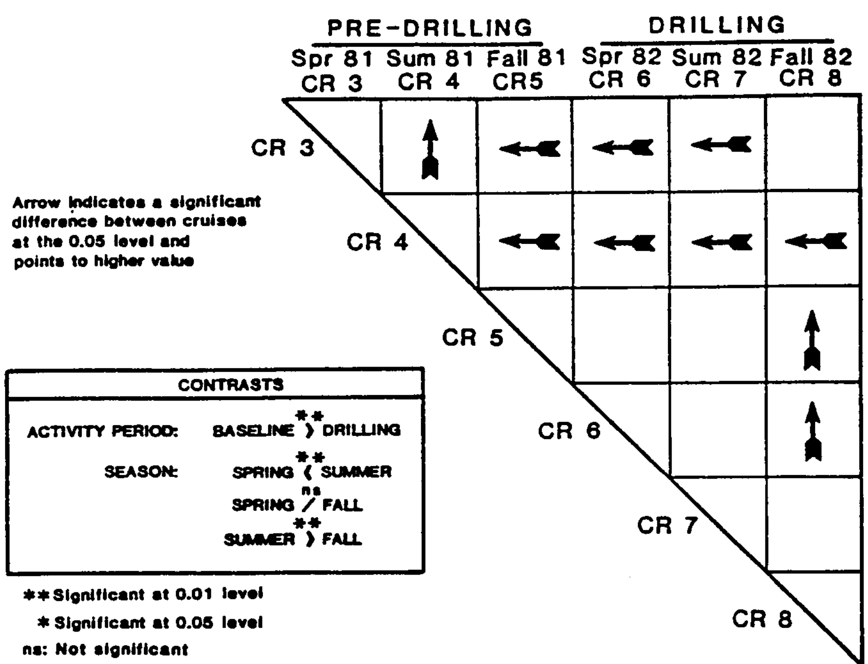
No significant differences at $\alpha = 0.05$

Blue and brown chromis (Chromis spp.)
Habitat Type 1 - Upper Coral Reef

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	5	7.4555	1.4944	20.7400	.0001
Error	793	57.0114	.0718		
Total	798	64.4670			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	.3628	5.8200	.0001
Spring-Summer	-.2586	-4.8000	.0001
Spring-Fall	.0614	1.2400	.2150
Summer-Fall	.3200	6.5000	.0001

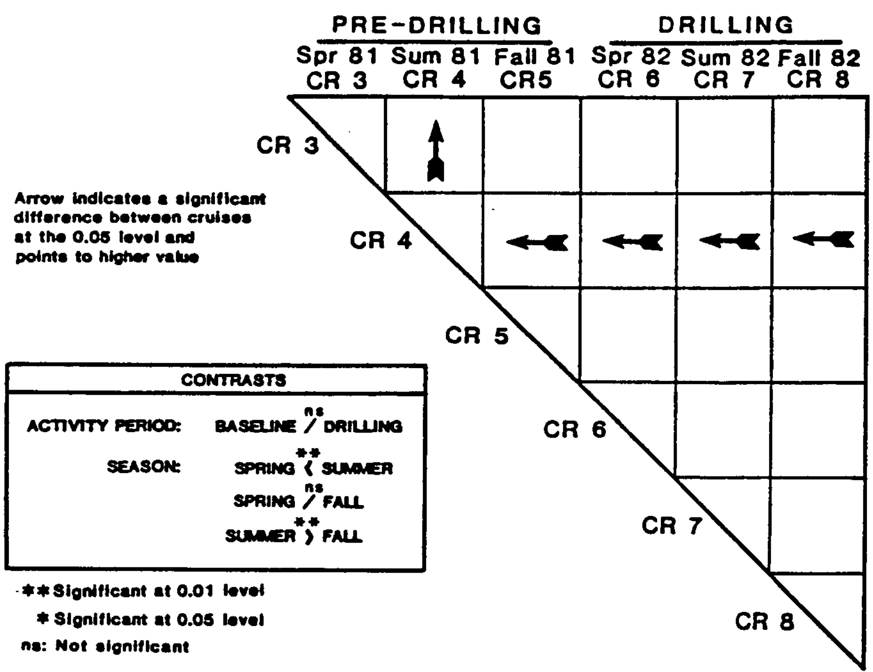


Creole wrasse (*Clepticus parrai*)
Habitat Type 1 - Upper Coral Reef

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	5	.6847	.1369	4.6100	.0004
Error	793	23.5499	.0296		
Total	798	24.2344			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	.0432	1.0800	.2812
Spring-Summer	-.1001	-2.8900	.0039
Spring-Fall	-.0087	-.2800	.7834
Summer-Fall	.0913	2.8900	.0040



Yellowtail reeffish (*Chromis enchrysurus*)
Habitat Type 1 - Upper Coral Reef

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	5	.0075	.0015	1.9800	.0781
Error	793	.6078	.0007		
Total	798	.6154			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	-.0085	-1.3200	.1864
Spring-Summer	-.0100	-1.8100	.0704
Spring-Fall	-.0105	-2.0600	.0399
Summer-Fall	-.0004	-.0900	.9319

CONTRASTS

ACTIVITY PERIOD:	BASELINE / DRILLING (ns)
SEASON:	SPRING / SUMMER (ns)
	SPRING < FALL (*)
	SUMMER / FALL (ns)

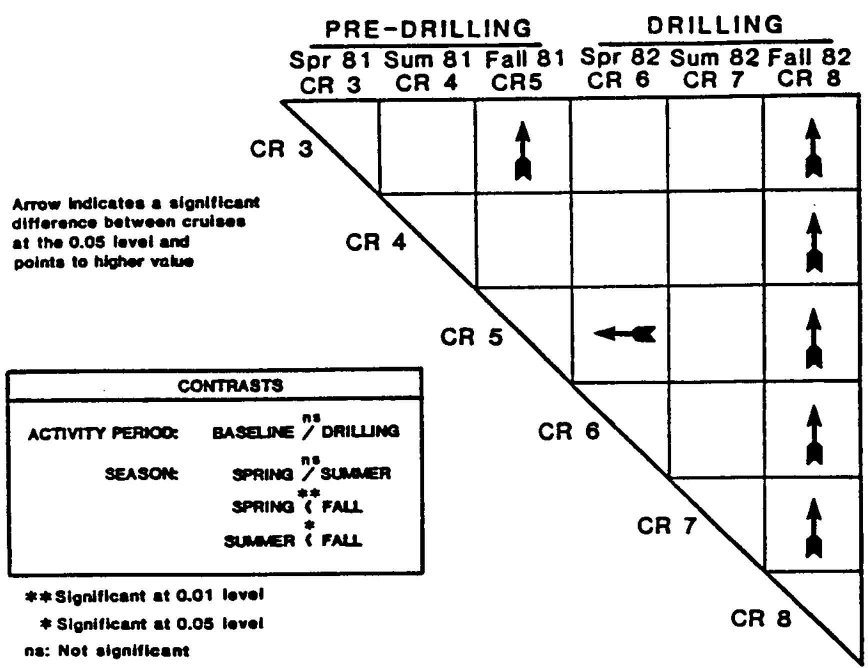
** Significant at 0.01 level
* Significant at 0.05 level
ns: Not significant

Yellowtail reeffish (<u>Chromis enchrysurus</u>)
Habitat Type 3 - Algal Nodule Zone

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	5	.0239	.0047	6.8300	.0001
Error	606	.4254	.0007		
Total	611	.4494			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	-.0150	-1.1700	.2441
Spring-Summer	-.0076	-.6100	.5446
Spring-Fall	-.0280	-3.0300	.0025
Summer-Fall	-.0204	-2.1300	.0336

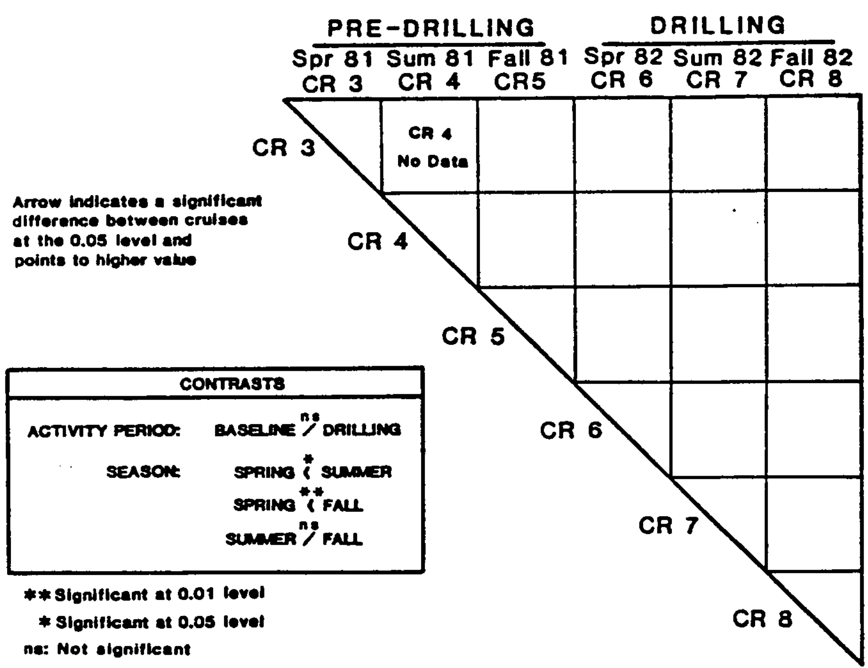


Yellowtail reeffish (Chromis enchrysurus)
Habitat Type 72 - Shallow Drowned Reef

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	3	.2791	.0930	10.3400	.0001
Error	731	6.5789	.0089		
Total	734	6.8580			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	-.0108	-1.2400	.2168
Spring-Summer	-.0219	-2.2800	.0231
Spring-Fall	-.0335	-3.7800	.0002
Summer-Fall	-.0116	-1.4100	.1593



Yellowtail reeffish (*Chromis enchrysurus*)
Habitat Type 7 - Deep Drowned Reef

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	3	.0584	.0194	.8100	.4916
Error	141	3.3788	.0239		
Total	144	3.4372			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	.0440	1.5500	.1228
Spring-Summer	-.0036	-.1000	.9199
Spring-Fall	-.0195	-.6300	.5307
Summer-Fall	-.0158	-.4900	.6222

No significant differences at $\alpha = 0.05$

Yellowtail reeffish (*Chromis enchrysurus*)
Habitat Type 72 - Shallow Drowned Reef
Cruise #5

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Quadrat	4	.4448	.1112	5.9300	.0002
Error	137	2.5686	.0187		
Total	141	3.0124			

Quadrat 10>6,7,8,9 at $\alpha = 0.05$

Cruise #8

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Quadrat	4	.4848	.1212	6.0700	.0001
Error	341	6.8103	.0199		
Total	345	7.2951			

Quadrat 8>6,7,9,10 at $\alpha = 0.05$

Quadrat #8

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	3	.7589	.2529	16.5600	.0001
Error	457	6.9821	.0152		
Total	460	7.7410			

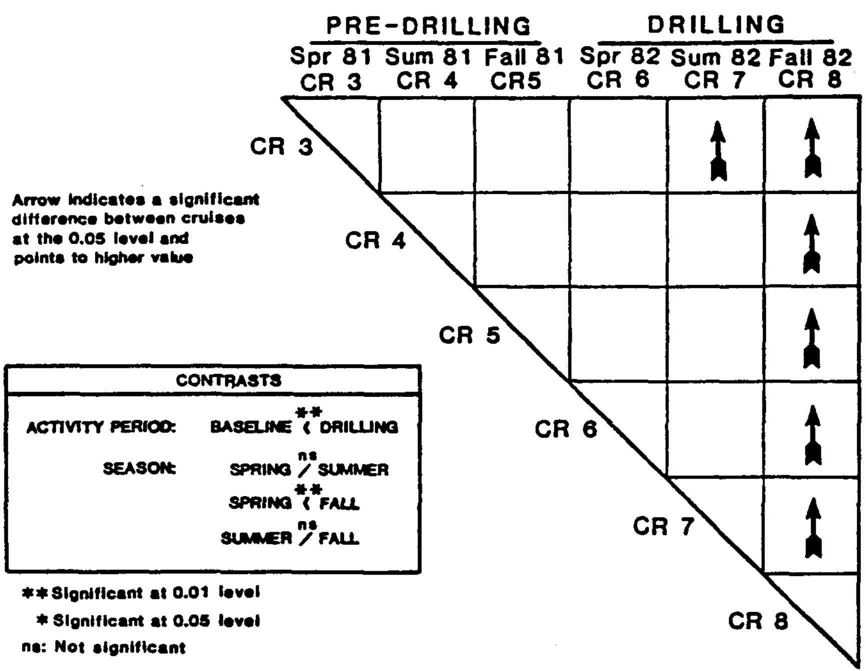
Cruise 8>5,6,7 at $\alpha = 0.05$

Spotfin hogfish (*Bodianus pulchellus*)
Habitat Type 1 - Upper Coral Reef

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	5	.0383	.0746	5.4700	.0001
Error	793	10.8203	.0136		
Total	798	11.1934			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	-.0995	-3.6600	.0003
Spring-Summer	-.0393	-1.6700	.0944
Spring-Fall	-.0771	-3.5800	.0004
Summer-Fall	-.0378	-1.7600	.0784



Spotfin hogfish (*Bodianus pulchellus*)
Habitat Type 3 - Algal Nodule Zone

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	5	.0050	.0010	1.8500	.1002
Error	606	.3319	.0005		
Total	611	.3370			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	.0231	2.0300	.0433
Spring-Summer	-.0255	-2.3100	.0214
Spring-Fall	-.0049	-.6000	.5480
Summer-Fall	.0206	2.4300	.0153

CONTRASTS	
ACTIVITY PERIOD:	BASELINE > DRILLING (*)
SEASON:	SPRING < SUMMER (*)
	SPRING / FALL (ns)
	SUMMER > FALL (*)

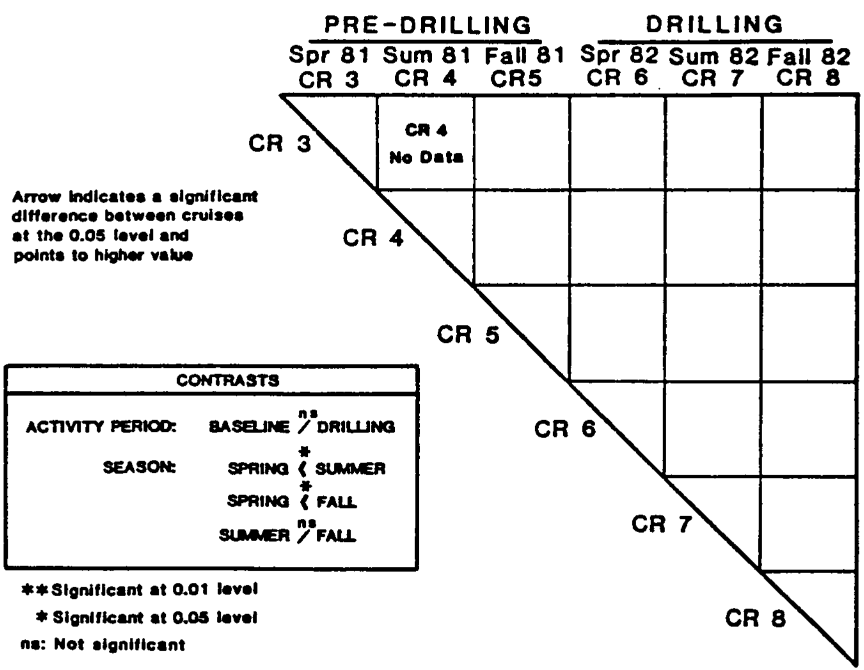
** Significant at 0.01 level
* Significant at 0.05 level
ns: Not significant

Spotfin hogfish (Bodianus pulchellus)
Habitat Type 72 - Shallow Drowned Reef

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	3	.1938	.0646	5.5900	.0010
Error	731	8.4491	.0115		
Total	734	8.6429			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	-.0179	-1.8000	.0716
Spring-Summer	-.0225	-2.0700	.0390
Spring-Fall	-.0219	-2.1800	.0298
Summer-Fall	.0006	.0700	.9425



Spotfin hogfish (*Bodianus pulchellus*)
Habitat Type 7 - Deep Drowned Reef

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	3	.0135	.0045	.9600	.4127
Error	141	.6602	.0046		
Total	144	.6737			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	.0206	1.6400	.1030
Spring-Summer	-.0065	-.4100	.6818
Spring-Fall	-.0122	-.8900	.3740
Summer-Fall	-.0056	-.4000	.6895

No significant differences at $\alpha = 0.05$

Knobbed porgy (*Calamus nodosus*)
Habitat Type 1 - Upper Coral Reef

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	5	.0483	.0096	1.9900	.0770
Error	793	3.8540	.0048		
Total	798	3.9023			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	.0000	0.0000	.9999
Spring-Summer	-.0114	-.8200	.4126
Spring-Fall	-.0289	-2.2500	.0245
Summer-Fall	-.0175	-1.3700	.1719

CONTRASTS	
ACTIVITY PERIOD:	BASELINE ns / DRILLING
SEASON:	SPRING ns / SUMMER
	SPRING * < FALL
	SUMMER ns / FALL

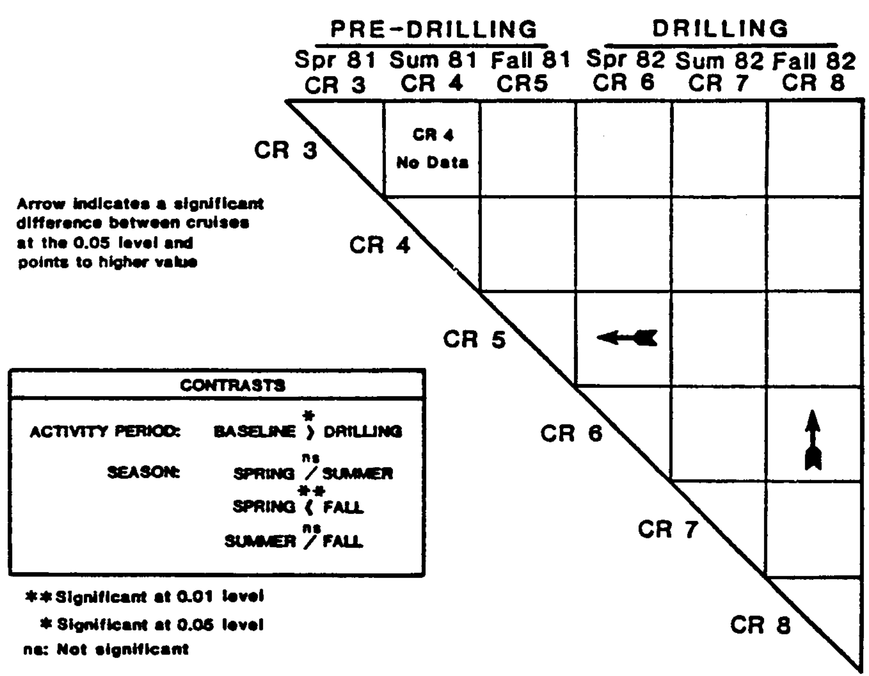
** Significant at 0.01 level
* Significant at 0.05 level
ns: Not significant

Knobbed porgy (<u>Calamus nodosus</u>)
Habitat Type 72 - Shallow Drowned Reef

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	3	.0621	.0207	4.6000	.0036
Error	731	3.2934	.0045		
Total	734	3.3555			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	.0133	2.1500	.0316
Spring-Summer	0.0000	-1.9100	.0565
Spring-Fall	-.0231	-3.6900	.0002
Summer-Fall	-.0101	-1.7400	.0817



French angel (*Pomacanthus paru*)
Habitat Type 1 - Upper Coral Reef

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	5	.0220	.0044	.9800	.4283
Error	793	3.5599	.0045		
Total	798	3.5820			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	-.0034	-.2200	.8237
Spring-Summer	-.0059	-.4400	.6580
Spring-Fall	-.0091	-.7400	.4578
Summer-Fall	-.0032	-.2600	.7935

No significant differences at $\alpha = 0.05$

French angel (*Pomacanthus paru*)
Habitat Type 3 - Algal Nodule Zone

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	5	.0137	.0027	1.0800	.3723
Error	606	1.5509	.0025		
Total	611	1.5646			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	.0117	.4800	.6346
Spring-Summer	-.0170	-.7100	.4775
Spring-Fall	-.0218	-1.2400	.2162
Summer-Fall	-.0048	-.2600	.7916

No significant differences at $\alpha = 0.05$

French angel (*Pomacanthus paru*)
Habitat Type 72 - Shallow Drowned Reef

ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr >F
Cruise	3	.0014	.0004	.1200	.9440
Error	731	2.8693	.0039		
Total	734	2.8707			

Contrast	Estimate	T For Ho: Parameter=0	Pr > T
Baseline-Drilling	-.0016	-.2900	.7711
Spring-Summer	.0030	.4800	.6312
Spring-Fall	.0033	.5700	.5669
Summer-Fall	.0003	.0600	.9555

No significant differences at $\alpha = 0.05$