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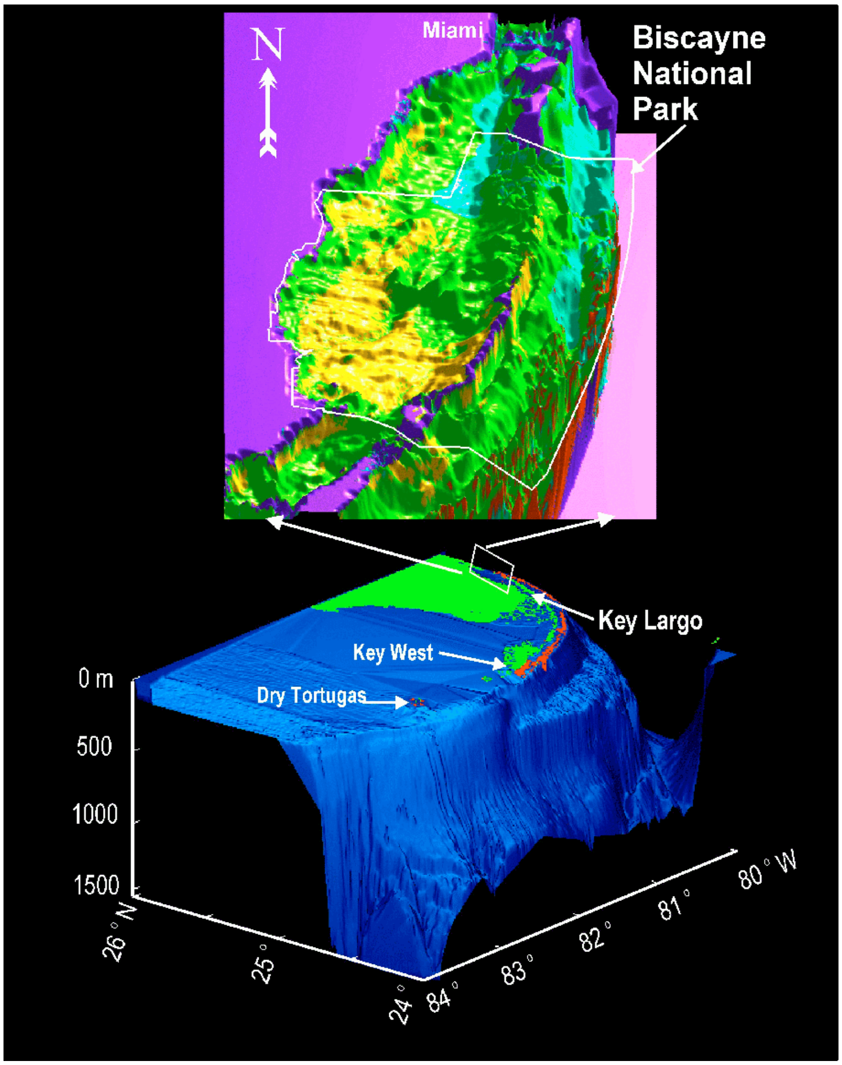
Site Characterization for Biscayne National Park: Assessment of Fisheries Resources and Habitats

Jerald S. Ault, Steven G. Smith, Geoffrey A. Meester, Jiangang Luo, and James A. Bohnsack



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National Marine Fisheries Service
Southeast Fisheries Science Center
75 Virginia Beach Drive
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Executive Summary

Biscayne National Park (BNP) in southeastern Florida is a unique tropical marine environment of national significance, renown for its productive coral reef ecosystem, diverse natural resources, important fishing opportunities, and spectacular scenic beauty. BNP's coastal bay and coral reef habitats play a critical role in the function and dynamics of the larger Florida Keys coral reef ecosystem and contribute substantially to the multibillion dollar tourism and fishing industry. Park waters provide critical nursery habitats and food web links for many important commercial and recreational fishery resources including: bonefish, snook, tarpon, permit, pink shrimp, spotted seatrout, oysters, clams, blue crabs and stone crabs, baitfishes; and, numerous coral reef fishes that include snappers, groupers, grunts, barracuda, spadefish, spiny lobster, parrotfish, surgeonfish and triggerfish. The production dynamics of these valuable natural resources are inextricably linked not only to fishing and rates of exploitation but also to the spatial distribution and quality of bay waters and habitats, themselves greatly affected by growing human uses and management practices. Since BNP's natural resources are intimately related to the broader regional ecosystem through water movements and animal migrations, any Park degradation will have consequences well beyond its boundaries.

Fishery management strategies now being proposed for BNP require precise spatial data and estimates of resource distribution and status prior to implementation of any spatial management policy. These data will facilitate concise and unambiguous baseline estimation of the Park resource status, provide critical inputs for models used to forecast potential impacts of policy changes, and enable design of an efficient sampling program to monitor future performance of a given management policy.

In a proactive movement towards development of strategic planning, this report takes the first steps in establishing the quantitative characterization and assessment of fisheries resources and habitats in BNP. The site characterization was based on an extensive overview and analysis of pertinent scientific and technical literature and biological, fishery, and physical databases relevant to the status and dynamics of fishery resources in Biscayne National Park, Florida. The estimation and simulation modeling "process" involved database assimilation, visualization and mapping of fish-habitat linkages, and multispecies assessments. In the process, we developed a new approach to stock assessment of multispecies coral reef fisheries that compare status of stocks relative to Federal fishery management guidelines. Our assessment research focused on 3 data sets containing more than 25 years of fishery-dependent (1976-1999 via BNP recreational creel survey) and fishery-independent (1979-2000 via SCUBA diver visual census and rollerframe trawls) survey sampling in BNP. Digital maps were created for a variety of spatial "habitats" including bathymetry, benthic substrates, salinity and other water quality parameters that relate to fishery resource distributions and abundances. Biological data were separated into 4 life-stage phases in terms of length for analysis: juveniles; pre-exploited; mature; and, exploited. Habitat data were co-plotted with species life-stage abundance and community diversity distributions to assess the spatial distribution and dynamics of fisheries and their dependence on habitats found in BNP. We noted:

C Biscayne Bay plays an important role as primary nursery area for many coastal bay and coral reef fishes and macroinvertebrates (i.e., gray, mutton, lane, schoolmaster and yellowtail snappers; bonefish, tarpon, permit, sharks, molluscs, sponges, snook, seatrout, and pink shrimp, blue crabs, and spiny lobsters). Therefore, we conducted our analyses with respect to the relevant life stages of each species partitioned into four phases:

juvenile (from length of recruitment to size of sexual maturity); pre-exploited (recruitment length to minimum legal harvest size); mature (length of sexual maturity to maximum size); and, exploited (minimum legal to maximum size). We found that thirty-five (35) species of fish (about 11% of total BNP fishes) were present in all three survey types (TRAWL, CREEL, RVC), suggesting that there is use of habitats amongst lifestage phases. Fish diversity was lowest on the western fringe of Biscayne Bay (particularly at areas proximal to SFWMD canal outfalls and attendant freshwater influxes), increased moving seaward, and was highest in eastern BNP (areas on the barrier coral reef system open towards the Straits of Florida). The diverse spatial patterning of many species distributions reflects specialized ontogenetic use of certain habitats across the seascape. This suggests that a critical mosaic of interconnected habitats may be essential for sustaining fishery resources and ecosystem productivity.

We used a systems science approach to conduct a new multispecies assessment on exploited fishery resources found in BNP. The analyses used both fishery-independent and fishery-dependent data sources. We also acquired extensive biological and fishery information on population dynamics including age-growth, age (size) class distribution, and natural mortality rates. We estimated new fishery indicator variables developed from fishery-independent diver visual census data and fishery-dependent creel survey for 91 exploited species to assess the current status of the stocks. However, the reliability of population dynamic parameter datasets for a number of these species were suspect, or unavailable. As a result, this study focused on 35 important reef fish species that reflected the predominance of species and reliable population dynamics data. Commercial fisheries data were also acquired, but were deemed generally unreliable. Combining population-dynamic parameters and estimates of fisheries indices with the LBAR and REEFS assessment models facilitated evaluation of a series of fishery management benchmarks and estimated exploitation levels. We compared these estimates of current stock biomass and fishing mortality levels to the Federal standards. The following points summarize our findings:

- For all of the harvested species analyzed, the average sized fish within the exploited phase of these populations for the last 25 years has remained relatively constant and is very close to minimum harvest sizes, not natural historical unfished population size. Many species with extremely low average length in the past have had very little change in average length even though new minimum size limits were imposed. The average size of black grouper is now 40% of what it was in 1940 and the spawning stock is now less than 5% of its historical unfished maximum.

- Overall, 77% of the 35 individual stocks that could be analyzed are overfished. An analysis of the Spawning Potential Ratios (SPR) of exploited reef fish shows that 13 of 16 grouper species, 11 of 13 snapper species, barracuda, and 2 of 5 grunt species for which there are reliable population dynamics data are below the SPR that constitutes overfishing by Federal definitions (Magnuson-Stevens Fishery Management Conservation Act).

- Stock biomass is critically low for most of the key targeted species within the recreational fishery. For example, the current level of fishing mortality for grouper stocks range from 3 to 10 times the exploitation level that would achieve Maximum Sustainable Yield (MSY). Some stocks appear to have been chronically overfished since at least the late 1970's.

- Exceptionally high and sustained exploitation pressures have precipitated "serial overfishing" of key fishery resources. Smaller and less desirable species have consistently increased in the catch as larger more vulnerable species are eliminated.

- The recreational fishing fleet in South Florida has grown at a near exponential rate since 1964 (a 444% increase in recreational boats from 1964 to 1998) with no limits on the number of boats allowed to fish. The relative effective vessel "fishing power" of the recreational fleet has quadrupled due to depth indicators and fish finders, global positioning systems, improved vessel designs, larger motors, and two-way radio communications.

- A proportion of the fish in catches observed at the Biscayne NP boat ramps during creel surveys are **smaller** than the minimum size limit for legal harvest. This is as high as 70% for yellowtail and mutton snapper! Inadequate enforcement and knowledge of fishery regulations (reflected in preponderance of undersized "illegal" fish seen in creel catch size frequency distributions) and the extremely poor status of reef fish resources (BNP is the worst situation in the entire Keys) signals eminent resource collapses. Enforcement needs to be stronger to discourage poachers.

- In fact, we also found that 13 of 35 species we analyzed have their minimum size of legal harvest set lower than the minimum size of sexual maturity, that is, these fishes are being captured before they have ever had a chance to spawn.

- Little is known about a number of highly-prized species like bonefish, tarpon and permit, despite the fact that they are the focus of extremely important recreational fisheries. For example, bonefish have undoubtedly been under sampled, as only seven (7) fish have been reported in 23 years of BNP creel sampling, despite the fact that bonefish support an enormous regional recreational fishery. There are no monitoring programs for pink shrimp despite the large inshore biomass of juvenile shrimp that fed a broad range of juvenile and adult fishes in the BNP ecosystem, but is also under heavy exploitation pressures from an intensive commercial bait-shrimp and recreational wing-net fishery. In addition, economically-important spiny lobster, blue crabs and stone crabs lack monitoring in BNP.

The history of fishery management actions by the State and Federal Fishery Management Council for Biscayne NP waters clearly reflects the characteristics of trying to manage fisheries under increasing stress with conventional approaches. Actions have been taken only after declines have already occurred and were finally acknowledged. Actions are then usually only minimal and not at a level that ensures recovery will take place. (The history of increasingly more restrictive size limits placed on several grouper species until the fishery for some was eventually closed is a prime example of failure in conventional management approaches). Fisheries are not sustainable in BNP under the present levels of exploitation affecting stock status and habitat quality. We make the following recommendations:

- We believe that a broader, more integrated strategy of monitoring, assessment and modeling is needed for effective fishery management in BNP. This comprehensive strategy must consider sampling of Bay, mangrove, coral reef, and pelagic fishery environments, and some consideration of new or enhanced use of data and technologies (e.g., recreational creel and commercial catches, visual census, trawls and other nets, acoustics, LIDAR, etc.). There are severe limitations to the use of a single survey gear-type to conduct a meaningful synoptic study of fish and shellfish. The current, somewhat piecemeal, monitoring program must be reconfigured to meet assessment data demands. Monitoring efforts need to be integrated into a overarching design to facilitate short term fishery and "habitat" surveys. The analysis of a cost-effective composite design for *n* key target species is needed. In the course of the design, some special attention must be given to the barrier islands, mangrove fringe, and patch reef environments of the Park which have been sparsely sampled to date.

C Envisaged ecosystem modeling and management endeavors must rely on a precise and cost-effective mechanism to understand and manage these valuable and essential fishery resources. Advanced monitoring efforts will also require refined resolution and precision of existing base habitat maps, including directed efforts to fill in data gaps. An experimental design to assess water quality effects of Everglades restoration on fishes in the "tide" will be important to develop. Monitoring activities should be designed at a time frequency dependent on key process rates, and such these integrated data will be critical for monitoring the efficacy of proposed management alternatives, ultimately leading to design of a longer-term program of optimal sampling, monitoring and assessment of the coral reef fish community and associated habitats in BNP.

C Many of BNP's most important fishery resources have received little attention (e.g., shellfish, bonefish, tarpon, snook, etc.). There is great need to develop additional population dynamics models and conduct fishery-independent surveys for these resources. This will require an improved capacity at BNP to monitor fishery resources across the breadth of environments. Little to no information was available for bonefish-tarpon, two mainstays of the highly valuable inshore recreational fishery, and broad knowledge gaps exist. There is an obvious need to protect "flats" environments from excessive use and degradation, and to develop a quantitative reef and coastal fish community index which may help in determining how close the "real" situation approximates "ideal" community structure.

The qualities that make BNP and the Florida Keys such venerable tourism and fishing destinations are eroding. Clearly, without some type of immediate proactive fishery management in BNP, collapse of many important fisheries resources is imminent. A multistock recovery strategy to sustainable target levels is needed. This strategy must address the great fleet fishing capacity and develop strategies to buffer exploitation in productive regions and reduce stress on key habitats The obvious system connectivity that links BNP with the rest of the Florida Keys coral reef ecosystem means that long-term planning efforts for BNP should also include close integration of efforts with FKNMS, DTNP and the State of Florida. Marine protected areas and research natural areas are being implemented regionally; these may be a necessary step to build sustainable fisheries and to conserve marine biodiversity. To facilitate recovery of the region's precious natural resources, it is clearly in the best interests of BNP to strongly support marine reserve development and implementation in the Dry Tortugas and other suitable upstream candidate sites.

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1.0 Introduction

Biscayne National Park (BNP), encompassing approximately 728 km^2 in southeastern Florida (**Figure 1**), is a unique tropical marine environment of national significance, renown for its productive coral reef ecosystem, diverse natural resources, broad fishing opportunities, and spectacular scenic beauty. Explosive regional population growth and documented resource declines have raised concerns about the future of these resources. The NPS requires general management plans (GMP) for each national park unit. The GMP framework sets forth the management philosophy for decision making and problem solving in National Parks for the next 15 to 20 years to meet current and future conservation objectives and resource uses, while enhancing visitor experiences. In an effort consistent with the GMP framework and as an initial step leading towards development of a comprehensive fishery management plan for the Park, this report characterizes the current status of BNP's fisheries resources and associated habitats.

We view fisheries assessment and management from a systems science perspective (Ault 1996, Bohnsack and Ault 1996, Rothschild et al. 1996, Ault et al. 1998, Ault and Luo 1998, Bohnsack et al. 1999, Lindeman et al. 2000, Ault et al. 2000b), illustrated in **Figure 2**. In this approach, the fisheries assessment and management "system" is an organized set of scientific protocols and methods designed to achieve three main goals: (1) to understand fisheries resources and habitats within the context of the aquatic ecosystem; (2) to assess the impacts of human activities and economic drivers on these resources; and (3) to analyze and evaluate the degree of success of proposed and implemented management policies in mitigating human impacts on fisheries resources. A systems science overview of BNP fisheries resources is as follows. Located just south of Miami at the northernmost end of the Florida Keys, BNP's coastal bay and coral reef habitats play a critical role in the function and dynamics of the larger Florida Keys coral reef ecosystem. The inshore waters of Biscayne Bay serve as a nursery area for larvae and juveniles of a wide variety of fish and shellfish. Many of these live and reproduce in barrier coral reef and other offshore habitats as adults. The coastal bay environment also provides habitats for a number of highly prized gamefishes, such as bonefish, tarpon and snook. Fish and shellfish populations in the Florida Keys region currently support a multibillion dollar tourist and fishing economy. Over the past several decades, public use of and conflicts over fishery resources have increased sharply, while some fishery catches from historically productive snapper and grouper stocks have declined (Bohnsack et al. 1994). A recent quantitative retrospective assessment of the Florida Keys multispecies reef fish community showed that fishing mortality levels are very intense, that many stocks are "overfished", and that signs of overfishing have been evident since the late 1970's (Ault et al. 1997a, 1998). A series of management actions, begun in the early- to mid-1980s, included establishing size, season, and bag limits on a number of species. Several species have been closed to harvest altogether.

Habitats of fish and shellfish in the Florida Keys ecosystem, particularly those located in nearshore areas, have also been impacted and compromised by human activities. Over the last eight decades, the Florida Keys, Florida Bay and Biscayne Bay have undergone dramatic changes in environmental conditions due to human alteration of the natural hydrology in southern Florida. These changes are now the focus of an intensive effort to restore the ecosystem by returning the hydrology to more natural conditions (Harwell et al. 1998, RESTUDY www.acoe.jax.mil). Coastal bay nursery grounds will likely bear the brunt of the proposed changes in freshwater outflows to estuarine and marine environments. The combination of rapidly growing human populations, overfishing, habitat degradation, pollution and changes in regional water quality from Everglades "restoration" make the Keys region an "ecosystem-at-risk" as one of the nation's most significant,

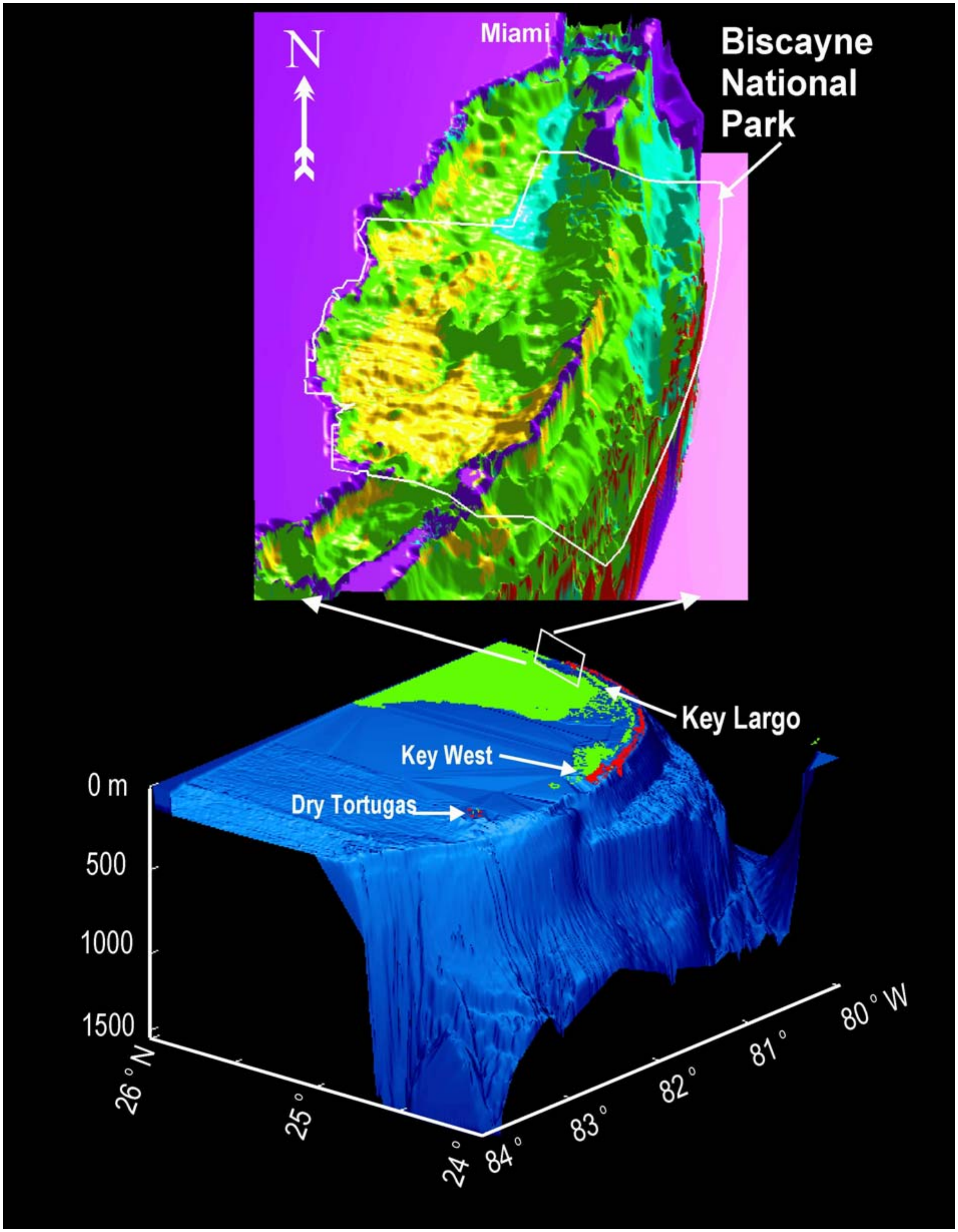
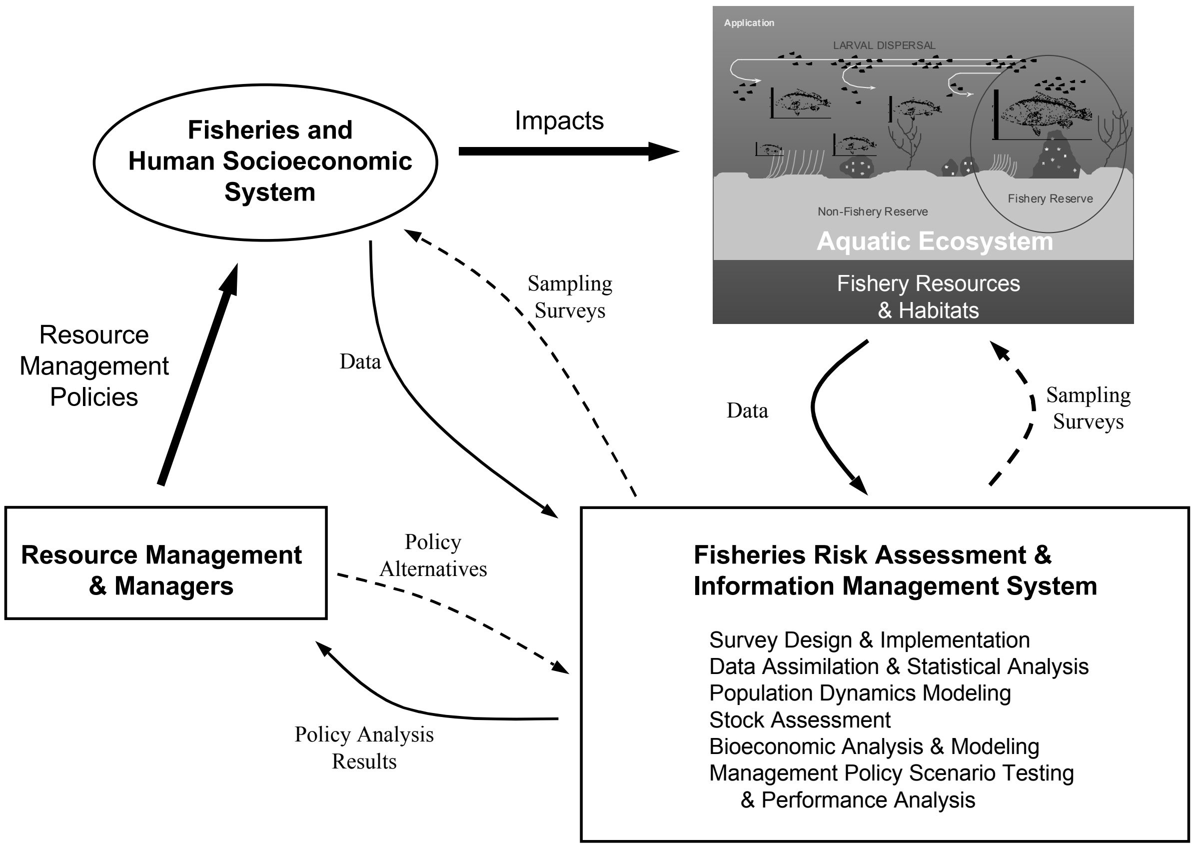


Figure 1.- Three-dimensional map of the Florida Keys coral reef ecosystem showing south Florida and the coral reef tract (red) stretching 380 km from Miami to the Dry Tortugas; and, Biscayne National Park habitats and fish sampling where the relative size of the blue balls inside Biscayne NP shows fish diversity as measured at trawl and visual sampling stations.

Figure 2: Conceptual overview of a systems science approach to fisheries assessment and management.



yet most stressed, marine resource regions under management of NOAA, the State of Florida, and the National Park Service (Ault et al. 1997a, 1998, 2000ab; Schmidt et al. 1999).

The goal of this report is to formally employ the systems science approach to assess the baseline status of multispecies fishery resources in BNP *circa* 2000 (**Figure 3**). The approach links the acquisition and assimilation of physical, biological and fishery databases to advanced statistical and modeling procedures to conduct multispecies stock assessments. Therefore, the objectives of this report are:

- To assimilate BNP regional resource databases and overview both species and habitats.

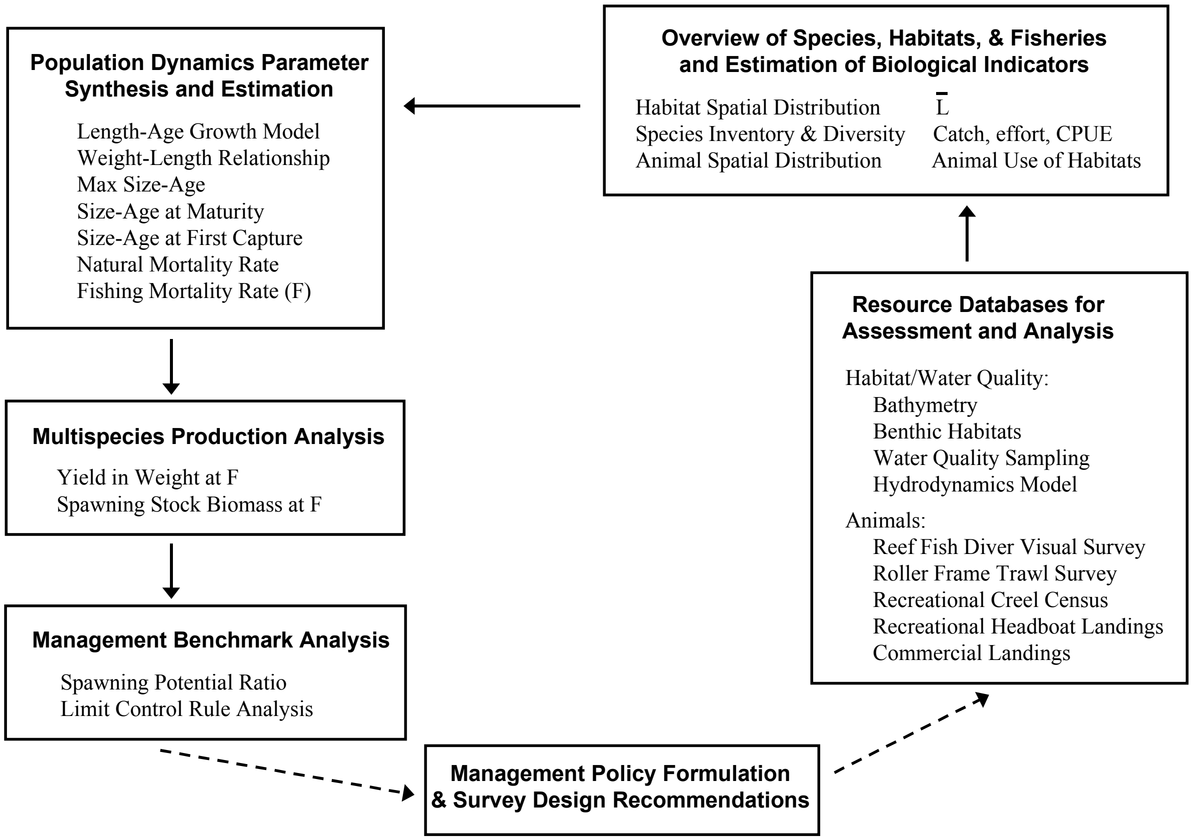
- To estimate biological indicators of stock status from several sources of fishery-independent and fishery-dependent survey data (i.e., creel census, coral reef visual census, and rollerframe trawl survey).

- To synthesize and estimate a suite of population dynamics parameters for assessment model building.

- To conduct length-based multispecies stock assessments for key exploited fishery resources in BNP waters using our new methods, to compare current estimates of exploitation to state-of-the-art fishery management benchmarks for fisheries sustainability, and to conduct a preliminary risk assessment of fishery management strategies for overfished stocks consistent with the Magnuson-Stevens Fishery Management Conservation Act.

The results of the analyses presented in this report provide guidance and identify priorities for developing comprehensive General Management and Fishery Management Plans for Biscayne National Park. In addition, these results will facilitate strategic formulation of policy alternatives that optimize conservation and use of Park fishery resources, and the design of high precision information systems that enable evaluation of the likelihood of success of a given policy in achieving Park natural resource management goals.

Figure 3.- Flow diagram of the systems science approach employed to assess Dry Tortugas region coral reef fishery resources. Solid lines depict analyses flow of this report, while dashed lines indicate future steps in fishery management plan development.



2.0 Databases for Resource Assessment and Analysis

We assimilated, analyzed and visualized a number of fishery-independent and fishery-dependent survey databases on fishes and macroinvertebrates in Biscayne National Park. Databases of physical and biological "habitat" features of BNP were also integrated into these analyses. In addition to the following descriptions, a brief summary of each database is provided in **Appendix A**.

2.1 Reef Fish Visual Census (RVC)

Biological data from Biscayne National Park were collected as part of a Florida Keys-wide fishery-independent sampling survey for reef fish conducted by NOAA Fisheries and University of Miami RSMAS scientists. The RVC (reef-fish visual census) survey database for BNP, extracted from the Keys-wide survey database, covered the years 1983 to 1992 and 1995 to 1999 for a total of 13 years. Data were collected by standard, non-destructive, *in situ* visual monitoring methods by highly trained and experienced divers using open circuit SCUBA (Bohnsack et al. 1999). Visual methods are ideal for assessing reef fishes in the Florida Keys because of prevailing good visibility and management concerns requiring the use of low impact assessment methods. The method provides reliable quantitative estimates of species composition, abundance (density per plot), frequency-of-occurrence, and individual size composition for the reef fish community. Data are collected by a stationary diver centered in a randomly selected circular plot (Bohnsack and Bannerot 1986, Ault et al. 1998). Divers sample 7.5 m radius circular plots for 5 minutes attempting to count all fish observed within each imaginary cylinder extending from the bottom to the limits of vertical visibility (usually the surface). Divers begin each sample by facing in one direction and listing all species within the field of view. When no new species are noted, new sectors are scanned sequentially by rotating in one direction for the 5 min period. Several complete rotations were usually made for each plot. After the initial 5 min, data are then recorded on abundance and minimum, mean, and maximum lengths for each species listed. Depth, bottom composition, estimated percentage cover, and maximum relief are recorded for each plot from the polar perspective of the centrally located observer. A calibration ruler held out perpendicularly at the end of a meter stick was used to reduce apparent magnification errors in size estimates. Divers periodically calibrate their sample radius estimates with either a meter stick or fiberglass tape. Species with few individuals (e.g. angelfish, barracuda, hogfish) are counted and their size estimated immediately. Highly mobile species that are unlikely to remain in the area (e.g. sharks, carangids) are tabulated when first observed and then ignored. For common species (e.g. damselfish, wrasses, etc.) one 360^{o} rotation is made for each species by working back up the list in reverse order of recording to reduce potential bias by avoiding counting a species when they were particularly abundant or obvious. The time required to record each sample averages 15-20 min (range 5-30), depending on the habitat.

We used a two stage stratified random survey design to optimize sampling effort and choose sampling locations (Cochran 1977). Bottom features are first classified into habitat strata and mapped based on bottom structure and location. The Florida Keys sampling domain was partitioned into strata based on geographical location and habitat characteristics. The Florida Keys domain is overlain in a Geographical Information System (GIS) with a grid of 1 km^2 cells. Each cell contains 25 blocks of 200 x 200 m which are the primary sample units. Block size was chosen such that divers can easily swim from a moored vessel to any location within the boundaries. Second stage sample stations are randomly positioned in each block. There are 226 non-overlapping possible 7.5

m radius fish sampling stations within each block. Because of concerns about autocorrelation and safe diving practices, each fish sampling station consists of the average of combined stationary point estimates from two individual divers (i.e., a "buddy pair"). From 1983 through 1999, a total of 863 diver stations were sampled in BNP. Annual and total sample sizes are given in **Table 1**.

Table 1.- Sample size summary of fish sampling for Biscayne National Park for fishery-independent stratified random trawl (TRAWL) surveys, two-stage stratified random visual census (RVC), and fishery-dependent BNP dock-intercept recreational creel (CREEL) surveys from 1976 to 1999.

Biscayne Bay Stratified Random Trawl Survey		Biscayne National Park Reef Fish Visual Census & Recreational Creel Census		
Month-Year	**TRAWL**	**Year**	**RVC**	**CREEL**
		1976		1388
		1977		2373
		1978		2845
		1979		2699
		1980		2326
		1981		2098
		1982		3161
		1983	18	2686
		1984	2	535
		1985	3	1191
		1986	4	1146
		1987	19	927
		1988	114	609
		1989	159	635
		1990	141	737
		1991	41	697
		1992	63	703
April - May **1996**	118	**1993**		620
August 1996	93	**1994**		844
Nov-Dec 1996	150	**1995**	68	366
March **1997**	122	**1996**	36	541
September 1997	151	**1997**	79	417
November 1997	120	**1998**	79	396
Oct-Nov **1999**	119	**1999**	37	
Feb-March **2000**	110			
Totals	**983**		**863**	**29,940**

2.2 Roller-Frame Trawl Survey (TRAWL)

Trawl sampling was conducted in Biscayne Bay from Rickenbacker Causeway to Long Arsenicker Key in Biscayne Bay, FL, at depths greater than 1 m, using a habitat-based stratified random survey design (see Ault et al. 1999a for details). Sampling was carried out exclusively at night to maximize the capture probability of shrimps, but captured about 120 finfish species. The survey employed a standard roller frame trawl used in the South Florida commercial live bait shrimp fishery (cf., Serafy et al. 1997a). The trawl consists of a 10 mm square mesh net attached to a 3 m wide by 0.5 m high metal frame outfitted with a slotted roller along the lower portion. At a given sampling station, two nets were towed simultaneously on either side of the sampling vessel. A station tow distance of 200 m yielded a tow area of 600 m^2 for each trawl net. Upon completion of a tow, captured fish and shrimp were processed separately for each trawl net. Pink shrimp were sorted from the total catch of fishes and other macroinvertebrates and brought back to the laboratory, where each individual was sexed and carapace length (CL) recorded as the distance from the postorbital margin to the posterior margin of the carapace (Diaz et al. 2001). Individual fish were immediately identified and sized (to nearest mm total length TL) onboard, and then released back into the water. Water temperature, salinity, dissolved oxygen, and depth were measured at each sampling station. Sampling strata were delineated into distinct "habitats" based on a combination of depth, bottom substrate, and salinity zone. Eight "snapshot" surveys (2-3 weeks in duration) were performed in different seasons over the period from spring 1996 to winter 2000. Trawl station locations were randomly selected within each strata for each survey. The TRAWL survey database contains a total of 983 randomized trawl stations. Sample sizes for each seasonal survey are listed in **Table 1**.

2.3 Recreational Fishery Creel Census (CREEL)

Creel census interviews of recreational fishers at public launch ramps have been conducted by BNP personnel and volunteers using standardized data collection procedures since 1976 (Davis and Thue 1979, Harper et al. 2000). Data collection included a fishing party interview and biological sampling of landings conducted at the conclusion of each recreational fishing trip. Information on angler effort and catches were distributed among areal partitions of BNP and detailed data collected included: date of trip, trip duration, number of anglers per vessel, hours fished, species, numbers and sizes of fish captured, numbers and species of fish released, targeted species, angler residence, trip origin, and party composition. Biological sampling consisted of recording fish lengths and numbers by species. The BNP CREEL census database from 1976 to 1998 covers 23 years of information obtained from a total of 29,940 interviews of sportfishers (**Table 1**) who fished either inside the Park boundaries or in the pelagic zone adjacent to the eastern Park boundary. Interviews of sportfishers who primarily fished in other areas outside the Park were not considered in our analysis.

2.4 Supplemental Fishery-Dependent Databases

Other fishery dependent databases were used to supplement the three primary biological databases described above. The 1981-1995 NMFS headboat landings database (Bohnsack et al., 1994; Dixon and Huntsman, 1992) provided information on multispecies stock status in the greater Florida Keys-Dry Tortugas coral reef ecosystem, including but not limited to the BNP region. We also obtained commercial fishery landings reported for the statistical area covering Biscayne Bay, Barnes Sound, and Card Sound for 1986-1998. These were extracted from the NMFS general canvas landings database for the south Florida region (P. Eyo, NOAA SEFSC).

2.5 Biological and Physical "Habitat" Databases

The principal physical and biological "habitat" data used in our analyses involved benthic substrate types, bathymetry, water quality, and hydrodynamics.

2.5.1 Benthic Habitats and Bathymetry

Geographical information system (GIS) layers of bottom substrate classifications interpreted from aerial photographic surveys were provided by the Florida Marine Research Institute and Miami-Dade County Department of Environmental Resources Management. Data for the Biscayne National Park region were extracted from the Florida Keys-wide database. Bottom types included multiple categories of coral reef, seagrass, hardbottom, and sand/rock substrates. Data layer coverages pertaining to land and shoreline delineations were also included.

We acquired the National Ocean Service Hydrographic Survey database of depth soundings for the Florida Coast (NOAA, Silver Spring, MD; NOS, Boulder, CO). Water depths at latitude-longitude point locations were extracted for the BNP region and gridded into GIS layers.

2.5.2 Water Currents and Salinity Dynamics

Water current and salinity dynamics were described for the BNP region using a 2D finite element numerical hydrodynamic model (Wang et al. 1988). Model inputs include empirical information on winds, tides, water currents, canal discharges, salinities, rainfall, evaporation, overland water flow, and groundwater flow collected at various times and locations within the region for approximately 25 years of observations (Wang et al. 2001). The model was developed to describe the currents, residence times, salinity patterns, and larval transport in the Biscayne Bay lagoonal system. The principal model outputs are water current vectors and salinity values along a horizontal spatial grid of resolution between 150 and 1000 m depending on the specific location in the model domain. The model was validated using point samples of surface, mid-water and bottom water quality parameters extracted from the DBHYDRO database provided by the South Florida Water Quality Management District. Data were utilized from 54 stations sampled within southern Biscayne Bay at 2-8 week time intervals during the period 1995-1998.

3.0 Overview of Species and Habitats

The databases described in Section 2 were assimilated and analyzed to characterize the species and habitats of fish and shellfish (macroinvertebrate) community in Biscayne National Park. In our assessments, we begin by documenting the community structure in BNP, and then discuss and quantify the spatial and temporal relationships between fishery resources and habitats.

3.1 BNP Fishery Ecosystem

Coastal fishes, particularly reef fishes and shellfish, are ideal indicators of environmental stress (e.g., fishing, habitat changes, etc.) because they are tightly linked to the southern Florida coastal ecosystem. Many important reef species directly use Biscayne Bay and inshore habitats as nursery and juvenile forage areas before migrating offshore to the coral reefs (**Figure 4A**). They are likely to be directly and indirectly impacted by the Everglades restoration efforts. Mature animals spawn at the deep edge of the bank reefs, and then their larvae are advected coastward where juveniles settle in lagoons and seagrass beds on barrier islands. Obvious examples include pink shrimp (*Farfantepenaeus duorarum*) spiny lobster (*Panulirus argus*), barracuda (*Sphyraena barracuda*), hogfish (*Lachnolaimus maximus*), Goliath grouper (*Epinephelus itajara*), gray snapper (*Lutjanus griseus*), as well as several other snappers (Lutjanidae), groupers (Serranidae), grunts (Haemulidae), spadefish (Ephippidae), surgeonfish (Acanthuridae), triggerfish (Balistidae), parrotfish (Scaridae) and jacks (Carangidae). Even tarpon and snook are closely tied to Biscayne Bay as they extensively utilize reef habitats as adults. In most cases, however, the relative importance of different habitats in Biscayne Bay and offshore of the Keys has rarely been quantified for different reef or coastal species.

Key aspects of the south Florida fishery ecosystem pertaining to BNP are diagramed in **Figure 4B**. Progressing from west to east, there are a wide variety of aquatic habitats spread over a relatively short distance. The western edge of BNP is lined with marsh and mangrove habitats which serve as the entry point for freshwater inflow to the Biscayne Bay environment via an extensive network of drainage canals. The Park's eastern boundary is characterized by an oceanic pelagic zone dominated by the Gulf Stream ocean current. A subtropical coastal bay environment, leeward barrier islands, and an offshore coral reef system are situated in between these boundaries along a west-to-east gradient of increasing salinity. Animal surveys, described above, targeted three principal habitats, the coastal bay (TRAWL and CREEL), coral reef tract (RVC and CREEL), and near-shore pelagic (CREEL) zones.

3.2 Species Inventory and Fishes at Risk

An overall species inventory for BNP was compiled by combining the following information from animal survey databases: (i) animals observed in the RVC survey that were identified to genus and species by NOAA and RSMAS divers; (ii) animals captured in the TRAWL survey that were identified to genus and species by RSMAS scientists; and (iii) animals captured and kept by sportfishers that were identified to genus and species by BNP scientists conducting the CREEL census. For the CREEL database, animals captured and released by sportfishers, and thus not positively identified by BNP scientists, were not included in the compilation because of the questionable reliability of these data. The overall compiled species inventory is provided in **Appendix B**. The three BNP animal survey databases contained 325 species of fishes and macroinvertebrates representing 77 different families (**Table 2**).

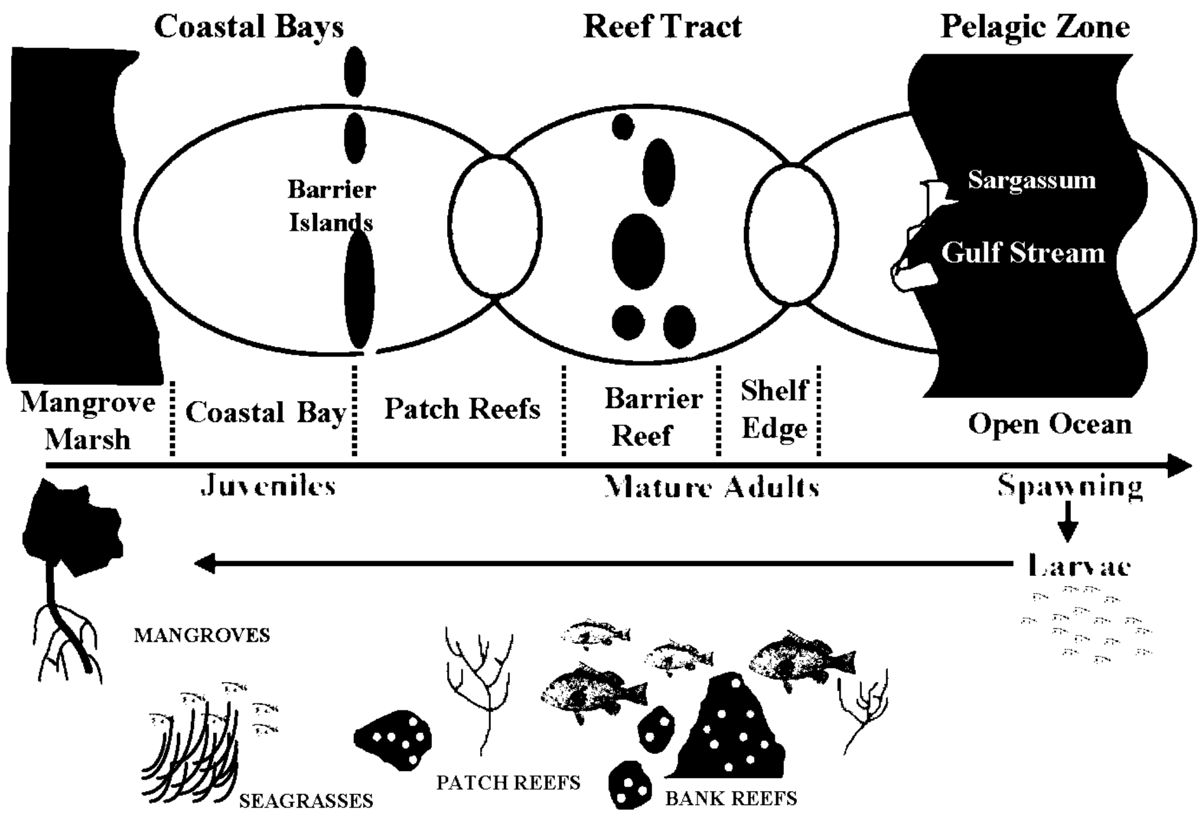


Figure 4a. - Conceptual organization of the south Florida ecosystem and key attributes of "bay to reef" ontogeny for many important coastal fishes and shellfishes. (A) Linkages between animal lifestages and coastal habitat environments extending from freshwater and mangrove marshes on the western fringe to deep reef - pelagic environments in the east. (B) Actual distribution of habitats in Biscayne National Park.

Figure 4b.- Biscayne National Park Fishery Ecosystem

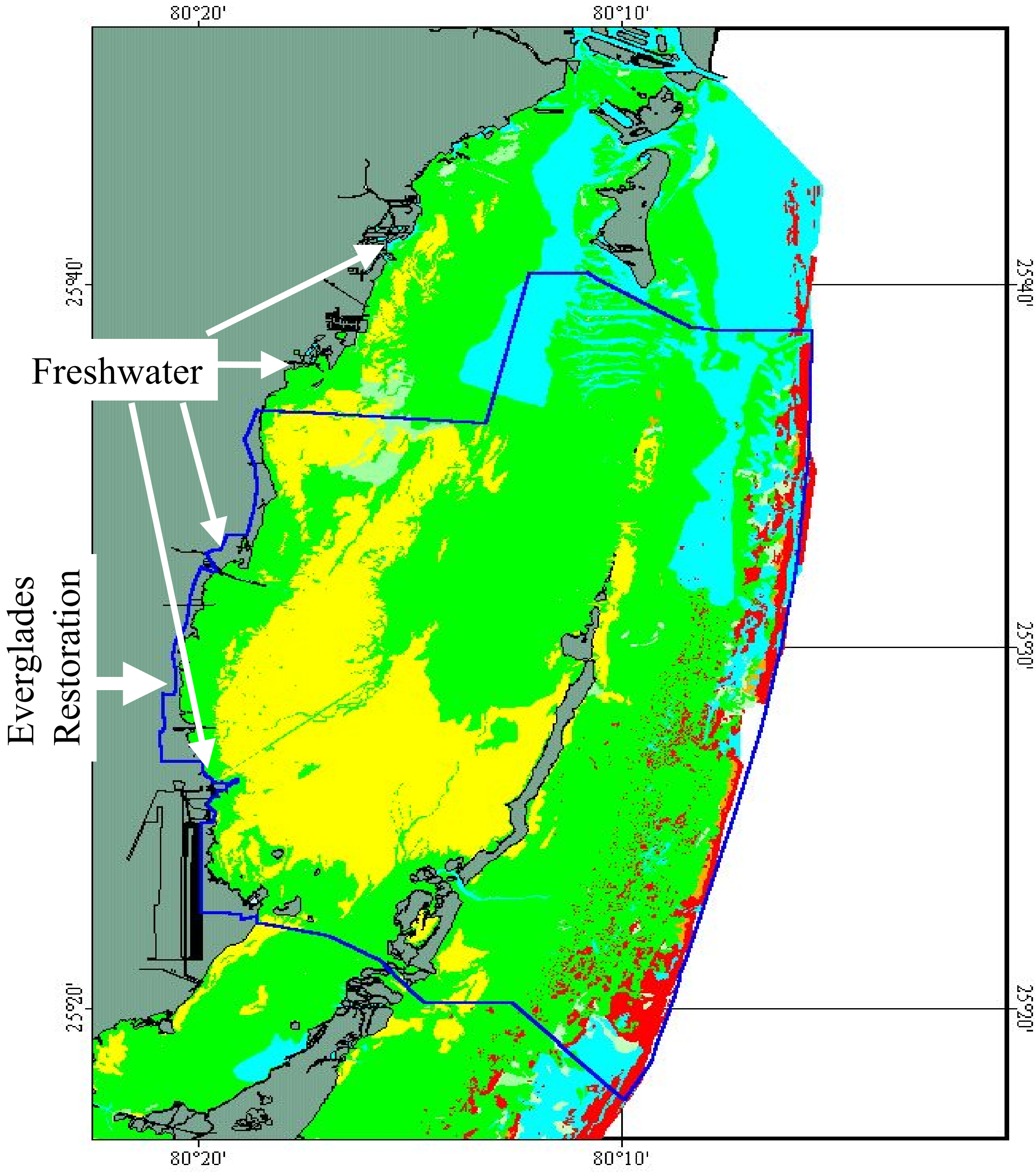


Table 2.- Number of species, families, and species unique to survey type within each dataset from three BNP fishery-independent (RVC, TRAWL) and fishery-dependent (CREEL) surveys.

	RVC	TRAWL	CREEL	Total
Species	182	155	143	325
Families	47	45	45	77
Unique Species	67	78	57	

In addition, each survey database contained a substantial number of species not seen or captured in other surveys (**Table 2**), reflecting differing survey targets with respect to habitats and species life stages. The TRAWL survey targets juvenile and subadult pink shrimp, as well as smaller pre-exploited life stages of fishes, in the coastal bay environment. The RVC survey targets all life stages of fishes in coral reef habitats within the offshore reef system. The CREEL census targets exploited life stages of animals in the coastal bay, offshore reef, and pelagic environments.

At present, none of the fishes that inhabit BNP are on federal or Florida lists of threatened or endangered species. However, it is only very recently that marine fish species have been proposed for inclusion on national and international rare or endangered animal lists (Musick 1998, 1999; Musick et al. 2000; Hudson and Mason 1996). This situation exists in part because: (1) there is societal and scientific doubt that marine fish species can become extinct, (2) the out of sight – out of mind concept; and, (3) they have traditionally been of lower conservation concern than their terrestrial counterparts. In 1996, the World Conservation Union (IUCN) and the World Wildlife Fund (WWF) published rare/threatened marine species criteria and revised animal lists to include marine fish species. The IUCN list includes 18 species found in Biscayne National Park (**Table 3**). Concurrently, the American Fisheries Society (AFS) has evaluated the risk of extinction for marine fish species using new quantitative criteria adopted by IUCN (Hudson and Mace 1996), and published a list of 82 marine fish species at risk in North America (Musick et al. 2000). Of these 82 marine finfish species, 22 are found in BNP.

3.3 Fish Habitats and Community Diversity

Habitats of BNP were described in terms of bottom substrates (**Figure 5**), bathymetry (**Figure 6**) and seasonal salinity patterns (**Figures 7 and 8**). The coastal bay-lagoonal environment of BNP exhibits a basin topography, with shallower (0-2 m) areas along the mainland (western) and leeward island (eastern) shorelines and deeper (2-4 m) areas in the central, mid-basin region. Bottom substrates of the coastal bay zone were grouped into three basic types: seagrass, hard bottom, and bare bottom **(Figure 5)**. Seagrass consisted of sandy or silt-clay sediments vegetated by the seagrasses *Thallasia* spp., *Halodule* spp., or *Syringodium* spp. Seagrasses in the coral reef tract were not identified to species. Hard bottom was characterized by a foundation of oolitic limestone covered by a thin sediment layer populated with a variety of soft coral and sponge species. Bare bottom was substrate generally devoid of large benthic organisms. Seasonal salinity patterns in the coastal bay zone (**Figures 7 and 8)** highlight three broad regions with respect to magnitude and variability of salinity. The first region is located in the eastern bay adjacent to the Atlantic Ocean

Table 3. - Draft list of marine and estuarine fish stocks at risk in Biscayne National Park and surrounding waters. Source: Tom Schmidt, NPS. Superscript [1] by common name indicates species were not observed in RVC surveys.

Family	Common Name	Scientific Name	BNP Habitat	Protection Criteria
Acanthuridae	Gulf surgeonfish[1]	Acanthurus randalli	Coral, seagrass	AFS vulnerable
Balistidae	Queen triggerfish	Balistes vetula	Coral reefs	IUCN vulnerable
Carcharhinidae	Blacktip shark	Carcharhinus limbatus	Coastal bays and reefs	IUCN vulnerable
Carcharhinidae	Dusky shark[1]	Carcharhinus obscurus	Coral, grassbeds	IUCN endangered
Centropomidae	Swordspine snook	Centropomus ensiferus	Mangrove, estuarine	AFS vulnerable
Centropomidae	Fat snook[1]	Centropomus parallelus	Mangrove, estuarine	AFS vulnerable
Centropomidae	Tarpon snook[1]	Centropomus pectinatus	Mangrove, estuarine	AFS vulnerable
Gobiidae	Spot-tail goby	Gobionellus stigmaturus	Seagrass, tidal flats	AFS vulnerable
Gobiidae	Orangespotted goby	Nes longus	Mud and sand bottoms	AFS vulnerable
Labridae	Hogfish	Lachnolaimus maximus	Coral reefs, seagrass	IUCN vulnerable
Lutjanidae	Mutton snapper	Lutjanus analis	Coral reefs, seagrass	IUCN vulnerable
Lutjanidae	Cubera snapper	Lutjanus cyanopterus	Coral reefs, seagrass	IUCN vulnerable
Myliobatidae	Spotted eagle ray	Aetobatus narinari	Coastal bays and reefs	State of Florida protected
Pristidae	Smalltooth sawfish[1]	Pristis pectinata	Coastal bays	IUCN/AFS endangered, FL protected
Scaridae	Scarus guacamia	Rainbow parrotfish	Coral reefs, seagrass	IUCN vulnerable
Sciaenidae	Blue croaker[1]	Bairdella batabana	hardbottoms, seagrass	AFS vulnerable
Scombridae	Bluefin tuna[1]	Thunnus thynnus	Oceanic	IUCN endangered
Serranidae	Speckled hind	Epinephelus drummondhayi	Coral reefs	IUCN/AFS critically endangered
Serranidae	Yellowedge grouper	Epinephelus flavolimbatus	Coral reefs	AFS endangered
Serranidae	Jewfish	Epinephelus itajara	Coral reefs, mangroves	AFS endangered, U.S./FL protected
Serranidae	Marbled grouper	Epinephelus inermis	Coral reefs	IUCN vulnerable
Serranidae	Warsaw grouper[1]	Epinephelus nigritus	Coral reefs, hardbottoms	IUCN/AFS critically endangered
Serranidae	Snowy grouper[1]	Epinephelus niveatus	offshore hardbottoms	IUCN/AFS vulnerable
Serranidae	Nassau grouper	Epinephelus striatus	Coral reefs, seagrass	AFS/IUCN threatened, U.S./FL protected
Serranidae	Blue hamlet	Hypoplectus gemma	Coral reefs	AFS vulnerable
Serranidae	Black grouper	Mycteroperca bonaci	Coral reefs, hardbottoms	AFS vulnerable
Serranidae	Yellowmouth grouper	Mycteroperca interstitialis	Coral reefs, hardbottoms	AFS vulnerable
Serranidae	Gag grouper	Mycteroperca microlepis	Coral reefs, seagrass	AFS/IUCN vulnerable
Serranidae	Scamp	Mycteroperca phenax	Coral reefs, hardbottoms	AFS vulnerable
Syngnathidae	Fringed pipefish[1]	Anarchopterus cringer	Seagrass	AFS vulnerable
Syngnathidae	Lined seahorse	Hippocampus erectus	Seagrass	IUCN vulnerable
Syngnathidae	Longsnout seahorse	Hippocampus reidi	Seagrass	AFS/IUCN vulnerable
Syngnathidae	Dwarf seahorse	Hippocampus zosterae	Seagrass	AFS/IUCN vulnerable
Syngnathidae	Oppossum pipefish[1]	Microphis brachyurus	Seagrass	AFS vulnerable

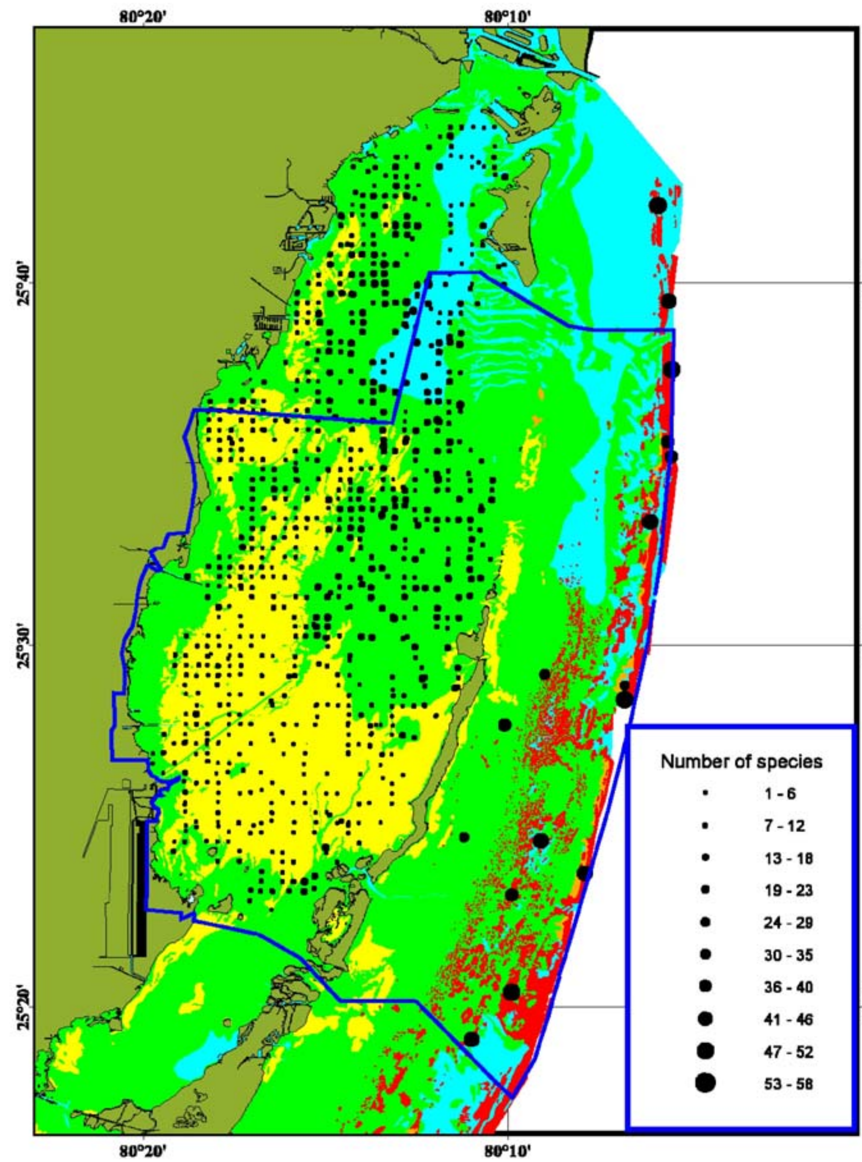


Figure 5. - Diversity of BNP fish community (number of species per surveyed site as determined by TRAWL and RVC sampling methods) overlain on digital map of benthic substrate types (green is seagrass, red is coral reef reefs, yellow is hardbottom mixed with seagrass, orange is hardbottom, light blue is mud or sand substrate.

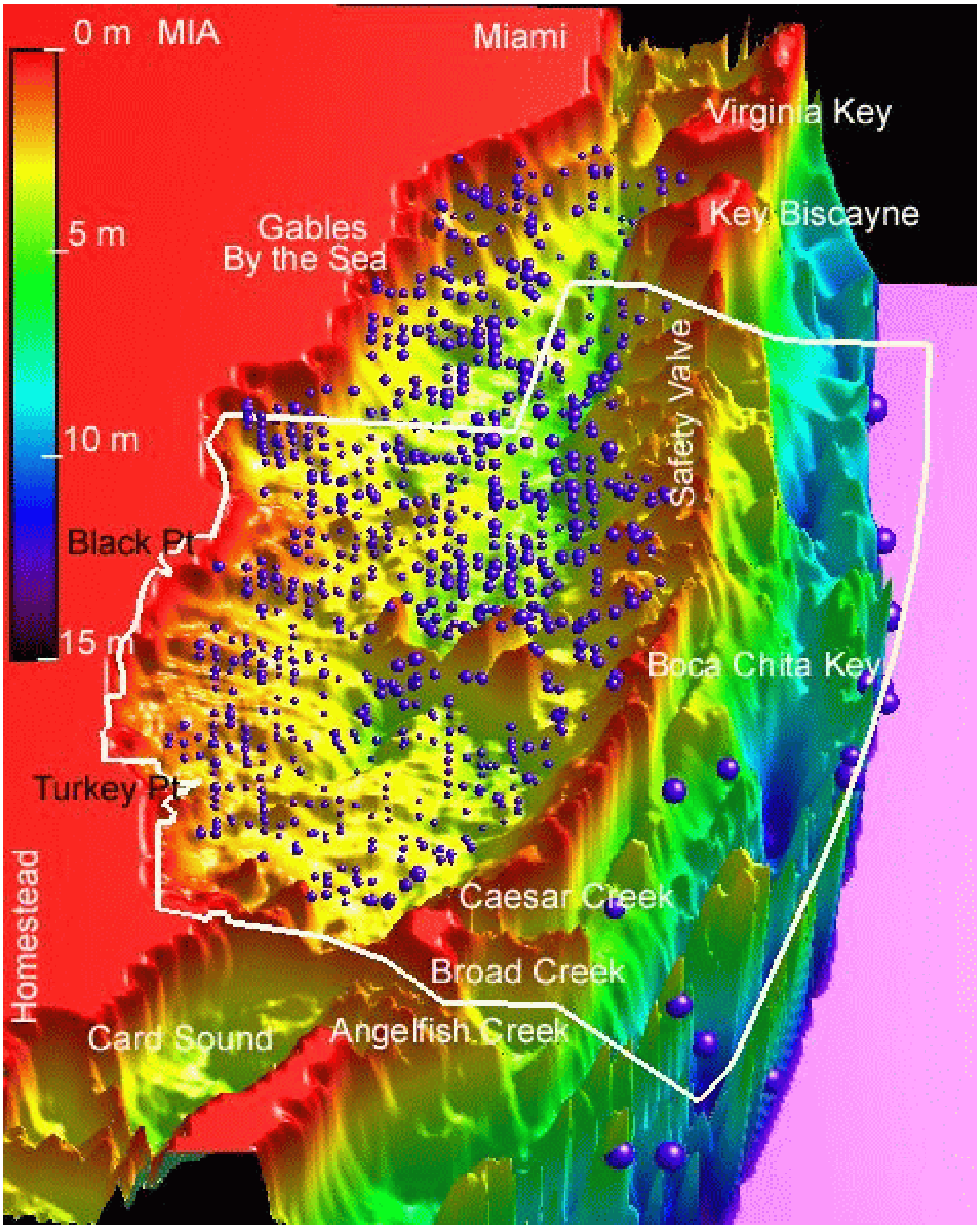


Figure 6.- Biscayne Bay and BNP regional 3-dimensional bathymetery from Miami to North Key Largo. Depth scale (m) is shown in upper right. Shallowest is red while deepest is blue. White line indicates boundary of BNP.

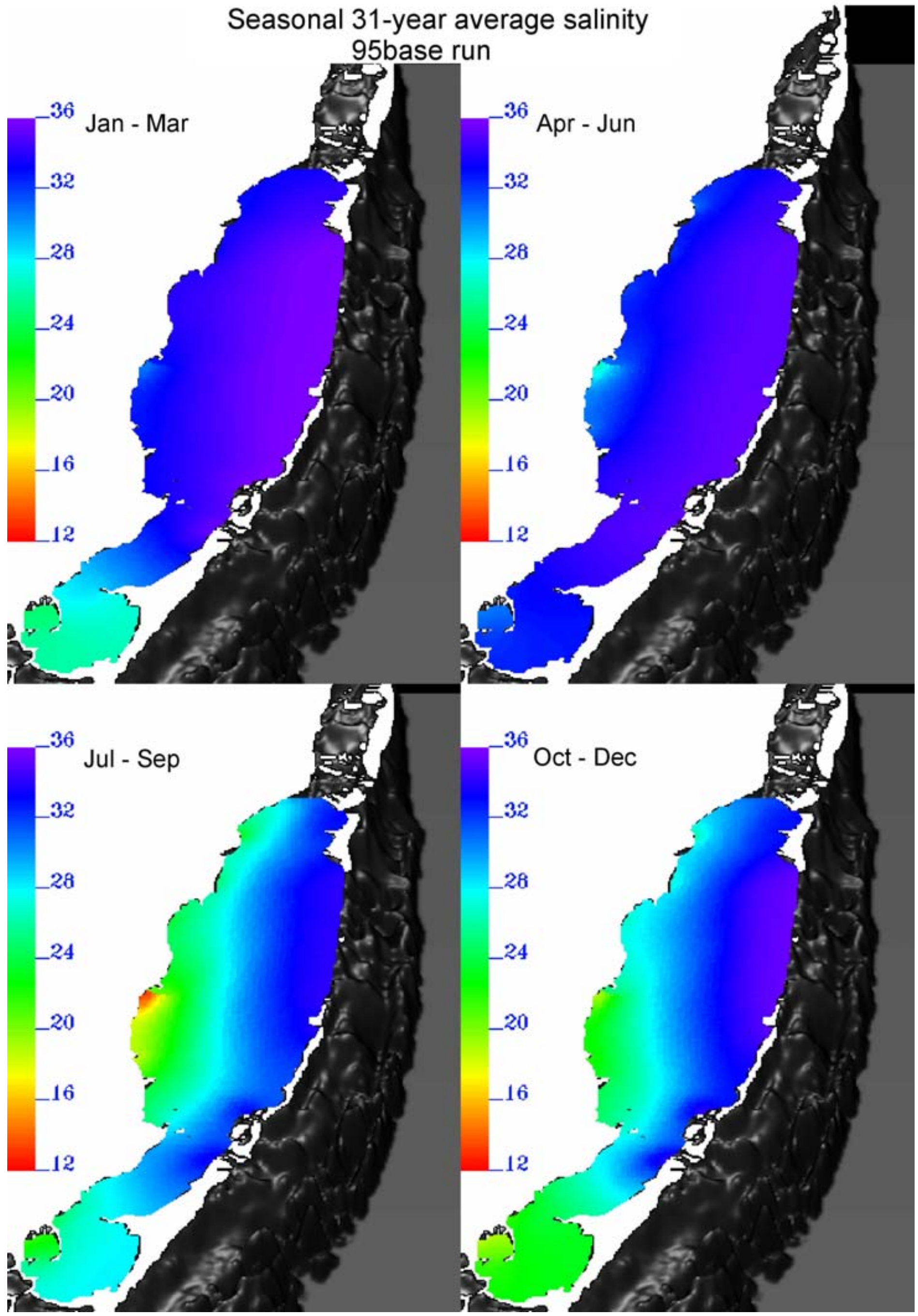


Figure 7.- Maps for Biscayne National Park showing 31-year averages of water column salinity for the 1995 Base inflow (South Florida Water Management District) as computed from the Wang et al. (2001) hydrodynamic model shown by season: (A) January to March; (B) April to June; (C) July to September; and (D) October to December.

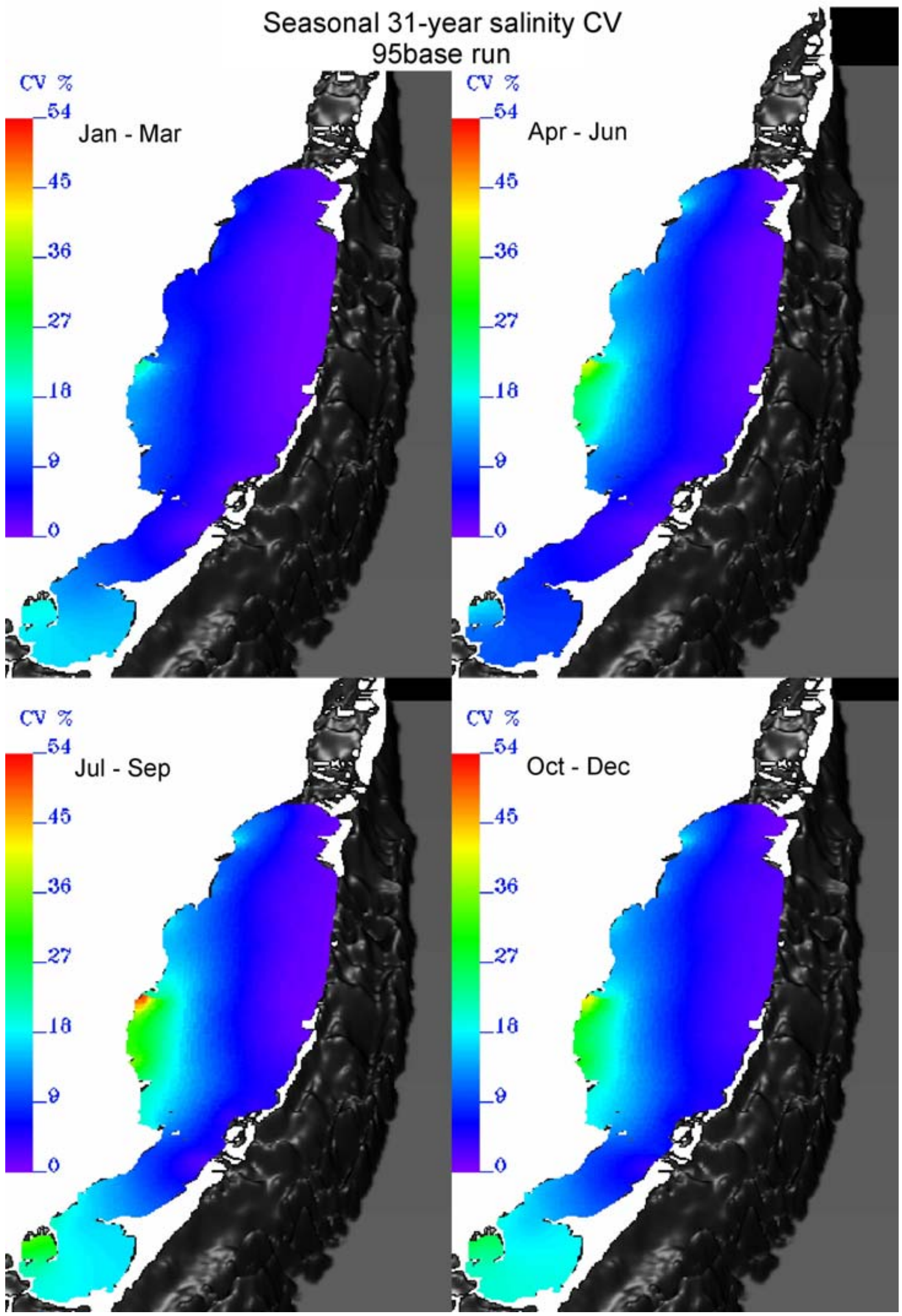


Figure 8.- Maps for Biscayne National Park showing 31-year seasonal coefficient of variation (CV) of water column salinity for the 1995 Base inflow (SFWMD) as computed from the Wang et al. (2001) hydrodynamic model: (A) January to March; (B) April to June; (C) July to September; and, (D) October to December.

and is characterized by near-oceanic salinities that vary little throughout the year. The second mid-basin region is characterized by somewhat lower average salinities during the peak of the wet season (Jul-Sep) that also vary to a moderate degree. The third is a lower-salinity region with high variability located in the western bay, an area influenced by freshwater discharges along the coastline from drainage canals.

The reef environment extends eastward from the barrier island shallow (0-2 m) shoreline area to the deeper (>20-25 m) outer edge of the coral reef tract (**Figure 5**). Bottom substrates include large areas of seagrass, hard bottom, and bare sand categories; however, coral reefs are the most prominent substrate feature. Two types of coral reef communities are present in the BNP reef system, inshore patch reef and offshore platform margin reef. The platform margin reef or 'reef tract' community is characterized by coral reefs that form a quasi-continuous offshore platform or shelf edge parallel to the axis of the Florida Current. Inshore patch reefs are comprised of small and moderate size discrete coral communities that occur between the barrier island shoreline and the western edge of the platform margin reef. Salinities are oceanic with very little variability year-round in the reef and adjacent deeper pelagic environments (**Figures 7 and 8**).

Spatial point values of fish community species richness, a measure of diversity, were overlain on maps of bottom substrate (**Figure 5**) and bathymetry **(Figure 6)**. Values in the coastal bay environment represent the number of fish species captured at an individual TRAWL station location (sampling area 1,200 m^2). Point values in the reef system represent the number of fish species observed by divers within a 200m by 200m primary sampling unit (area 40,000 m^2). For primary units sampled repeatedly over multiple years, point values represent the annual average species richness for the latest 3-year period.

Although a comparable number of species were observed in the RVC and TRAWL surveys (**Table 2**), diversity was substantially higher at reef sampling locations compared to bay sampling locations (**Figures 5 and 6**). These differences are perhaps partly due to the smaller station sampling area and restricted gear size-selectivity of the TRAWL survey compared to the RVC survey. Within the bay, diversity was generally higher in mid-basin seagrass habitats. Low diversity was apparent in the southern bay hard bottom habitat and also in the highly variable salinity zone proximal to the mainland **(Figures 5 and 8)**. In the reef system, diversity was higher along the platform margin reef and somewhat lower in inshore patch reefs.

3.4 Water Currents and Juvenile Recruitment Pathways

The hydrodynamics of Biscayne Bay have been well studied (Wang et al. 1988, Wang et al. 2001). Principal flows enter and exit the Bay through the Safety Valve, and Angelfish-Broad-Caesar's creeks (**Figure 9**). Residence time in the Bay varies widely from several months in the more enclosed Barnes Sound, to on the order of a month in western parts of south Biscayne Bay, and to near zero in the vicinity of ocean inlets (e.g., Safety Valve).

The hydrodynamic model was coupled to a biological dynamics model for the Lagrangian drift dynamics and recruitment of pink shrimp (Ault et al. 1999b, Wang et al. 2001). In model simulated larval drift and transport experiments, we placed particles (i.e., cohorts of shrimp and fishes) in the physical circulation model near the Safety Valve entrance. Both passive (driven only by advection by currents) and behavioral (swimming vertically) cohorts were used in transport simulations. Passive particles cycled in drift trajectories corresponding to tidal cycles (**Figure 9**). Behavioral particles moved directly into preferred low salinity (~20 ppt) areas. Passive particles took twice as long to reach the Bay's western shoreline. Simulations of drift trajectories of pink

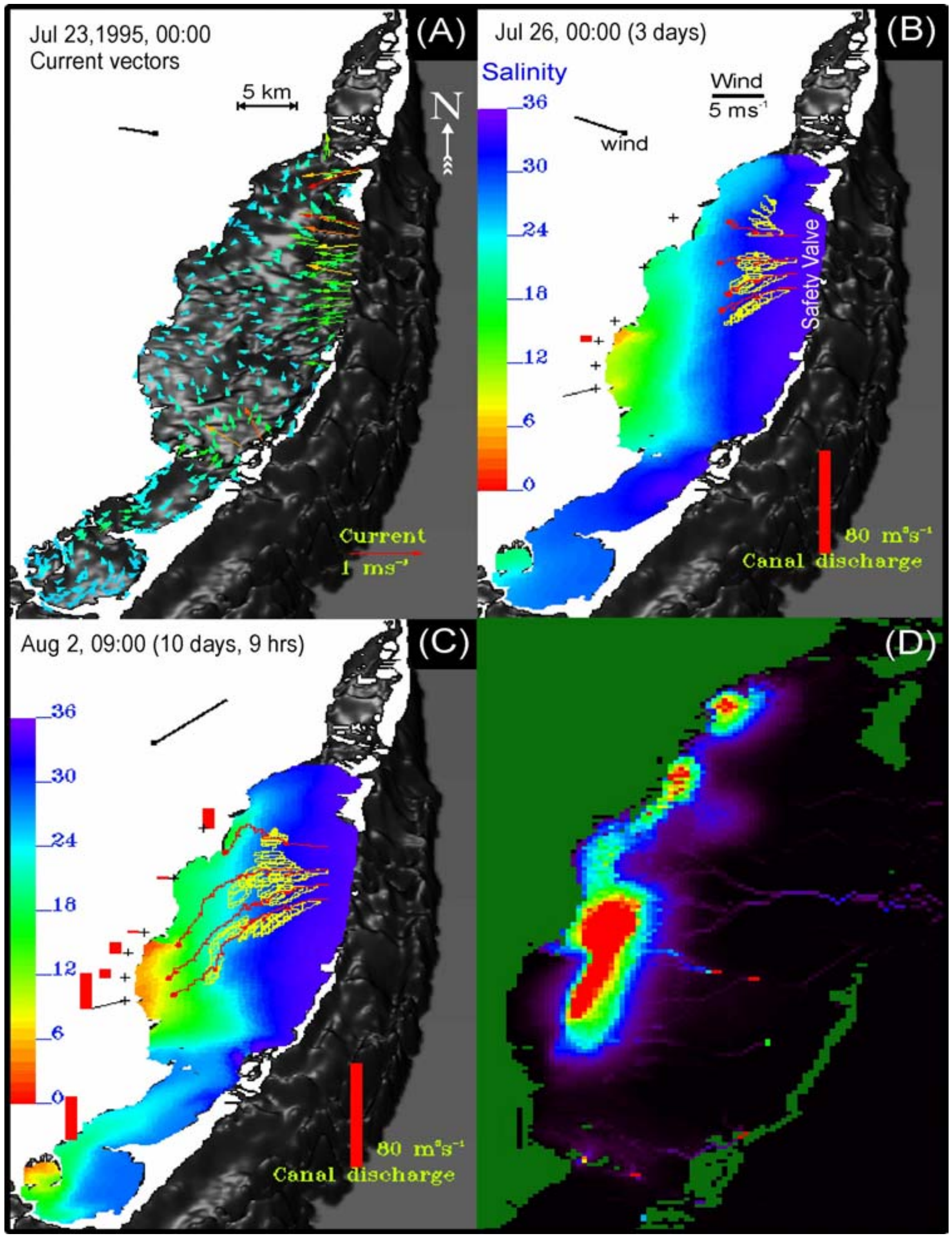


Figure 9.- Drift trajectories of passive (yellow) and active (red) particles from model simulations (cf., Wang et al. 2001): (A) simulated current vectors for 0000 July 23, 1995; (B) 3 days into simulation; (C) 4 days and 19 hours; and, (D) spatial distribution of simulated settled juveniles. The size of the map is approximately 40 km across and 82 km from top to bottom. Current vectors are pointing in direction of motion and length and color of individual vectors indicate speed. The background colors in panels B and C and the color scale indicate the salinity obtained from the hydrodynamic model. The vertical bars at the western shore of the Bay indicate the canal discharge based on the scale in the lower right corner. The vector in the upper part of each panel indicates wind direction and speed.

shrimp larvae and recruited juvenile shrimp spatial abundance distributions were in good agreement with settlement patterns of live shrimp from synoptic sampling surveys (Ault et al. 1999a).

3.5 Size Distributions and Spatial Ontogeny for Exploited Species

The three animal survey databases were synthesized to describe spatial distributions of different life stages for species captured by sportfishers in BNP. Life stage was viewed from both biological (juvenile, adult) and fishery (pre-exploited, exploited) perspectives. For a given species, biological life stages were defined according to length at sexual maturity (L_m), where juveniles<L_m#adults. Fishery life stages were demarcated using length at first capture (L_c), where pre-exploited<L_c#exploited. Presence-absence maps were constructed from fishery-independent survey data (RVC and TRAWL) in the following manner. For the reef system, RVC primary unit point locations where a given species life stage was observed were indicated with a solid dot, whereas an open circle denoted sampling locations where the species life stage was not observed. A similar procedure was used for TRAWL station locations in the coastal bay system, with the exception that only stations where a species life stage was observed were plotted to avoid potential seasonal biases. To aid in the interpretation of the presence-absence maps, we developed length-frequency histograms comparing the size structure for the TRAWL (coastal bay system) and RVC (reef system) surveys. Presence-absence maps and accompanying length-frequency histograms are shown for representative species in the exploited snapper-grouper-grunt complex: black grouper (**Figures 10** and **12B**), red grouper (**Figures 11** and **12A**), mutton snapper (**Figures 13** and **16A**), gray snapper (**Figures 14** and **16B**), yellowtail snapper (**Figures 15** and **16C**), white grunt (**Figures 17** and **19A**), and bluestriped grunt (**Figures 18** and **19B**). CREEL survey data provided very coarse spatial information on distributions of exploited life stages among the general coastal bay, reef, and pelagic environments of BNP functionally limiting its usefulness for spatially-explicit analysis. A list of gear-specific capture regions for species in the CREEL database is provided in **Table 4**. For a given species, gears comprising >5% of database records and capture regions accounting for >10% of gear-specific records are listed.

At least three distinct ontogenetic patterns of species' habitat use in BNP are evident in the snapper-grouper-grunt fisheries complex (**Figures 10-19**, **Table 4**). Mutton snapper, gray snapper, and bluestriped grunt individuals appear to primarily utilize habitats in the coastal bay environment as early juvenile nursery grounds, and then extend their spatial domain out to the reef system as late juveniles and adults. Yellowtail snapper and white grunt individuals seem to utilize both coastal bay and reef system habitats as early juvenile nursery areas, and remain in these general environments as late juveniles and adults. Early juvenile nursery areas in BNP for red and black grouper have not been identified. Sampling surveys conducted in other areas of the Florida Keys indicate that nearshore shallow hard bottom habitats in the reef system may serve this function (personal communication, James Colvocoresses, Florida Marine Research Institute). This particular habitat has not been targeted to date by fishery independent surveys conducted in BNP. Late juvenile and adult groupers primarily utilize the reef system (red grouper) or a mixture of bay and reef habitats (black grouper). Great barracuda, a top-level predator in BNP, occurs in all environments (bay, reef, pelagic) at both juvenile and adult life stages (**Figure 16D**, map not shown). A summary list of species captured or seen in all three animal surveys (TRAWL, RVC, CREEL) is provided in **Table 5**. We can infer the following characteristics for these species: they are subject to exploitation by sportfishers, they occur in both bay and reef systems, and they utilize coastal bay habitats as juvenile nursery grounds to some extent.

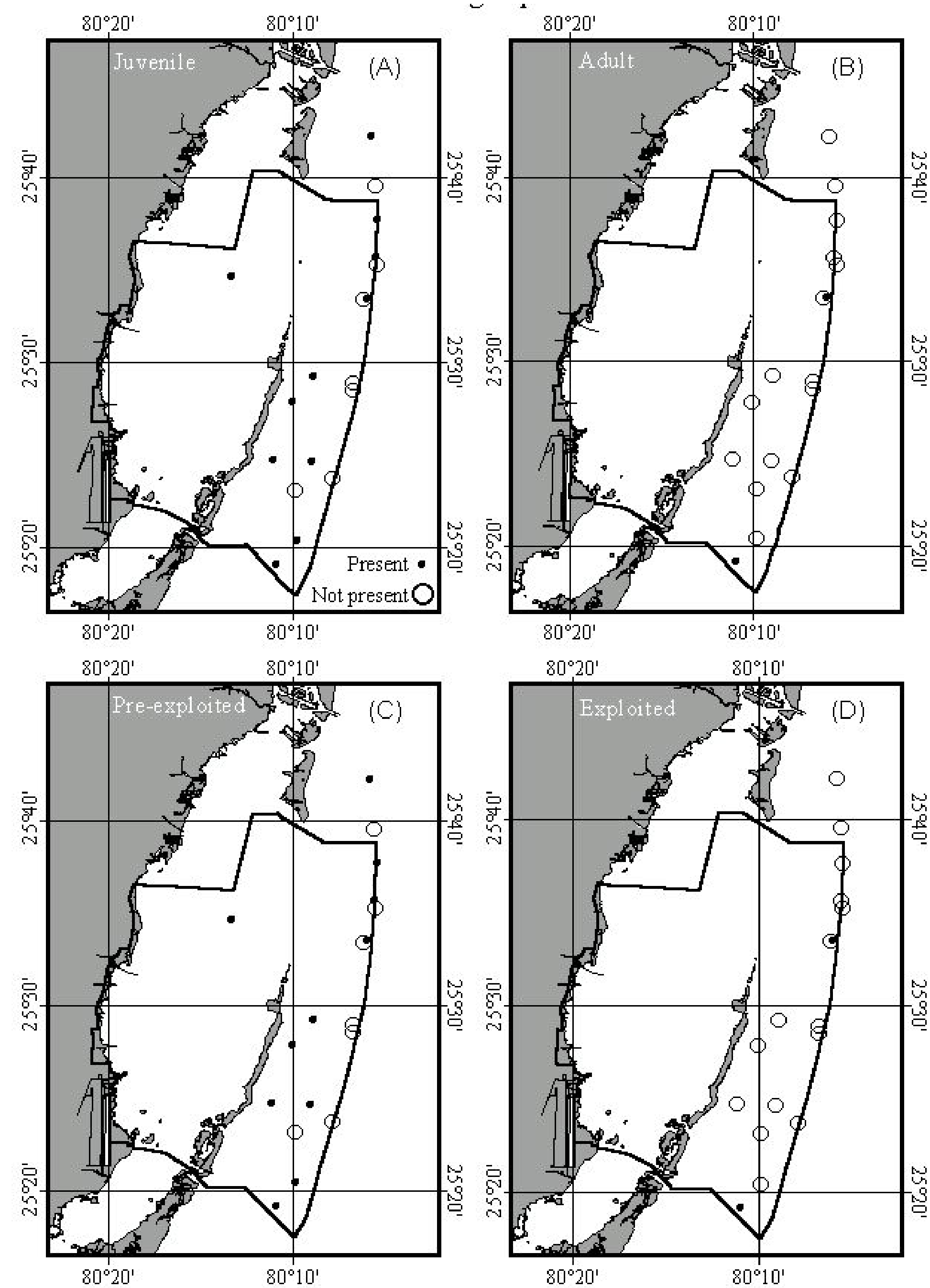


Figure 10.- Presence (solid circle) - absence (open circle) of 4 life stages of black grouper in Biscayne National Park as determined by TRAWL baywide and RVC reef fish surveys: (A) juvenile; (B) mature adult; (C) pre-exploited; and (D) exploited phase fish.

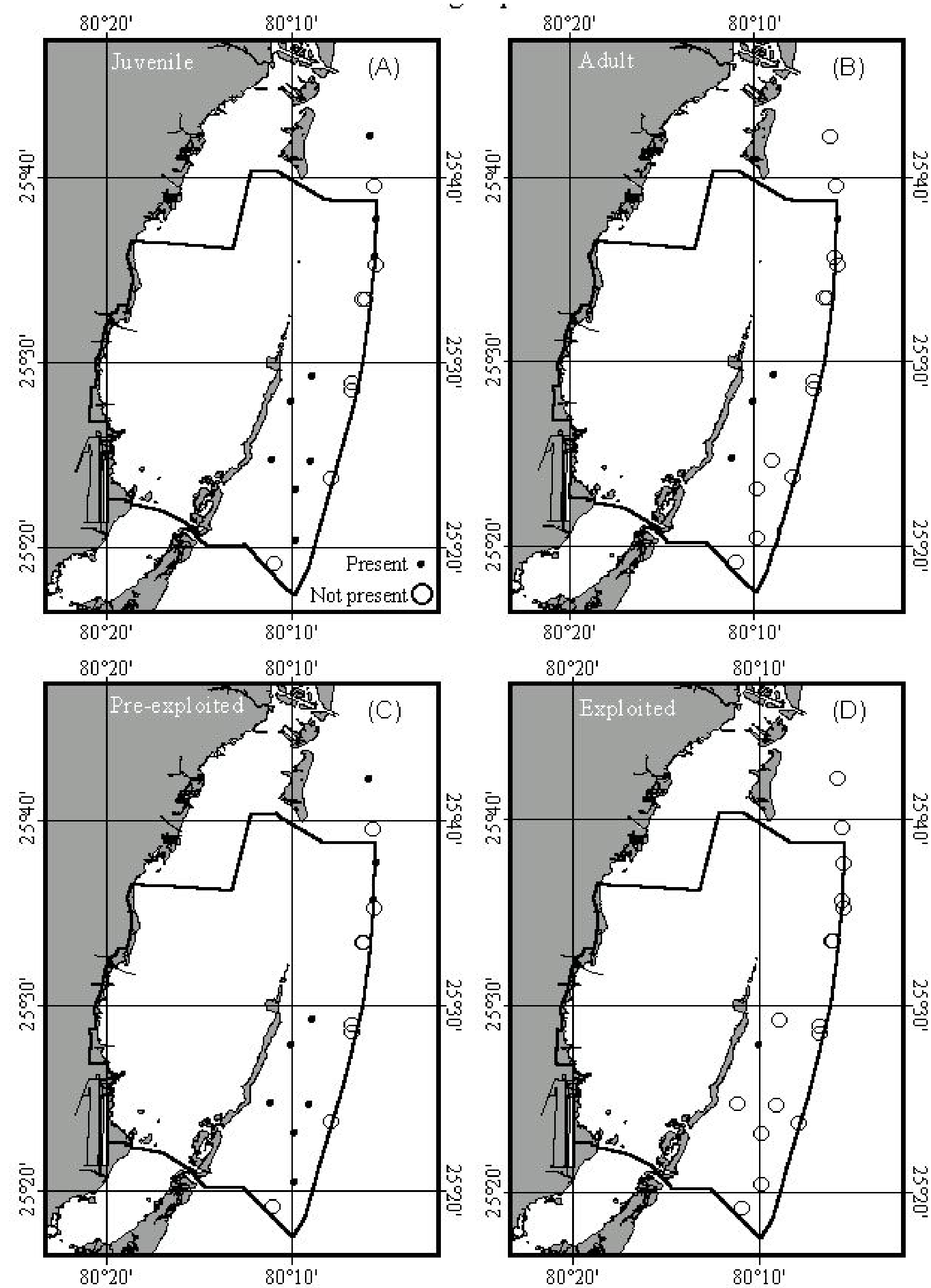


Figure 11.- Presence (solid circle) - absence (open circle) of 4 life stages of red grouper in Biscayne National Park as determined by TRAWL baywide and RVC reef fish surveys: (A) juvenile; (B) mature adult; (C) pre-exploited; and (D) exploited phase fish.

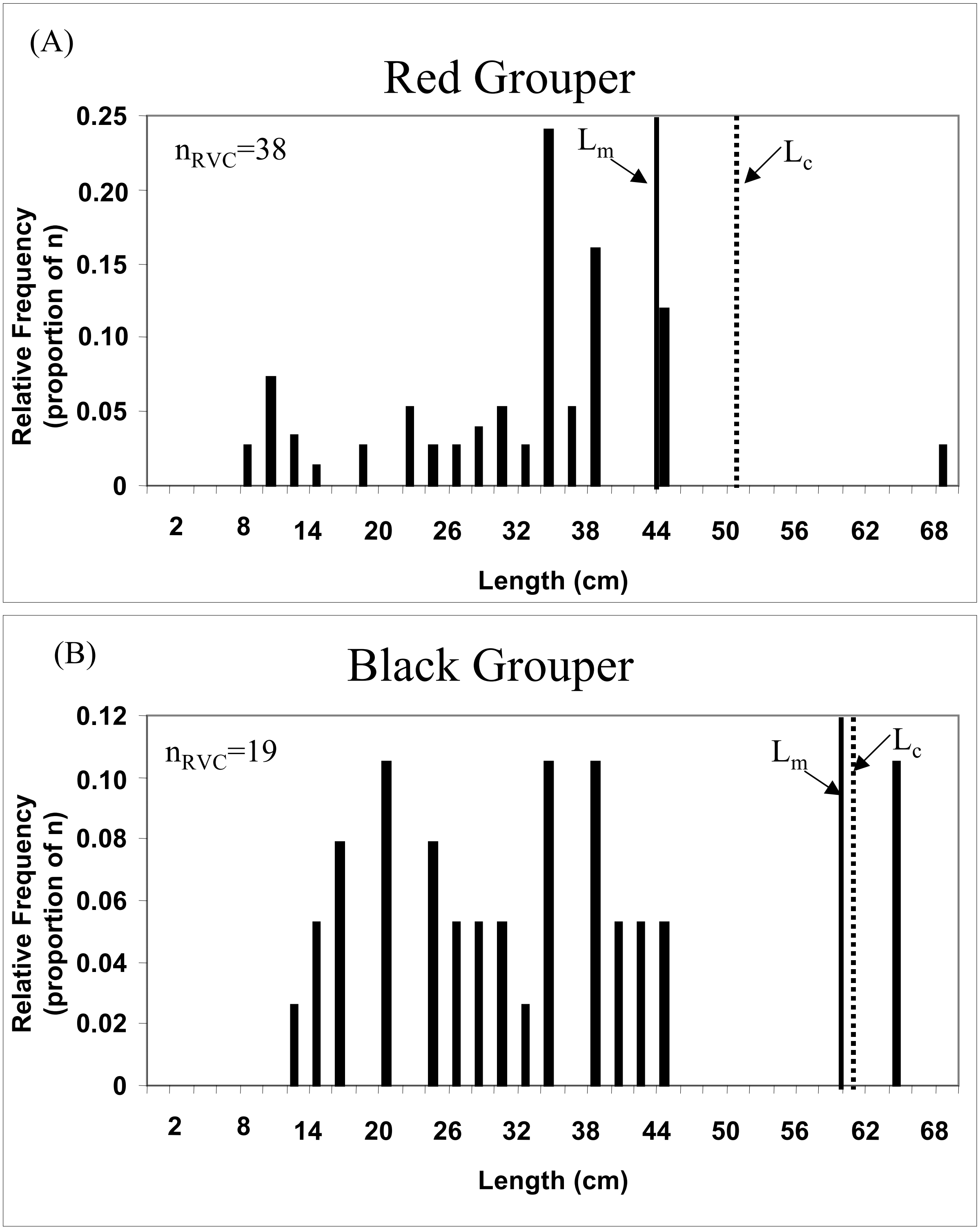


Figure 12.- Length frequency distributions for TRAWL (hatched bar) and RVC (solid bar) surveys in Biscayne National Park for: (A) red grouper; and (B) black grouper. Total number of individuals (n) observed in each survey, length at maturity (L_m), and length at first capture (L_c) are denoted for each species.

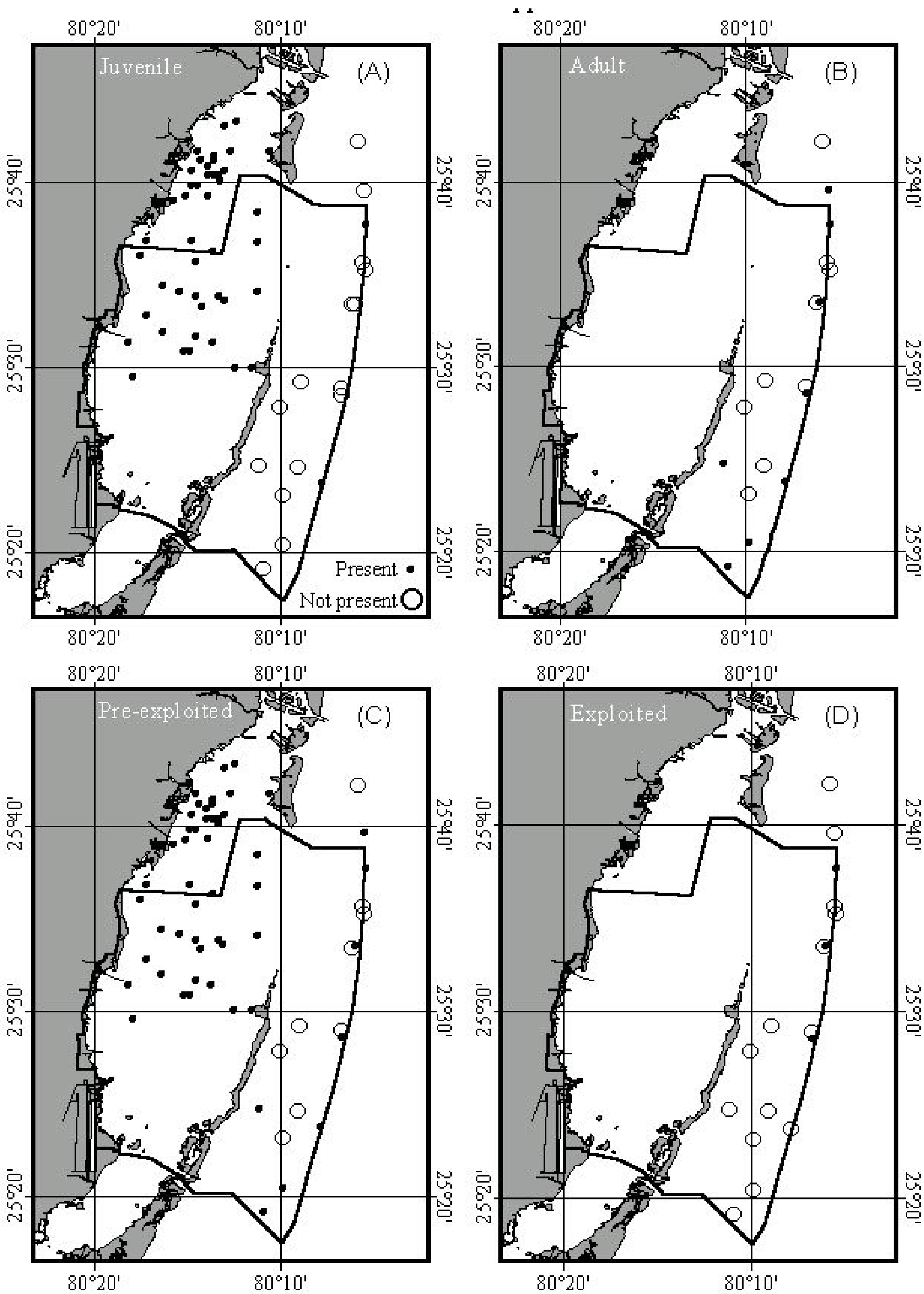


Figure 13.- Presence (solid circle) - absence (open circle) of 4 life stages of mutton snapper in Biscayne National Park as determined by TRAWL baywide and RVC reef fish surveys: (A) juvenile; (B) mature adult; (C) pre-exploited; and (D) exploited phase fish.

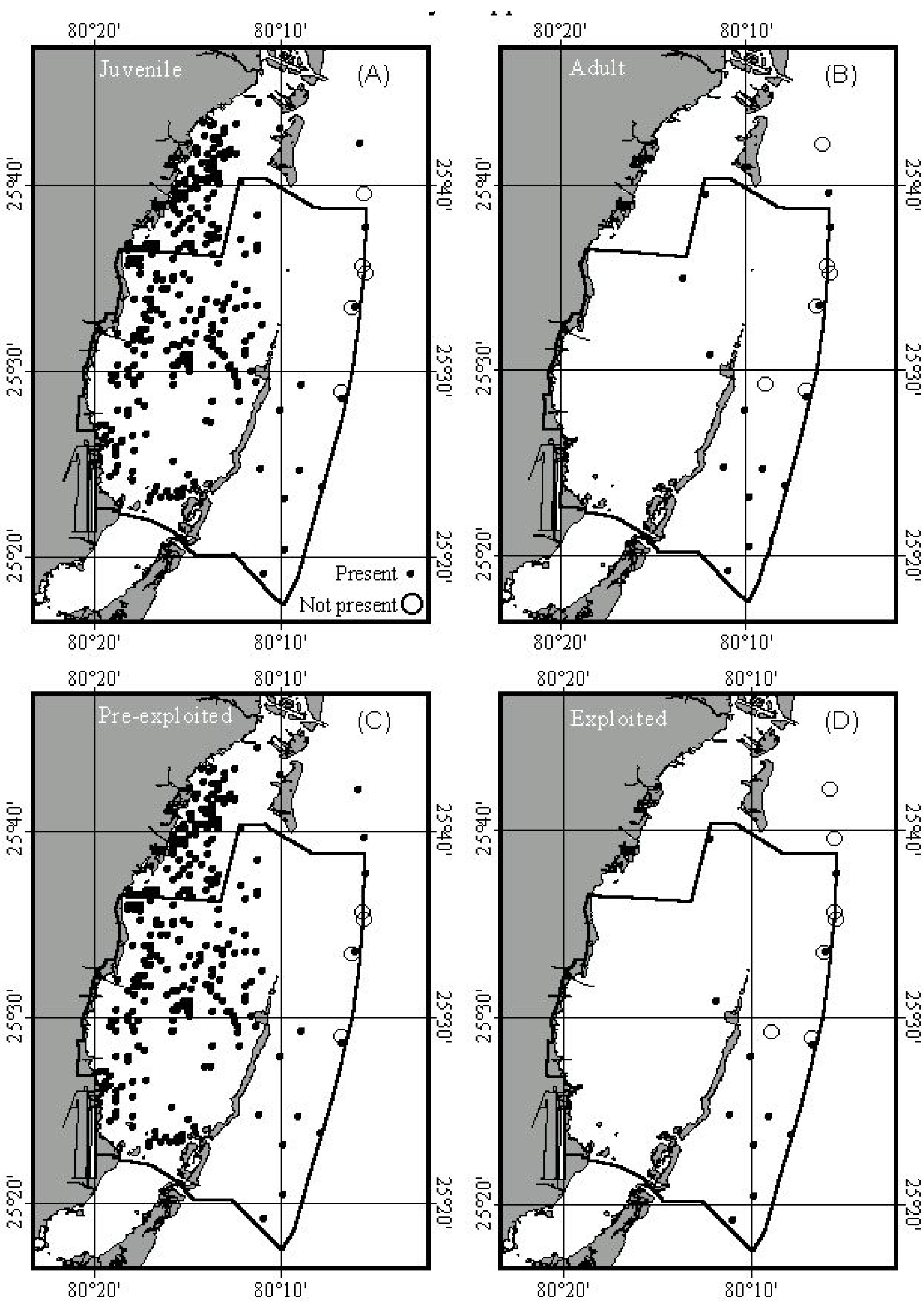


Figure 14.- Presence (solid circle) - absence (open circle) of 4 life stages of gray snapper in Biscayne National Park as determined by TRAWL baywide and RVC reef fish surveys: (A) juvenile; (B) mature adult; (C) pre-exploited; and (D) exploited phase fish.

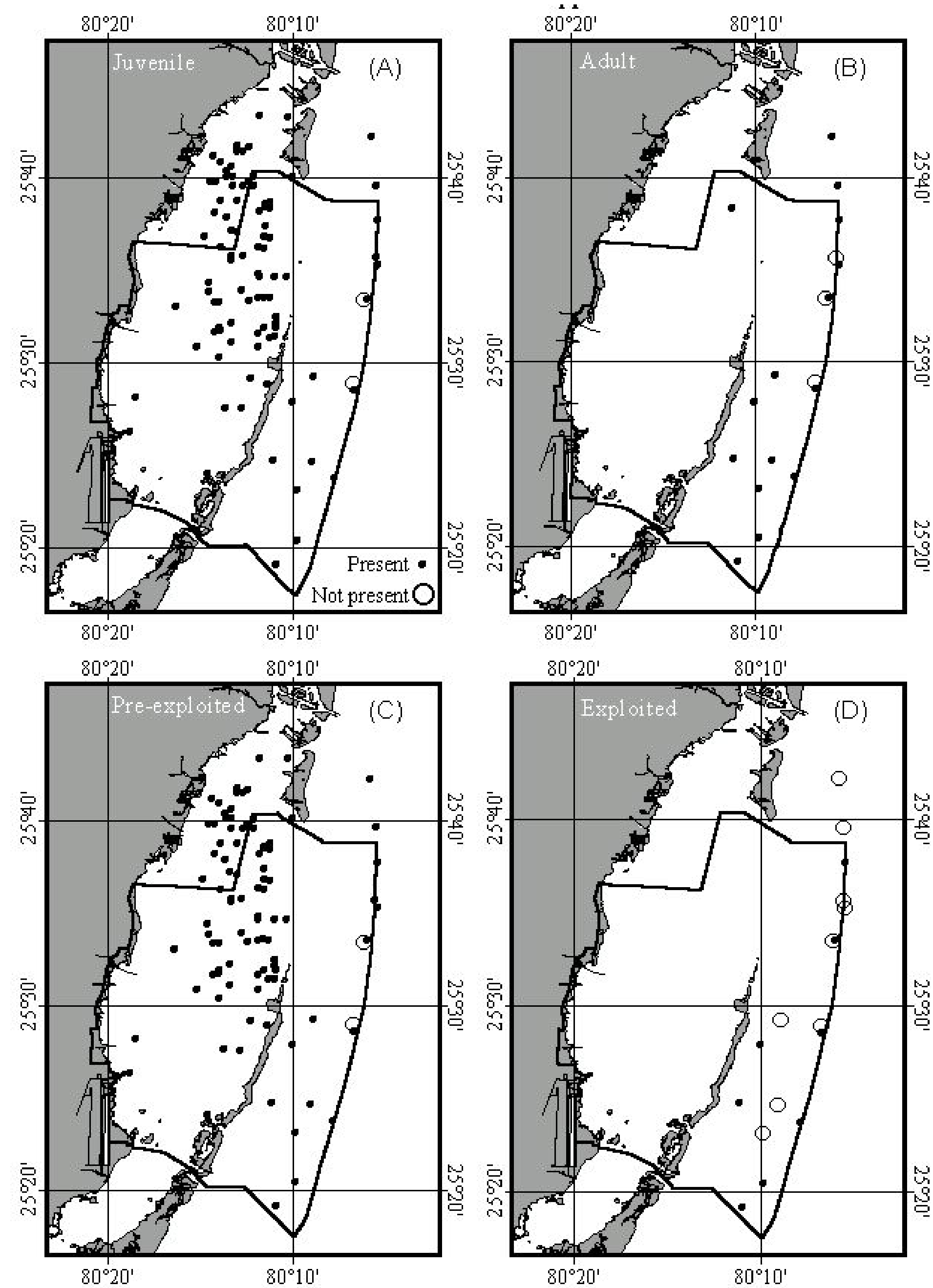


Figure 15.- Presence (solid circle) - absence (open circle) of 4 life stages of yellowtail snapper in Biscayne National Park as determined by TRAWL baywide and RVC reef fish surveys: (A) juvenile; (B) mature adult; (C) pre-exploited; and (D) exploited phase fish.

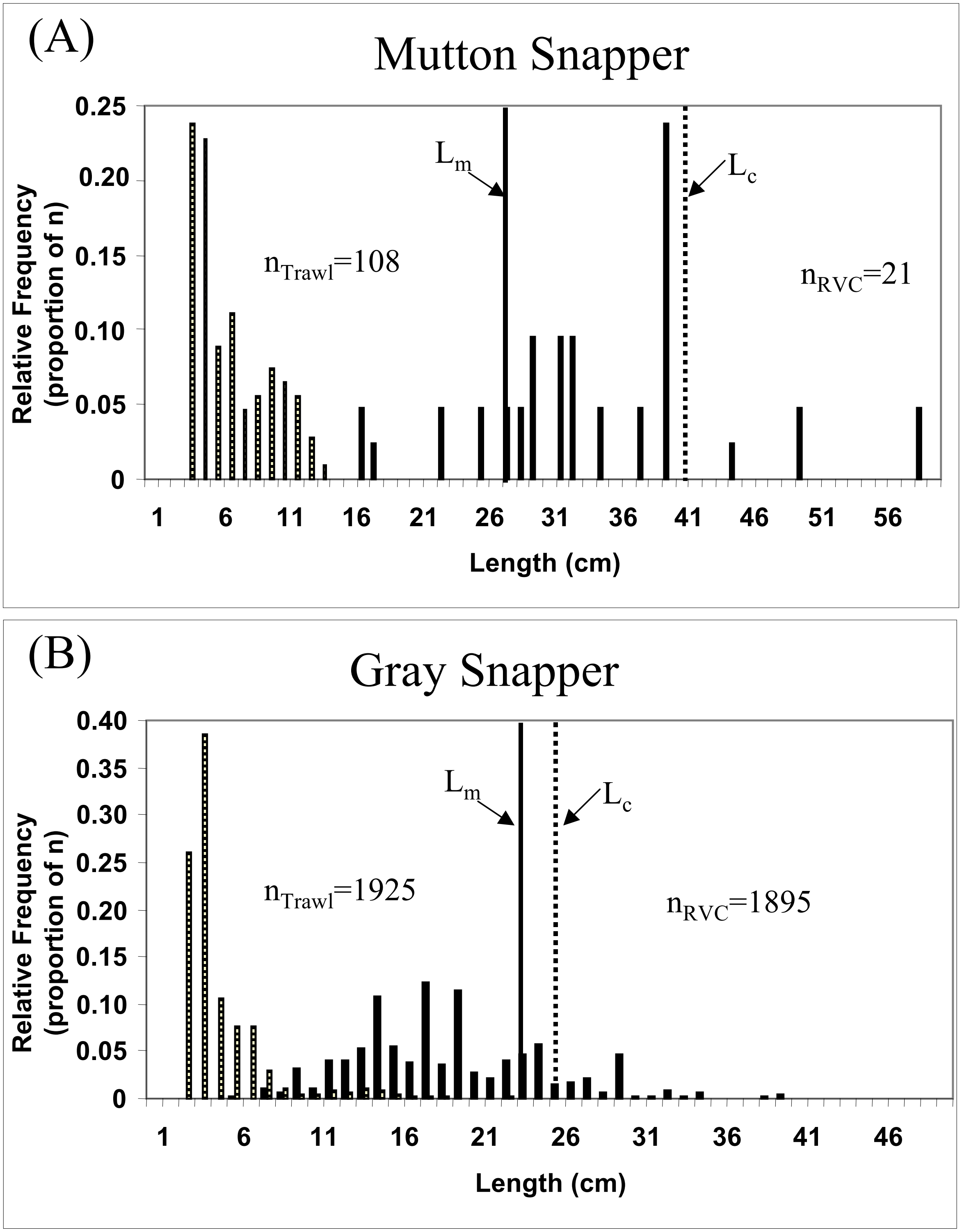
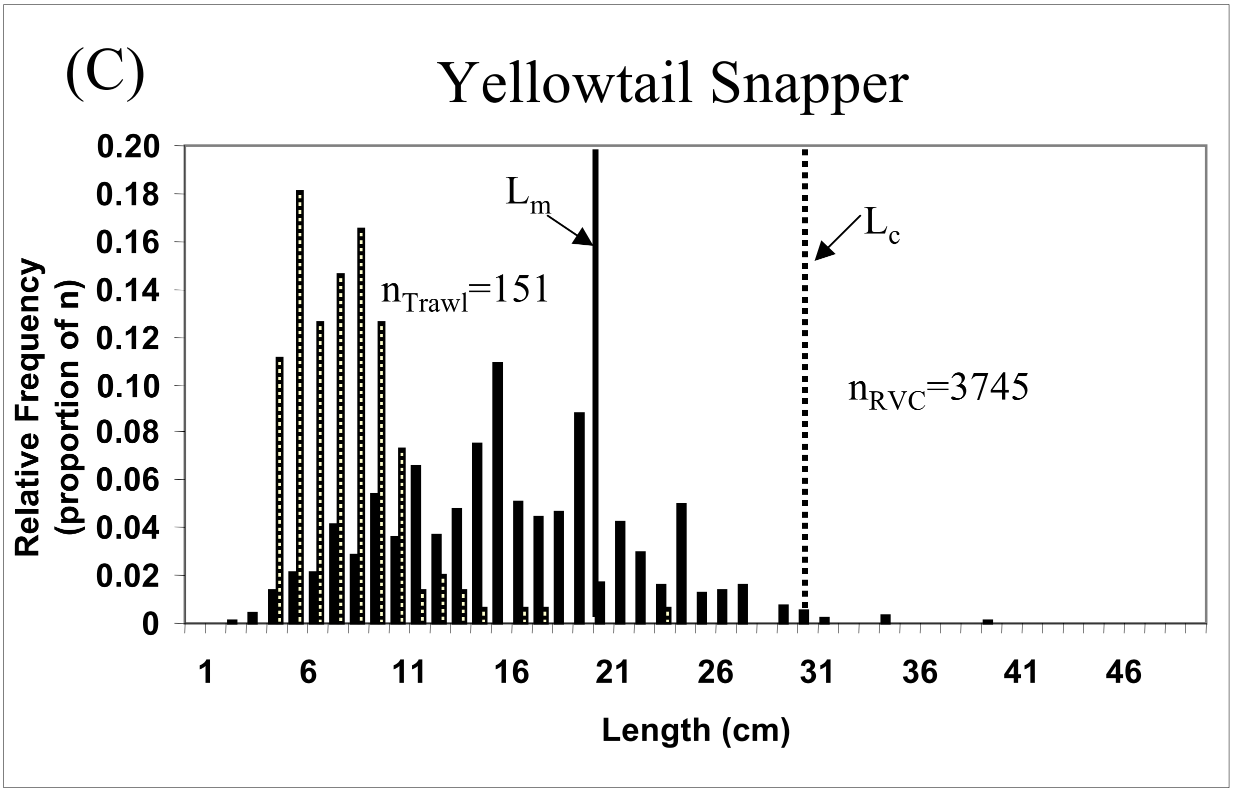


Figure 16.- Length frequency distributions for TRAWL (hatched bar) and RVC (solid bar) surveys in Biscayne National Park for: (A) mutton snapper; (B) gray snapper; (C) yellowtail snapper; and (D) great barracuda. Total number of individuals (n) observed in each survey, length at maturity (L_m), and length at first capture (L_c) are denoted for each species



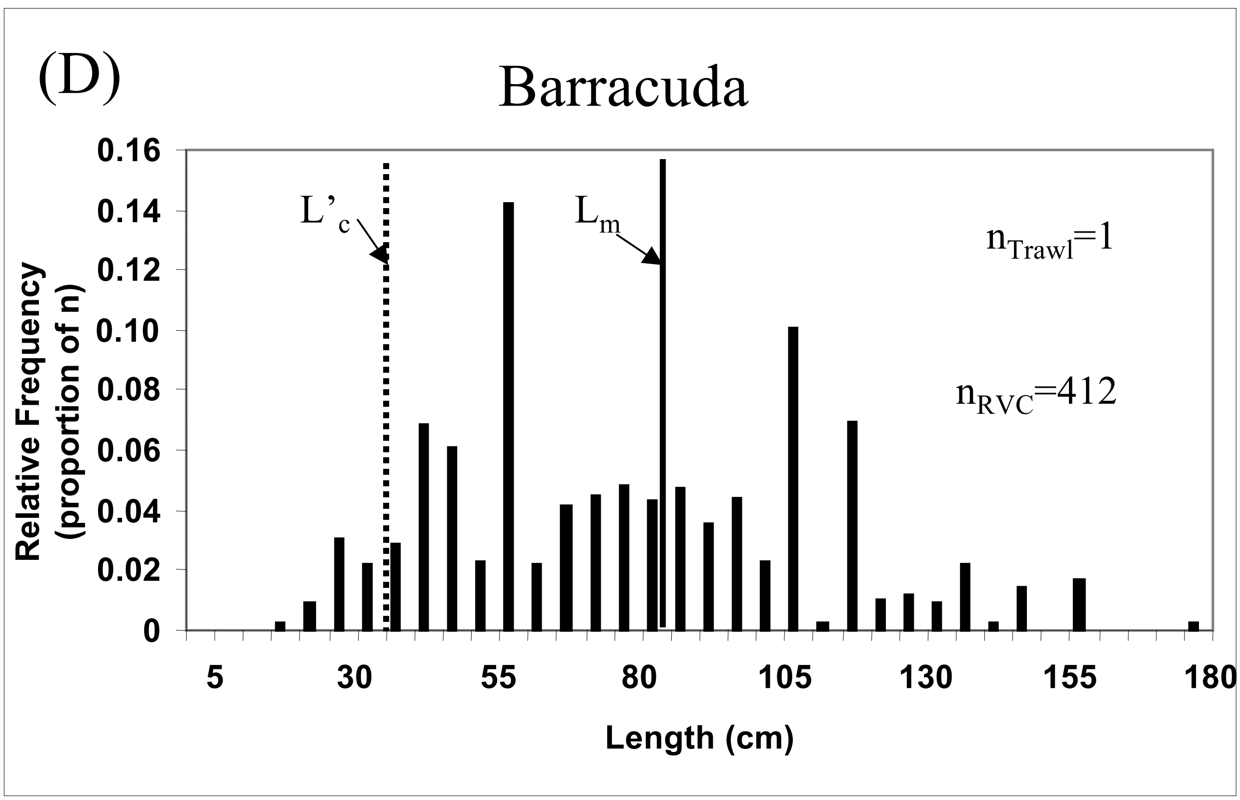


Figure 16.- (continued)

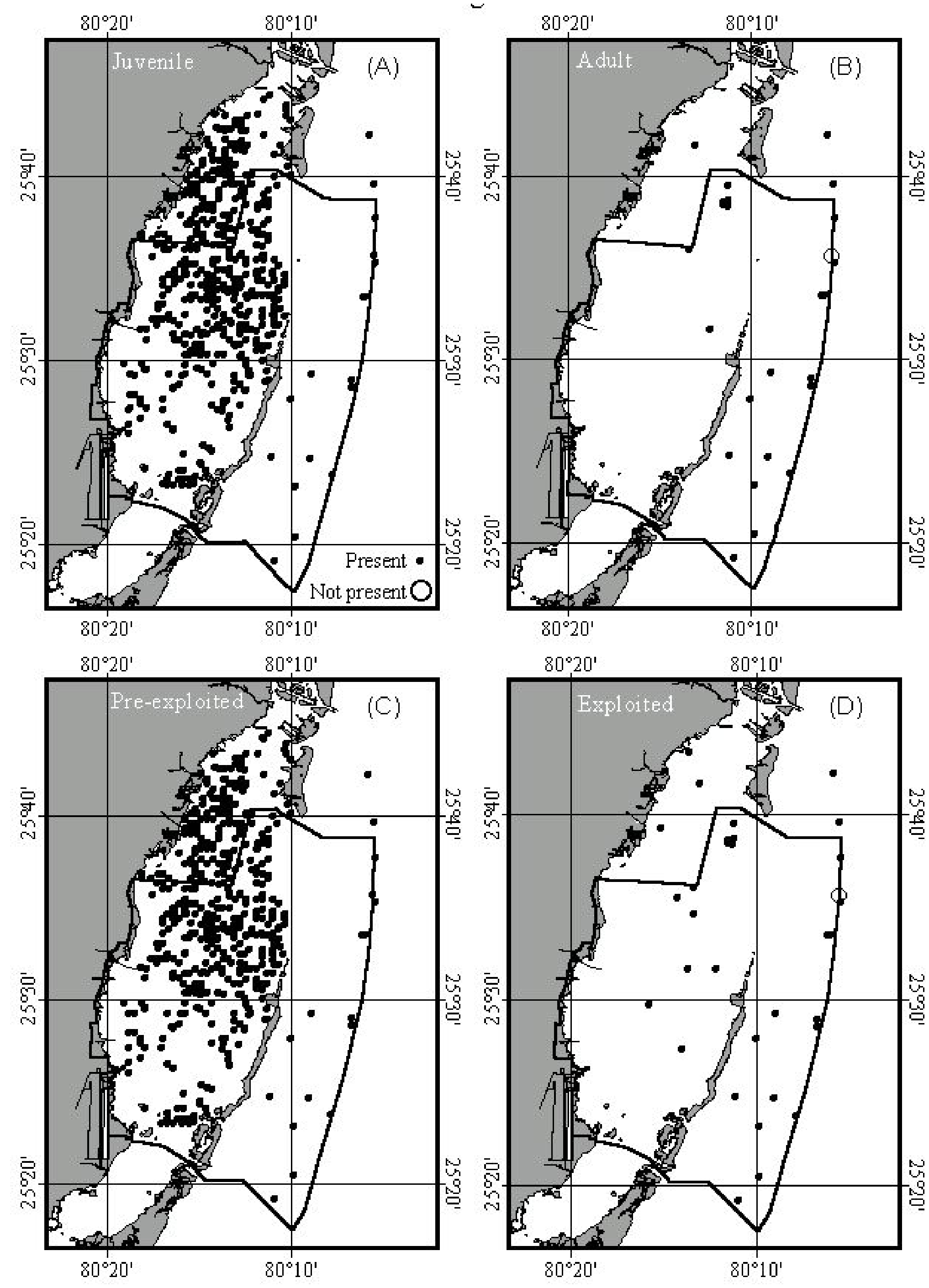


Figure 17.- Presence (solid circle) - absence (open circle) of 4 life stages of white grunt in Biscayne National Park as determined by TRAWL baywide and RVC reef fish surveys: (A) juvenile; (B) mature adult; (C) pre-exploited; and (D) exploited phase fish.

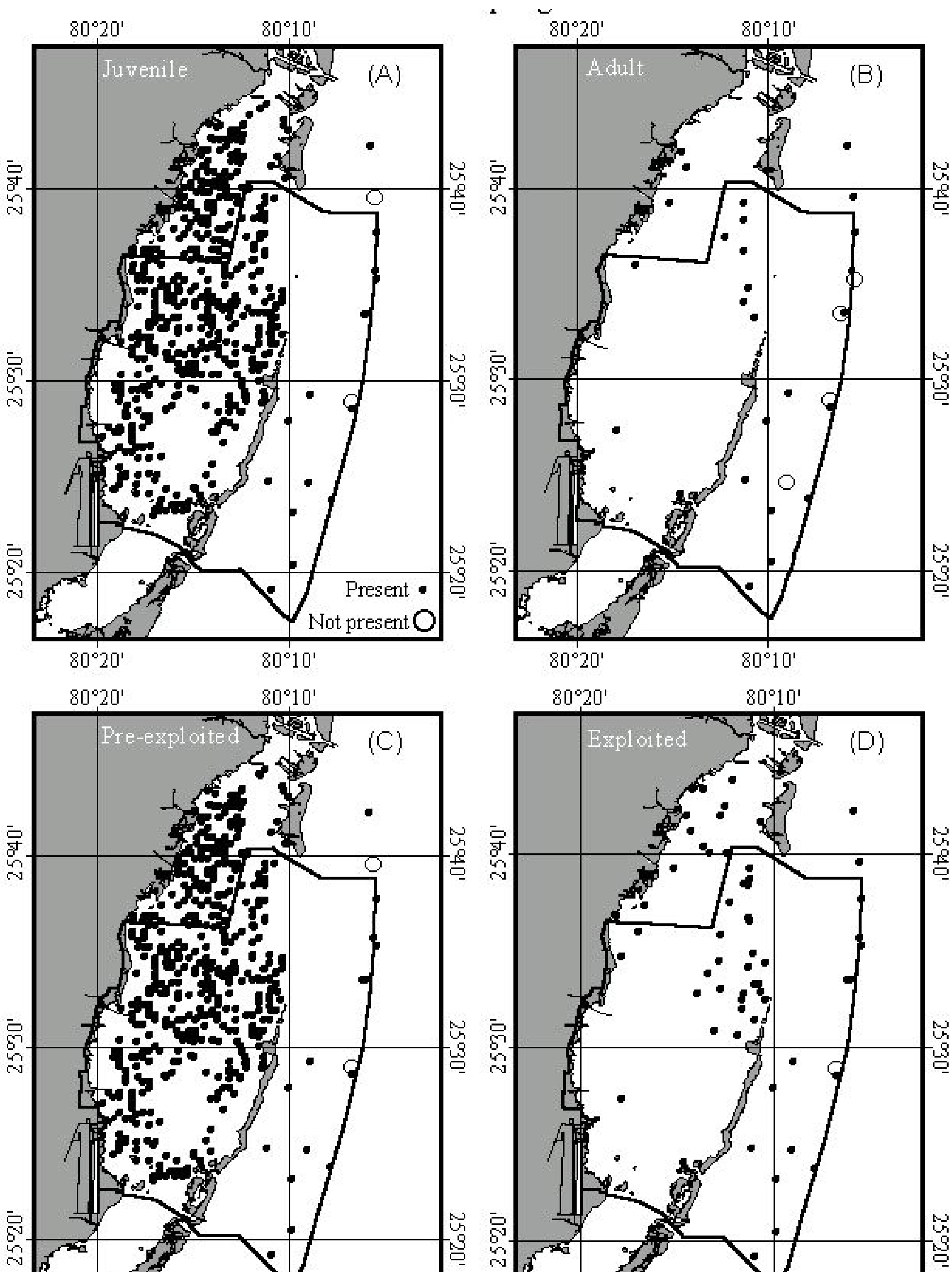
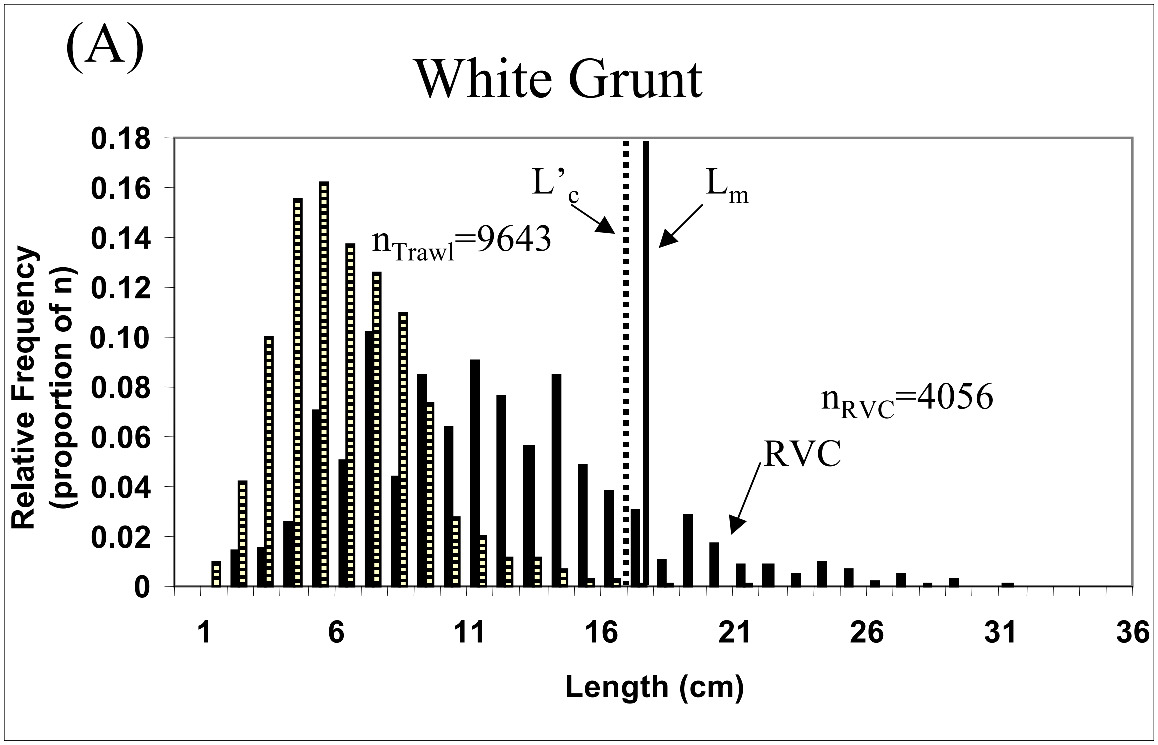


Figure 18.- Presence (solid circle) - absence (open circle) of 4 life stages of bluestriped grunt in Biscayne National Park as determined by TRAWL baywide and RVC reef fish surveys: (A) juvenile; (B) mature adult; (C) pre-exploited; and (D) exploited phase fish.



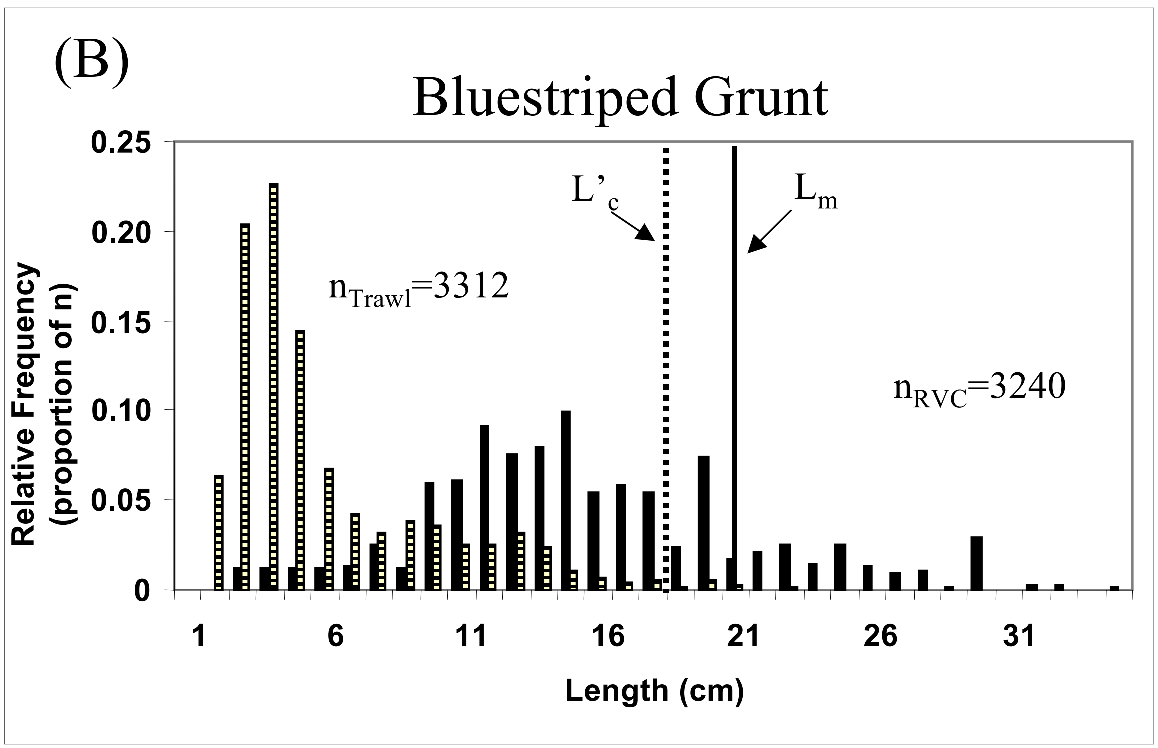


Figure 19.- Length frequency distributions for TRAWL (hatched bar) and RVC (solid bar) surveys in Biscayne National Park for: (A) white grunt; and (B) bluestriped grunt. Total number of individuals (n) observed in each survey, length at maturity (L_m), and length at first capture (L_c) are denoted for each species.

Table 4 - Summary of CREEL survey catches by Family by gear types and capture regions where species were captured, as well as the principal gear responsible for the majority of captures in the recreational fishery survey.

FAMILY	*Scientific Name*	Common Name	Fishing Gears & Capture Regions	Principal Gear
Groupers				
Serranidae	*Epinephelus adscensionis*	rock hind	Hook & Line--Reef Spearfishing--Reef	Hook & Line
Serranidae	*Epinephelus cruentatus*	graysby	Hook & Line--Reef Spearfishing--Reef	Hook & Line
Serranidae	*Epinephelus drummondhayi*	speckled hind	Hook & Line--Reef	Hook & Line
Serranidae	*Epinephelus flavolimbatus*	yellowedge grouper	Hook & Line--Bay, Reef Spearfishing--Reef	Spearfishing
Serranidae	*Epinephelus fulvus*	coney	Hook & Line--Reef Spearfishing--Reef	Hook & Line
Serranidae	*Epinephelus guttatus*	red hind	Hook & Line--Reef Spearfishing--Reef	Hook & Line
Serranidae	*Epinephelus itajara*	Goliath grouper	Hook & Line--Bay, Reef Spearfishing--Reef	Spearfishing
Serranidae	*Epinephelus morio*	red grouper	Hook & Line--Reef Spearfishing--Reef	Hook & Line
Serranidae	*Epinephelus striatus*	nassau grouper	Hook & Line--Bay, Reef Spearfishing--Reef	Hook & Line
Serranidae	*Mycteroperca bonaci*	black grouper	Hook & Line--Bay, Reef Spearfishing--Reef	Hook & Line
Serranidae	*Mycteroperca interstitialis*	yellowmouth grouper	Hook & Line--Bay, Reef Spearfishing--Reef	Hook & Line
Serranidae	*Mycteroperca microlepis*	gag	Hook & Line--Bay, Reef Spearfishing--Reef	Hook & Line
Serranidae	*Mycteroperca phenax*	scamp	Hook & Line--Bay, Reef Spearfishing--Reef	Hook & Line
Serranidae	*Mycteroperca venenosa*	yellowfin grouper	Hook & Line--Bay, Reef Spearfishing--Reef	Spearfishing
Snappers				
Lutjanidae	*Lutjanus analis*	mutton snapper	Hook & Line--Bay, Reef Spearfishing--Reef	Hook & Line
Lutjanidae	*Lutjanus apodus*	schoolmaster	Hook & Line--Bay, Reef Spearfishing--Reef	Hook & Line
Lutjanidae	*Lutjanus cyanopterus*	cubera snapper	Hook & Line--Reef Spearfishing--Reef	Spearfishing
Lutjanidae	*Lutjanus griseus*	gray snapper	Hook & Line--Bay, Reef Spearfishing--Reef	Hook & Line
Lutjanidae	*Lutjanus jocu*	dog snapper	Hook & Line--Bay, Reef Spearfishing--Reef	Spearfishing
Lutjanidae	*Lutjanus mahogoni*	mahogony snapper	Hook & Line--Bay, Reef Spearfishing--Reef	Hook & Line
Lutjanidae	*Lutjanus synagris*	lane snapper	Hook & Line--Bay, Reef	Hook & Line

Table 4.- (Continued)

FAMILY	*Scientific Name*	Common Name	Fishing Gears & Capture Regions	Principal Gear
Lutjanidae	*Ocyurus chrysurus*	yellowtail snapper	Hook & Line--Bay, Reef	Hook & Line
Lutjanidae	*Rhomboplites aurorubens*	vermilion snapper	Hook & Line--Reef	Hook & Line
Grunts				
Haemulidae	*Anisotremus surinamensis*	black margate	Hook & Line--Bay, Reef Spearfishing--Reef	Spearfishing
Haemulidae	*Anisotremus virginicus*	porkfish	Hook & Line--Bay, Reef Spearfishing--Reef	Hook & Line
Haemulidae	*Haemulon album*	margate	Hook & Line--Bay, Reef Spearfishing--Reef	Hook & Line
Haemulidae	*Haemulon aurolineatum*	tomtate	Hook & Line--Bay, Reef	Hook & Line
Haemulidae	*Haemulon carbonarium*	ceasar grunt	Hook & Line--Bay, Reef Spearfishing--Reef	Hook & Line
Haemulidae	*Haemulon flavolineatum*	french grunt	Hook & Line--Bay, Reef	Hook & Line
Haemulidae	*Haemulon macrostomium*	spanish grunt	Hook & Line--Bay, Reef Spearfishing--Reef	Hook & Line
Haemulidae	*Haemulon parra*	sailors choice	Hook & Line--Bay, Reef	Hook & Line
Haemulidae	*Haemulon plumieri*	white grunt	Hook & Line--Bay, Reef	Hook & Line
Haemulidae	*Haemulon sciurus*	bluestriped grunt	Hook & Line--Bay, Reef	Hook & Line
Haemulidae	*Haemulon striatum*	striped grunt	Hook & Line--Bay, Reef	Hook & Line
Haemulidae	*Orthopristis chrysoptera*	pigfish	Hook & Line--Bay, Reef	Hook & Line
Other Fish and Shellfish				
Labridae	*Lachnolaimus maximus*	hogfish	Hook & Line--Bay, Reef Spearfishing--Reef	Spearfishing
Sphyraenidae	*Sphyraena barracuda*	great barracuda	Hook & Line--Bay, Reef, Pelagic	Hook & Line
Sparidae	*Calamus bajonado*	jolthead porgy	Hook & Line--Bay, Reef	Hook & Line
Sparidae	*Calamus calamus*	saucereye porgy	Hook & Line--Bay, Reef	Hook & Line
Carangidae	*Caranx bartholomaei*	yellow jack	Hook & Line--Bay, Reef Spearfishing--Reef	Hook & Line
Carangidae	*Caranx crysos*	blue runner	Hook & Line--Bay, Reef	Hook & Line
Carangidae	*Caranx hippos*	crevalle jack	Hook & Line--Pelagic	Hook & Line
Carangidae	*Caranx latus*	horse-eye jack	Hook & Line--Pelagic	Hook & Line
Carangidae	*Caranx ruber*	bar jack	Hook & Line--Bay, Reef Spearfishing--Reef	Hook & Line
Kyphosidae	*Kyphosus sectatrix*	bermuda chub	Hook & Line--Bay, Reef Spearfishing--Reef	Hook & Line
Balistidae	*Balistes capriscus*	gray triggerfish	Hook & Line--Bay, Reef	Hook & Line
Balistidae	*Balistes vetula*	queen triggerfish	Hook & Line--Reef	Hook & Line
Balistidae	*Cantherhines sufflamen*	ocean triggerfish	Hook & Line--Reef, Pelagic Spearfishing--Reef	Hook & Line
Sciaenidae	*Cynoscion nebulosus*	spotted seatrout	Hook & Line--Bay	Hook & Line
Carangidae	*Trachinotus falcatus*	permit	Hook & Line--Bay, Reef Spearfishing--Reef	Hook & Line
Carangidae	*Alectis ciliaris*	african pompano	Hook & Line--Pelagic	Hook & Line
Coryphaenidae	*Coryphaena hippurus*	dolphin	Hook & Line--Pelagic	Hook & Line

Table 4.- (Continued)

FAMILY	*Scientific Name*	Common Name	Fishing Gears & Capture Regions	Principal Gear
Scombridae	*Sarda sarda*	atlantic bonito	Hook & Line--Pelagic	Hook & Line
Scombridae	*Euthynnus alletteratus*	little tunny	Hook & Line--Reef, Pelagic	Hook & Line
Istiophoridae	*Istiophorus platypterus*	sailfish	Hook & Line--Pelagic	Hook & Line
Scombridae	*Katsuwonus pelamis*	skipjack tuna	Hook & Line--Pelagic	Hook & Line
Scombridae	*Thunnus atlanticus*	blackfin tuna	Hook & Line--Pelagic	Hook & Line
Scombridae	*Scomberomorus cavalla*	king mackerel	Hook & Line--Pelagic	Hook & Line
Scombridae	*Scomberomorus maculatus*	spanish mackerel	Hook & Line--Pelagic Spearfishing--Reef	Hook & Line
Scombridae	*Scomberomorus regalis*	cero	Hook & Line--Bay, Reef, Pelagic Spearfishing--Reef	Hook & Line
Carangidae	*Seriola dumerili*	greater amberjack	Hook & Line--Reef, Pelagic Spearfishing--Reef	Hook & Line
Lobotidae	*Lobotes surinamensis*	tripletail	Hook & Line--Pelagic	Hook & Line
Palinuridae	*Panulirus argus*	Caribbean spiny lobster	Lobster Diving--Bay, Reef	Lobster Diving
Scombridae	*Acanthocybium solandri*	wahoo	Hook & Line--Pelagic	Hook & Line
Acanthuridae	*Acanthurus chirurgus*	doctorfish	Hook & Line--Bay, Reef	Hook & Line

Table 5.- Species captured or seen in all three fishery surveys (RVC, CREEL, TRAWL) during 1976-1999. Strong bay-to-reef ontogenetic linkages suggest candidate species list for "restoration" indicator species.

Common name	Family	Scientific Name
Groupers		
Black grouper	Serranidae	*Mycteroperca bonaci*
Snappers		
Mutton snapper	Lutjanidae	*Lutjanus analis*
Schoolmaster	Lutjanidae	*Lutjanus apodus*
Yellowtail snapper	Lutjanidae	*Ocyurus chrysurus*
Gray snapper	Lutjanidae	*Lutjanus griseus*
Dog snapper	Lutjanidae	*Lutjanus jocu*
Lane snapper	Lutjanidae	*Lutjanus synagris*
Hogfish	Labridae	*Lachnolaimus maximus*
Grunts		
Porkfish	Haemulidae	*Anisotremus virginicus*
Tomtate	Haemulidae	*Haemulon aurolineatum*
French Grunt	Haemulidae	*Haemulon flavolineatum*
Sailors choice	Haemulidae	*Haemulon parrai*
White grunt	Haemulidae	*Haemulon plumieri*
Bluestriped grunt	Haemulidae	*Haemulon sciurus*
Other Reef Fishes		
Great barracuda	Sphyraenidae	*Sphyraena barracuda*
Atlantic spadefish	Ephippidae	*Chaetodipterus faber*
Ocean surgeonfish	Acanthuridae	*Acanthurus bahianus*
Doctorfish	Acanthuridae	*Acanthurus chirurgus*
Rainbow parrotfish	Scaridae	*Scarus guacamaia*
Gray triggerfish	Balistidae	*Balistes capriscus*
Ocean triggerfish	Balistidae	*Cantherhines sufflamen*
Scrawled filefish	Balistidae	*Aluterus scriptus*
Trunkfish	Ostraciidae	*Lactophrys trigonus*
Sea bream	Sparidae	*Archosargus rhomboidalis*
Littlehead porgy	Sparidae	*Calamus proridens*
Sand perch	Serranidae	*Diplectrum formosum*
Spotted moray eel	Muraenidae	*Gymnothorax moringa*
Gray angelfish	Pomacanthidae	*Pomacanthus arcuatus*
Coastal Inshore baitfishes		
Ballyhoo	Exocoetidae	*Hemiramphus brasiliensis*
Yellowfin mojarra	Gerreidae	*Gerres cinereus*
Blue runner	Carangidae	*Caranx crysos*
Macroinvertebrates		
Caribbean spiny lobster	Palinuridae	*Panulirus argus*

3.6 Quantitative Assessment of Habitat Use

Although the primary focus of this report is to conduct a multispecies stock assessment for exploited species in BNP, assessment and management of important habitats that provide critical support to animals is also a concern. Here we present a case study for the pink shrimp population in Biscayne Bay to demonstrate an analysis approach that provides a more detailed, quantitative understanding of habitat use by animals compared to the more qualitative overview presented above.

Fishery-independent TRAWL survey data (Ault et al. 1999a) were utilized to assess pink shrimp (*Farfantepenaeus duorarum*) habitat use in Biscayne Bay. Since a shift in spatial distribution occurs at the onset of sexual maturation (Ault et al. 1999a), juvenile (6-17 mm carapace length) and subadult (>17 mm CL) life stages were analyzed separately. Nine distinct "habitats" were delineated (**Figure 20, Table 6**) by combining three bottom substrates (seagrass, hard bottom, bare bottom) with three east-west depth gradients (mainland subtidal, 1-2 m; basin axis, >2 m; leeward subtidal, 1-2 m). We designated a basic habitat unit as a 600 m^2 trawl station sampling unit. Drawing on resource selection theory (Manly et al. 1993), three measures of habitat use by pink shrimp were evaluated for each habitat type: (1) probability of use *p*(use), i.e., the proportion of habitat units occupied by at least one animal; (2) per unit amount of use, i.e., animal density (numbers per m^2); and (3) population amount of use, i.e., animal abundance (number of animals). A design-based framework (Cochran 1977) was used to estimate the mean and variance of each measure. The three measures in concert provide a fairly comprehensive understanding of differential use of habitats.

Table 6.- Description of habitat codes of **Figure 20**, and the probability *p* of use of each habitat for juvenile and subadult pink shrimp in August and November 1996.

Habitat	Substrate	Depth (m)	Cross-shelf Position	August 1996 Juvenile *p*(use)	August 1996 Subadult *p*(use)	November 1996 Juvenile *p*(use)	November 1996 Subadult *p*(use)
1	Seagrass	1-2	Mainland	1.0	0.750	1.0	1.0
2	Seagrass	>2	Basin Axis	1.0	0.636	1.0	1.0
3	Seagrass	1-2	Leeward	1.0	0.813	1.0	1.0
4	Hardbottom	1-2	Mainland	1.0	0.545	1.0	1.0
5	Hardbottom	>2	Basin Axis	1.0	0.400	1.0	1.0
6	Hardbottom	1-2	Leeward	1.0	0.0	1.0	1.0
7	Barebottom	1-2	Mainland	1.0	1.0	1.0	1.0
8	Barebottom	>2	Basin Axis	1.0	0.500	1.0	1.0
9	Barebottom	1-2	Leeward	1.0	0.500	1.0	0.500

Habitat-specific estimates of *p*(use) for two seasons are given in **Table 6**. In late summer, just after the major period of postlarval immigration and settlement, *p*(use)=1.0 for juvenile pink

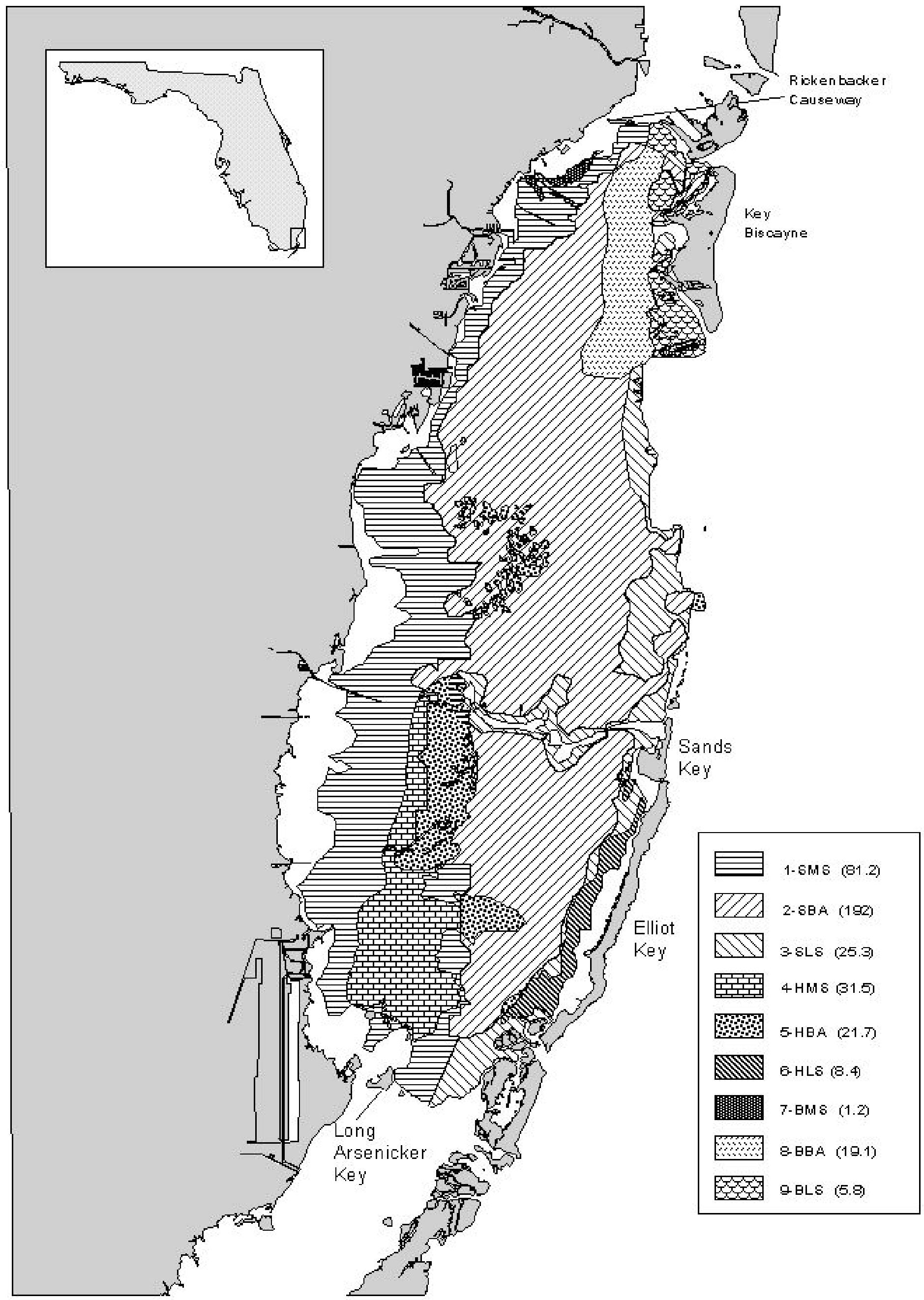


Figure 20. - Map of Biscayne Bay, Florida, showing nine habitat types. Habitat codes are as follows: SMS, seagrass mainland subtidal; SBA, seagrass basin axis; SLS, seagrass leeward subtidal; HMS, hard bottom mainland subtidal; HBA, hard bottom basin axis; HLS, hard bottom leeward subtidal; BMS, bare bottom mainland subtidal; BBA, bare bottom basin axis; bare bottom leeward subtidal.Habitat codes are further defined in **Table 6**. Habitat areas in km^2 are given in parentheses.

shrimp in all habitats. Even though subadult abundance is quite low during this season, from 60% to 80% of seagrass habitat units contained at least one subadult shrimp, with lower *p*(use) in other habitats. In late fall, the period between recruitment into (summer) and emigration from (late winter) Biscayne Bay, *p*(use)=1.0 for both juveniles and subadults in nearly all habitats. These results indicate that virtually every habitat unit in the Bay is occupied by at least one juvenile and one subadult pink shrimp at this time.

Habitat-specific mean density and corresponding 95% confidence intervals for the late fall season are plotted in **Figure 21** for juveniles (**Figure 21A**) and subadults (**Figure 21B**). The horizontal dotted line is the stratified random estimate of overall mean density in Biscayne Bay. Mean density of juveniles was 3-4 times higher in mainland shallow seagrass (habitat 1) compared to the average Bay value. Juvenile density in other habitats was at or below the average Bay value. Subadult shrimp were found in highest densities in mainland and basin axis seagrass (habitats 1 and 2). Density was also above the Bay average in leeward seagrass (habitat 3) and mainland and basin axis hard bottom (habitats 4 and 5). Lowest densities of subadults occurred in leeward hard bottom (habitat 6) and bare bottom habitats (7-9).

Results for population amount of use are expressed in terms of the proportion of the total population (abundance) that resides in a particular habitat (**Figure 22)**. Approximately 80-90% of both juvenile and subadult pink shrimp in Biscayne Bay are found in mainland and basin axis seagrass (habitats 1 and 2), with 10-20% of the population distributed among the remaining habitats (**Figure 22A**). A formal test for habitat selection is made by comparing the population proportion *p*(P) against the proportion of total area *p*(A) for a given habitat. Statistical differences between *p*(P) and *p*(A) were evaluated with a standard t-test (significance level "=0.05), with outcomes interpreted as follows:

$p(P) > p(A)$: positive habitat selection;
$p(P) = p(A)$: no selection;
$p(P) < p(A)$: negative selection.

While 85% of juveniles are in habitats 1 and 2, they are clearly selecting habitat 1 over habitat 2 (**Figure 22A**). Subadult shrimp also exhibit positive selection of habitat 1, but occupy habitat 2 in equal proportion *p*(P) to area *p*(A). Both life stages exhibit negative selection of bare bottom environments (habitats 7-9).

Broad-scale factors underlying pink shrimp habitat selection are illustrated in **Figures 22B** and **22C**, which group habitats in terms of bottom substrate (**Figure 22B**) and salinity zone-depth (**Figure 22C**). While juveniles exhibited positive selection for seagrass over other bottom types (**Figure 22B**), the selection of mainland shallow water environments without regard to bottom substrate is much more striking (**Figure 22C**). In contrast, subadult pink shrimp selected seagrass habitats irrespective of salinity zone and depth. Recruit shrimp (post-larvae) seem to settle on the western shore of Biscayne Bay in waters less than 1 m deep, then move seaward as they age, grow and mature (Ault et al. 1999a, G.A. Diaz, personal communication).

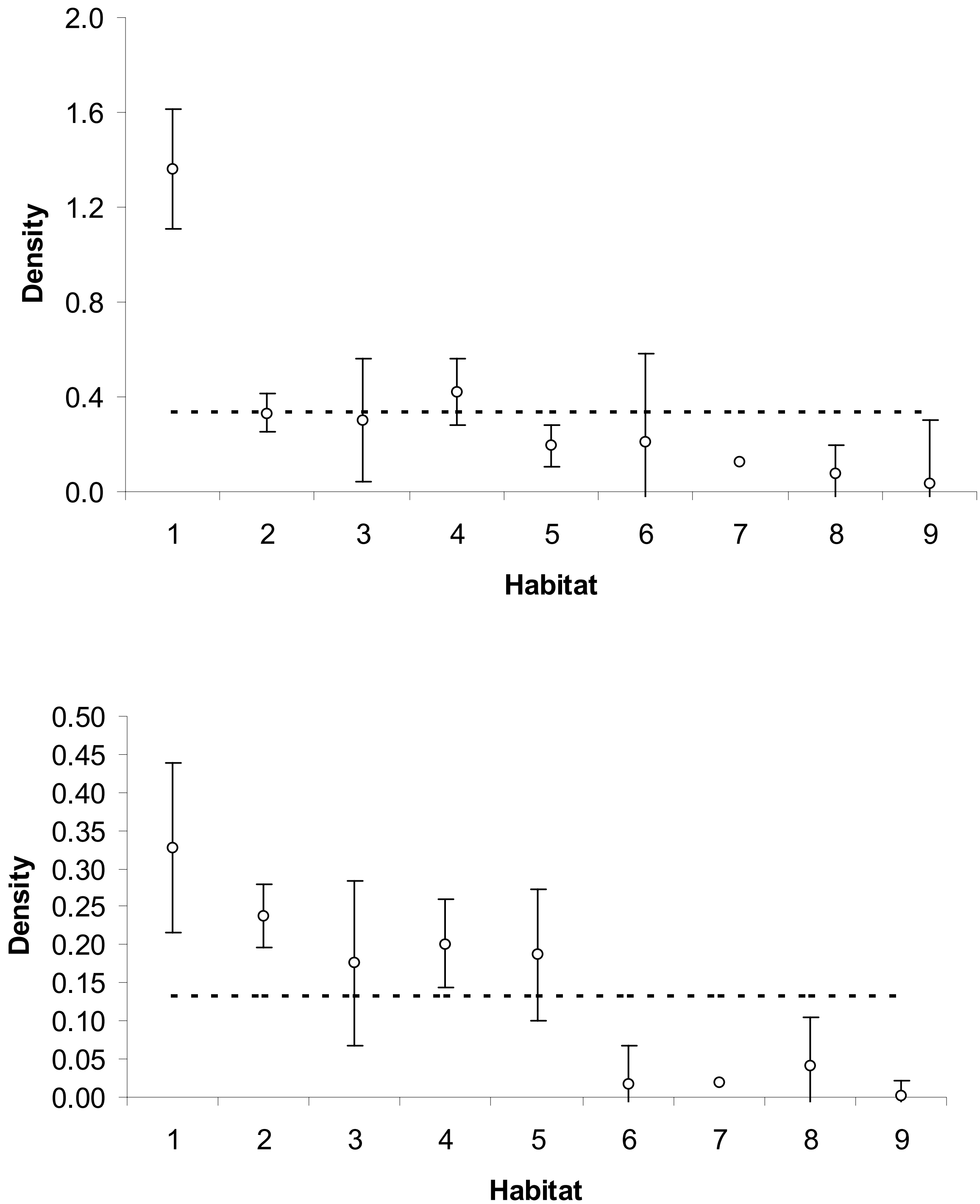


Figure 21.- Mean density and corresponding 95% confidence intervals by habitat type for pink shrimp (A) juveniles and (B) subadults. The dashed horizontal line represents the stratified random estimateof mean density for the entire sampling domain (Biscayne Bay).

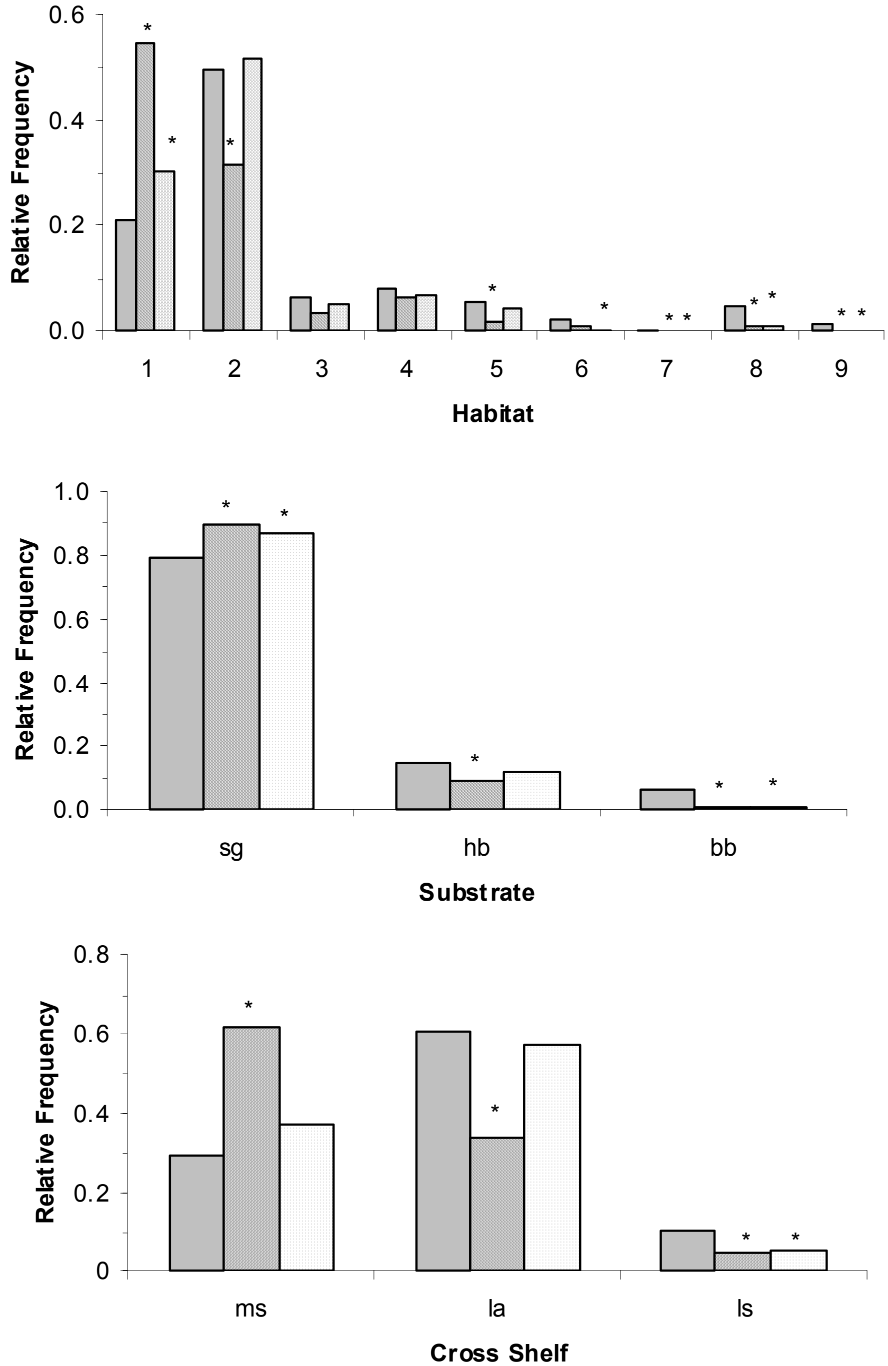


Figure 22.- Population proportion *p*(P) of pink shrimp juveniles (hatched bars) and subadults (stippled bars) and corresponding proportion of habitat area *p*(A) (shaded bars) for (A) nine habitat types specified in Figure 20, (B) bottom substrate habitats, and (C) cross-shelf salinity zone-depth habitats. Asterisks denote significant differences ($p<0.05$) between *p*(P) and *p*(A). Seagrass is sg, hardbottom is hb, and barebottom is bb. Mainland is ls, basin axis is la, and leeward is ls.

4.0 Fishery Overview and Estimation of Stock Status Indices

In this section we review and analyze a host of fishery-dependent and fishery-independent databases and scientific and technical literature on fishery resources in BNP and the broader Florida Keys region. These results were then used to facilitate evaluation of the current and historical levels of fishery catch and effort. We also use these data to estimate CPUE (catch-per-unit-effort) and $\overline{L}$ (average length of exploited phase individuals), two principal statistics or indicator variables essential to stock assessments.

4.1 Fishing Effort and Regional Human Population Growth

South Florida reef fish stocks in the Florida Keys and BNP are exploited by large and diverse commercial and recreational fleets. These fleets have experienced dramatic growth over the last several decades (1964-1998) in both absolute numbers of registered vessels and in the relative "fishing power" of each of those vessels. The recreational fleet has dramatically grown since 1964 (**Figure 23**). In Dade County, the number of registered vessels increased 2.83 times between 1964 (17,966 vessels) and 1998 (50,811). The five county area of south Florida including Dade, Monroe, Collier, Broward and Palm Beach counties, experienced a 444% increase in the nominal number of vessels over the same period of time (37,435 in 1994 to 166,343 in 1998). The commercial fleets have also grown over that same period, with a 1.65 times increase in the number of vessels registered in Dade County (1,242 to 2,046) and 1.97 times increase in the five county area (5,316 to 10,465). The growth of the fishing fleets is directly correlated with the growth of human populations in Florida (**Figure 24**). The Sunshine State has experienced explosive growth over the past 160 years. During 1960 to 2000 Florida's human population grew an astounding 223% (from 4.95 to 15.98 million persons)! During this same period, in addition to the sheer increase in both recreational and commercial fleet sizes, the relative effective vessel "fishing power" of these fleets has quadrupled due to better hydroacoustics (fish finders and depth gauges), global positioning systems (GPS), improved vessel designs and propulsion systems, air conditioning, and more advanced and effective communication networks utilized by both recreational and commercial fishermen (Bohnsack and Ault 1996, Mace 1997). These increases in fleets sizes and effective fishing power have not only directly impacted multispecies fishery stocks through exploitation in BNP, but have negative indirect impacts through habitat degradation and destruction (Rothschild et al. 1994, Ault et al. 1997b). Excessive boat traffic from a growing fleet and the presence of jet skis on and near flats are disturbing "habitats" (e.g., flats environments) and premier sportfishes like bonefish, tarpon, permit and sharks, and causing a significant increase in manatees and turtles hit and killed by boaters. These conditions have fueled widespread user conflicts between recreational and commercial fishermen in south Florida waters through interactions precipitated by intensive use of gillnets, excessive bycatch from shrimp trawls for food and "bait", and over-use of baitfish resources compromising the sensitive ecological balance of predator-prey dynamics. Some mitigation has occurred (e.g., banning of jet skis in BNP circa 1998), but serious concern has arisen because of documented "serial overfishing" of reef fishery resources in the Florida Keys (Bohnsack et al. 1994, Ault et al. 1997, 1998).

4.2 Commercial Landings

Commercial landings in weight by species reported for the area encompassing Biscayne Bay, Card Sound, and Barnes Sound for 1986-1999 are presented in **Tables 7** and **8**. These data provide a good indication of the magnitude of commercial extractive activities in the coastal bay portion of

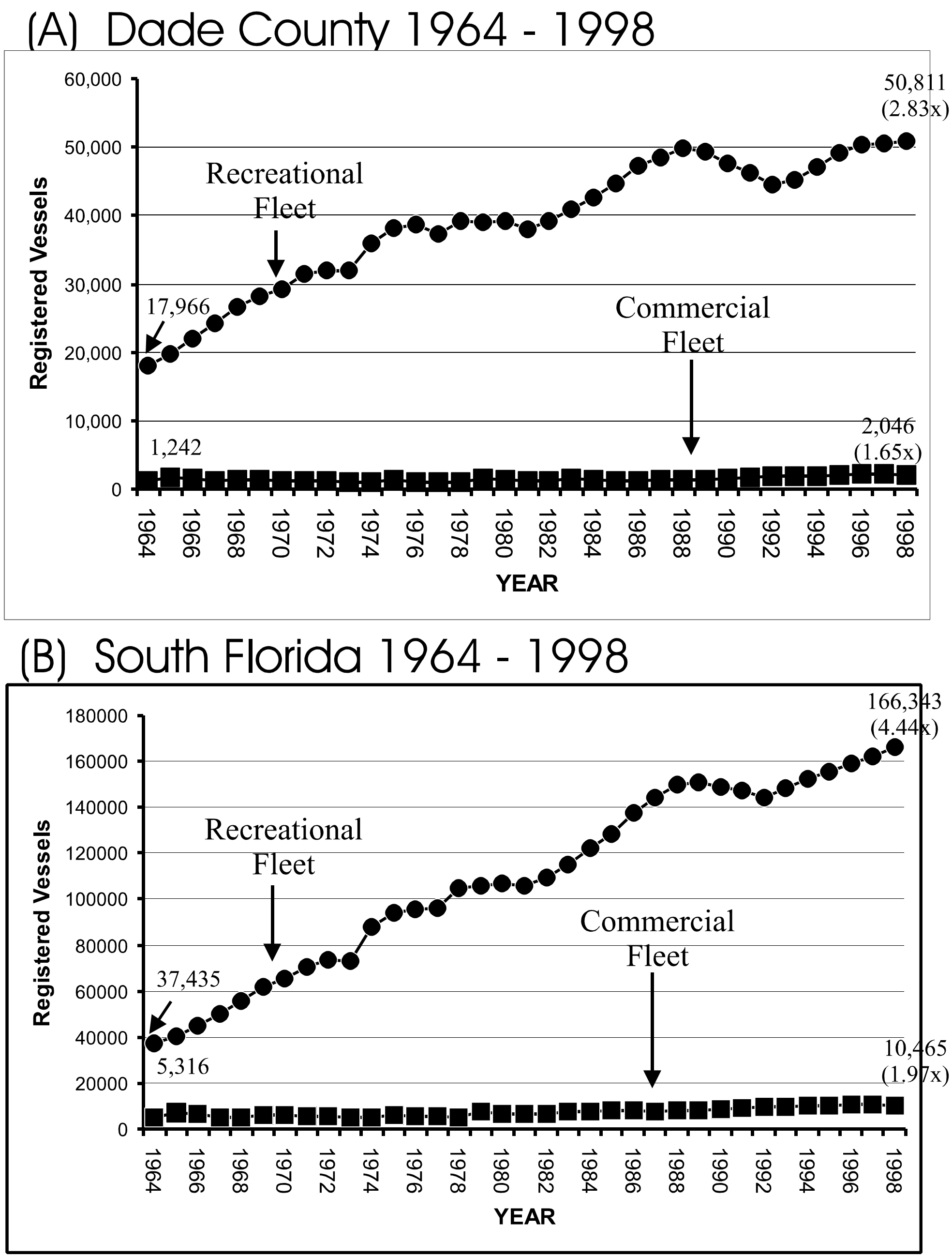


Figure 23.- Time series of two types of nominal fishing effort directed at BNP reef fish from 1964 to 1998 based on recreational (dark circles) and commercial (dark square) vessels registered in: (A) Dade County; and, (B) South Florida (Broward, Collier, Dade, Monroe and Palm Beach counties). Source: National Marine Fisheries Service SEFSC.

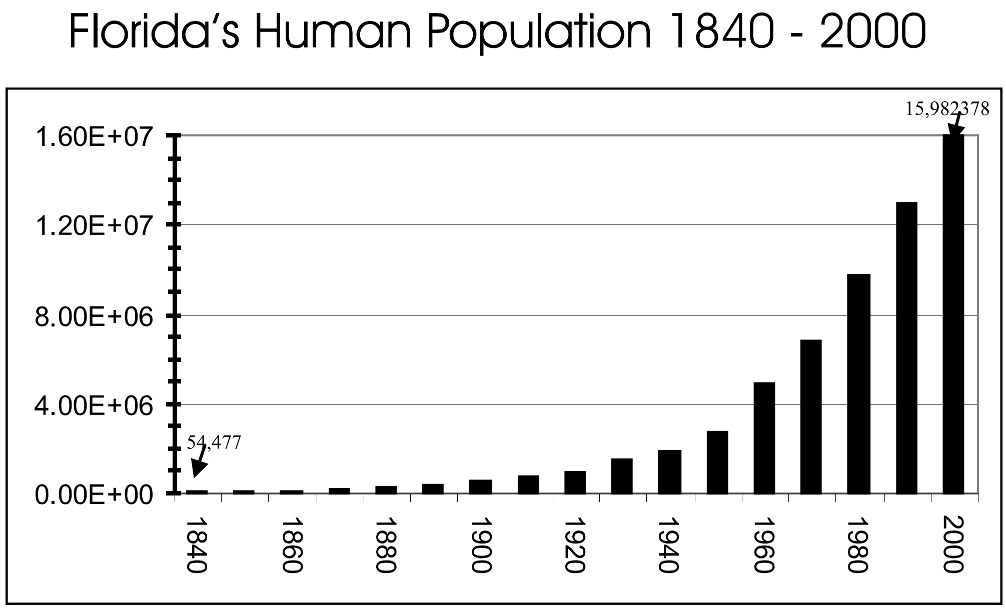


Figure 24.- The Sunshine State has experienced explosive growth over the past 160 years, making Florida the fourth largest state in the nation. State's human population has grown 223% since 1960. Source: U.S. Census Bureau.

Table 7. - Commercial landings (lbs) by species reported for the area encompassing Biscayne Bay, Card Sound, and Barnes Sound for 1986-1996. Source: FFWCC and NOAA.

	YEAR										
SPECIES	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Groupers, Snappers, Grunts											
Red Grouper							5				
Nassau Grouper		14									
Goliath		708									
Black Grouper	1003	1048	42		32	15					30
Gag Grouper		618	36	9		17					
Grouper, Other	7	510									
Gray Snapper	105	4	2197	1186		22	131	3	30		1123
Mutton Snapper		91	22		4					255	407
Yellowtail Snapper	2698	3269	1147	1433	1859	1824	2507	2214	571	479	2190
Snapper, Other	31	17548	10		405		167				
Hogfish		18	16		152						
Grunt Spp.	67	3757	866	59	77		100	11	7	176	327
Other Fishes											
Blue Runner	18		37							1364	530
Crevalle Jack				5			200			1195	6
Jack, Other	32		10	16	205						
Pompano spp.						2	71		84	270	129
King Mackerel		55									
Spanish Mackerel	8					128		95		602	100
Cero							521			2	16
Flyingfish spp.						72	924	155	22		
Cobia		87									10
Great Barracuda						6.25		322			
Shark spp.		99									
White Marlin	1094										
Triggerfish spp.		21									
Porgy spp.					6	108					
Spotted Seatrout	50	2301	395	58							
Seatrout, Other	25	15									
Spot											1687
Mullet spp.	21544	20965	26961	11555	11765	16625	11375	15445	1419	5460	19081
Mullet Roe	530	23						1683	923	886	1193
Sardine spp.									1642		4563
Baitfish (herrings, ballyhoo,, etc)	1895	4548	1739			194		460	3648	312	5002
Misc. Fishes	7193	10609	12906	11273	7358	592	3443	344	2430	186	
Macroinvertebrates											
Blue Crabs	278	2.5			72	1051	9725	36041	23777	41352	73836
Stone Crabs		6	3	326	895	108	167	419	1889	1778	5881
Spiny Lobster	1536	3645	2068	2029	4572	8615	7379	3716	1946	20192	18150
Pink Shrimp	1474	1257	2286.1	8499	17773	29458	37045	33655	58525	72849	135028
Misc. Invertebrates										150	
Sponges											
Grass Sponge				11950	6190	2435	59				
Sheepswool Sponge				51813	42531	20241	279				
Yellow Sponge				12866	4295	1802	47				

Table 8.- Commercial landings (lbs.) and dockside value (dollars) by species reported for the area encompassing Biscayne Bay, Card Sound, and Barnes Sound for 1997-1999. Source: FFWCC and NOAA.

	1997		1998		1999	
Species	**Landings**	**Value**	**Landings**	**Value**	**Landings**	**Value**
Groupers, Snappers, Grunts						
Red Grouper	31	$65				
Black Grouper	118	$200				
Gag Grouper	45	$95				
Rock Hind			83	$25		
Gray Snapper	101	$209	4	$9	65	$135
Mutton Snapper	306	$558				
Yellowtail Snapper	116	$250	895	$1,681	28	$63
Grunt spp.	2,169	$1,951	501	$422	217	$251
Other Fishes						
Blue Runner	1,435	$1,132	2,598	$2,838	33	$28
Crevalle Jack	18	$18	70	$70		
King and Cero Mackerel					437	$672
Spanish Mackerel			491	$636		
Flyingfish spp.			1,036	$134		
Great Barracuda			208	$416		
Shark spp.			104	$75		
Parrotfish spp.	30	$45				
Pinfish	113	$776	212	$1,647	145	$1,155
Sheepshead	36	$45				
Spotted Seatrout	30	$60				
Seatrout, Other			200	$140		
Flounder spp.	15	$9				
Spot	821	$698				
Mullet spp.	24,830	$20,754	20,120	$19,643	26,118	$27,241
Sardine spp.	3,673	$2,401	220	$165		
Misc. Fishes	410	$185	3,156	$1,988	4,674	$3,734
Macroinvertebrates						
Blue Crabs	89,135	$123,414	77,451	$105,690	117,858	$147,393
Stone Crabs	28,382	$45,245	19,244	$75,499	12,628	$55,422
Spiny Lobster	14,953	$69,031	4,107	$18,329	4,465	$19,307
Pink Shrimp	412,775	$1,225,735	412,265	$1,135,457	612,489	$1,343,564
TOTALS	**579,542**	**$1,492,876**	**542,965**	**$1,364,864**	**779,157**	**$1,598,965**

Biscayne National Park. Unfortunately, commercial landings data specific to the offshore coral reef habitat of BNP are not available. The magnitude of commercial catches of groupers, snappers, and grunts in the coastal bay environment of BNP were rather small throughout the reporting period, but nonetheless showed a declining trend. In contrast, commercial landings of macroinvertebrates generally showed an increasing trend. For pink shrimp in particular, this trend may partly be due to a fundamental change in data collection procedures used by the State of Florida and reflect more complete reporting of catches by commercial fishers in recent years (personal communication, Florida Fish & Wildlife Conservation Commission) which were functionally omitted early on. However, this increasing trend in recent years may also reflect increased fishing power of the fleet and a redirection of fishing effort from declining finfish species resources to the much more lucrative macroinvertebrate species. Sponges were landed in significant quantities in the late 1980s and early 1990s prior to the ban on harvest imposed in BNP waters. The aggregate dockside value of commercial catches for 1997-1999 was approximately 4.7 million dollars . Macroinvertebrates (pink shrimp, blue crab, stone crab, and spiny lobster) accounted for 93% of the total dollar value.

4.3 Size at First Capture Restrictions

To stem the tide of decreasing fisheries catches and resource productivity, the principal methods used by fishery resource managers for regulating and controlling fisheries impacts has traditionally been fish minimum size and fishing effort restrictions. Implementation of minimum size restrictions sets lower bounds on the sizes of fish allowed to be captured and in catches of the commercial and recreational fleets. The history of implementation and use of minimum size regulations in south Florida and the Florida Keys is shown in **Table 9.** The fishery management system for south Florida and BNP was *laissez faire* prior to management measures implemented by the South Atlantic Fishery Management Council in 1983. In 1985 the Florida Marine Fisheries Commission was formed and began implementation of a series of size, bag limit and gear restrictions (**note:** the history of Florida regulations is listed at http://www.dep.state.fl.us/mfc/MFC-rule-hist.htm). Some notable changes in size regulations pertaining to the reef fish complex are as follows. In 1985 (due to observed reductions in catches) 18 inch minimum size limits were set for several groupers (Goliath, red, nassau, black, gag, yellowfin), and 12 inch limits were set for several snappers (mutton, red, yellowtail) (**Table 9**). By 1990, non-response of the Goliath grouper stock to recovery by any conventional management efforts prompted a complete catch moratorium, which is still in effect today. In 1990, the red snapper size limit was increased to 13" (20" in 1992), and the FMC added schoolmaster (10"), blackfin, gray, dog, lane, silk, vermillion and queen snappers. Also in 1990, most groupers (and additionally yellowmouth and scamp) had minimum size limits increased to 20 inches. Hogfish size limits were set at 12" in 1994.

Normally, size restrictions are implemented to prevent "growth overfishing" and to prevent capture of individual species of fish before they have reached their individual potential to produce yields (in weight) to the fishery. Variations in setting minimum size limits relates to the fact that different species (and taxa) grow at different rates and reach different maximum sizes (e.g., groupers grow to much larger sizes than grunts and are substantially older). But probably a more important aspect of the setting of minimum sizes relates to the potential production of future generations of fish by the mature parent stock. That is, the minimum size of first capture by the fishery should ideally be set higher than the first size of sexual maturity to ensure that each fish has a chance to produce offspring at least once in its lifetime.

Table 9.- Fishing regulations promulgated by SAFMC and FL FMC from 1985-present. Regulations shown are the minimum size of capture (inches) and the year the size limit is implemented. The last column shows the current size restrictions. Ranges indicate size slot limits, and 'moratorium' means that the fishery for the species is completely closed.

	1983	1984	1985	1987	1989	1990	1992	1994	1996	1998	1999	2000	Current
Groupers													
Goliath			18			moratorium							closed
Red	12"		18			20							20
Nassau	12"		18			20					moratorium		closed
Black			18			20					24		24
Yellowmouth						20							20
Gag			18			20					24		24
Scamp						20							20
Yellowfin			18			20							20
Black Sea Bass			8								10		10
Southern Sea Bass			8										8
Snappers													
Mutton Snapper			12					16					16
Schoolmaster						10							10
Blackfin						12							12
Red Snapper	12"		12			13	20						20
Yellowtail Snapper			12										12
Cubera						12							12
Gray						10							10
Dog						12							12
Mahogany						12							12
Lane						8							8
Silk						12							12
Vermilion						8	10-20			10	11"		11
Hogfish								12					12
Queen						12							12
Pelagics and Others													
Gray Triggerfish								12					12
Permit									10-20				10-20
Pompano					10				10-20				10-20
African Pompano									24				24
King Mackerel								20				24	24
Spanish Mackerel											12		12
Amberjack						28							28
Lesser Amberjack										14-20		14-22	14-22
Red Porgy								12					12
Snook			24							26-34			26-34
Lobster				3									3
Spotted Sea Trout					14-24							15-20	15-20
Tripletail									15				15

4.4 Indicator Variables of Population Status

To understand the effects of fishing and environmental changes on fishery resources requires identification of a quantitative measure that reflects the status of a population subjected to fishing or other environmental changes, that is, a stock assessment indicator variable. Because reef fishes integrate aspects of the coastal ocean environment over their lifetime, a robust measure of population "health" or status can provide a sensitive indicator of direct and indirect stress on the stock, and perhaps the regional marine ecosystem (Fausch et al. 1990). The RVC and CREEL survey databases were utilized to produce annual estimates of two biological indicators, average catch-per-unit-effort (CPUE) and average length of exploited phase individuals ($\bar{L}$) for 90 exploited and/or ecologically important species in BNP (**Appendix C**). A flow diagram illustrating the data processing and analysis procedures employed for each survey is shown (**Figure 25**).

4.4.1 Catch-per-Unit Effort (CPUE)

The average population size (in average numbers of fish during the time interval *t* 6 *t+1*) during a given year *t* is written as

$$\bar{N}(t) = \frac{N_0(t)F(t)}{F(t) + M}\left(1 - e^{-(F(t)+M)}\right) = EN_0(t)$$

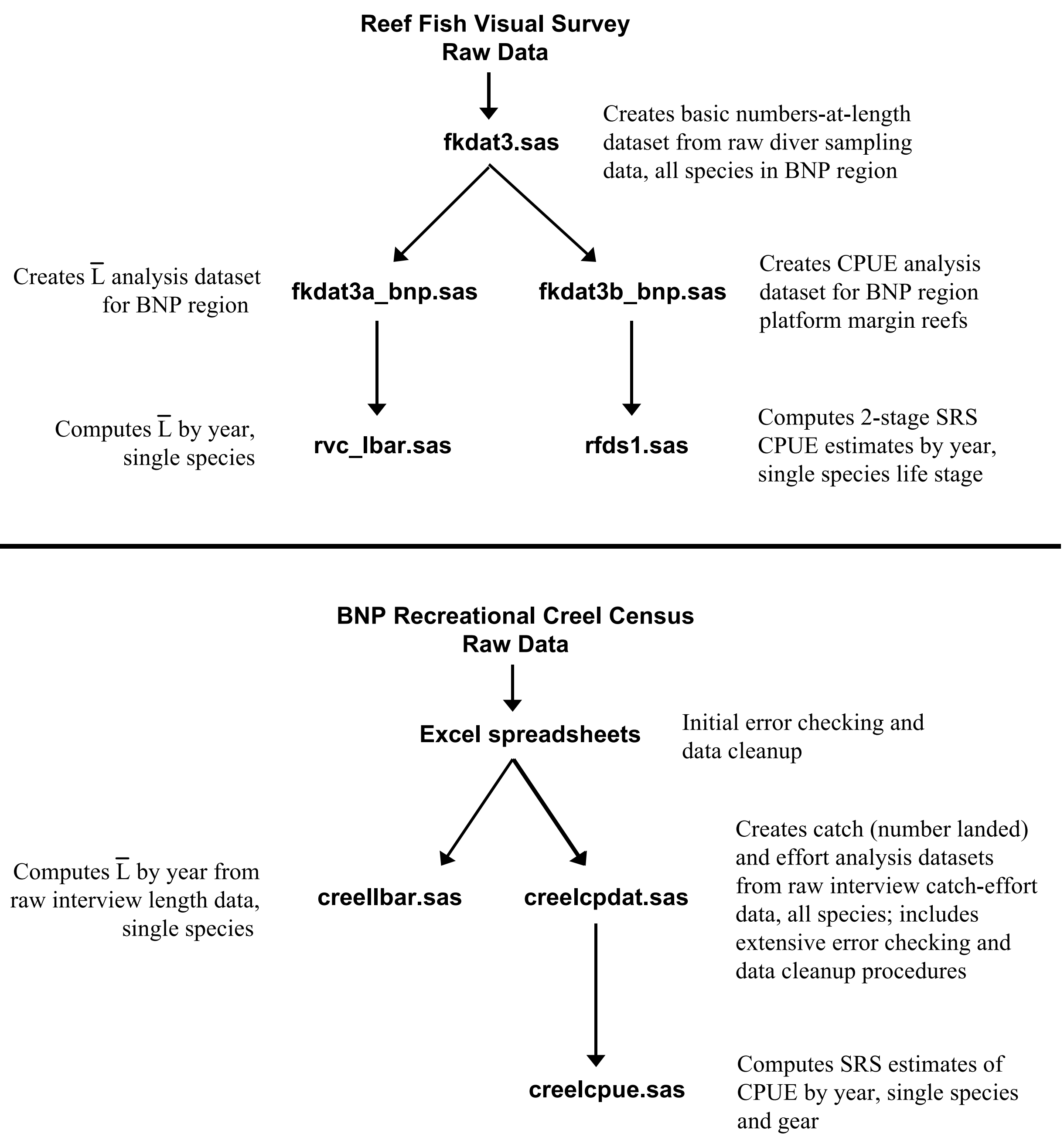
where $N_0(t)$ is the initial population size in year *t*, $F(t)$ is fishing mortality rate, M is the natural mortality rate, and E is the exploitation rate (Ricker 1975). Catches (or yields in number $Y_N(t)$ or weight $Y_w(t)$) are the product of fishing mortality and average population size. As a result, by allowing $F=qf(t)$, catch per unit nominal fishing effort $f(t)$ provides a quantitative index of fish population size

$$Y_N(t) = F(t)\bar{N}(t) \Rightarrow \frac{Y_N(t)}{f(t)} = q\bar{N}(t)$$

where q is the fraction of the stock removed per unit of nominal fishing effort (Beverton and Holt 1956, 1957). The index provides an average measure of relative population abundance $\bar{N}(t)$ when independent surveys of populations are made with gears or techniques where the individual effort units can be intercalibrated. For the RVC survey, CPUE is defined as the number of animals observed by a diver (Y_N) per sampling station (f=1 station). Since f covers a fixed area of 176 m^2 in this survey, and q (a measure of capture or 'observation' efficiency) is presumed near 1.0 for reef fish divers, CPUE reflects actual stock density (number per 176 m^2). For the CREEL survey, CPUE is the number of fish captured and kept (Y_N) per person-hour of fishing (f). Since q is unknown in this case, CREEL CPUE is a relative index of stock abundance.

The RVC survey sampled platform margin reef habitats consistently from year to year; however, this was not the case for inshore reefs, and data from these habitats were excluded from the analysis. The annual numbers of diver stations used for CPUE estimation are listed in **Table 1**. For the RVC survey, annual mean CPUE was estimated using a two-stage simple random sampling (SRS) design-based methodology following Cochran (1977) and shown in **Appendix D1**. Estimation was carried out for three life stages of each species, juvenile ($<L_m$), adult ($\$L_m$), and

Figure 25.- Data processing, analysis and synthesis flow diagram for estimation ($\bar{L}$) and CPUE from the reef fish diver visual survey (upper panel) and BNP recreational CREEL survey (lower panel). SAS source code for reef fish visual census RVC is listed in Appendix D1. SAS source code for BNP recreational CREEL survey is listed in Appendix D2.



exploited ($\$L_c$), as defined by the following length intervals:

Life History Phase	**Interval**	**Description**
Juvenile Phase	L_r –> L_m	Immature juveniles from the size of first recruitment to the size of first sexual maturity.
Mature Adult Phase	L_m –> $L8$	Size of first sexual maturity to the maximum size in the stock.
Exploited Phase	L_c –> $L8$	Size of first capture to the maximum size in the stock.

As shown above (sections 3.5 and 3.6), these intervals reflect logical ontogenetic groupings that pattern animals in space and time over the Biscayne National Park seascape. In many cases, exploited phase CPUE estimates were computed using two different length at first capture L_c values: 'legal' denotes the L_c value regulated by law in a particular year, whereas 'actual' denotes a modified L_c value (here referred to as L'_c) that sportfishers adhered to as determined from inspection of CREEL survey species length data (see section 4.5 for further discussion). The 'actual' exploited phase CPUE estimated from the RVC survey thus corresponds to the life stage comprising the CREEL survey CPUE estimates.

The CREEL database required extensive processing and error checking before estimation of CPUE could be carried out in a reliable fashion (see **Appendix D2**). Interview records with missing or mis-coded key information—e.g., gear type, area fished, number of persons fishing—were necessarily excluded from analysis. CREEL data indicated three principal gear types (hook and line, spearfishing, and lobster diving), and three fishing regions (coastal bay, reef, and pelagic). The annual number of CREEL fishing trip interviews by gear and region considered in CPUE estimation are listed in **Table 10**. A number of interviews recorded catch information for a general family category, e.g., unidentified snappers or groupers, rather than for a particular genus and species. Records containing combined catches for a given species group (e.g., snappers) were excluded from CPUE estimation for a particular species (e.g., gray snapper) in that group.

Annual average CPUE for CREEL survey species was estimated as follows:

$$CPUE = \frac{1}{n} \sum_i CPUE_i$$

where $CPUE_i$ is catch per person-hour for trip *i* and *n* is sample size. For a given species, CPUE was estimated from fishing trips for the principal gear type and associated capture regions as listed in **Table 4**. Sample size *n* (**Table 10**) was thus the sum of fishing trips for the principal gear over the capture regions inhabited by a given species. These numbers reflect BNP personnel sampling efforts and are not necessarily proportional to true fishing effort. Regions not inhabited by a species were not included in the estimation.

The complete time series of annual CPUE estimates derived from both the RVC and CREEL surveys for 90 species are provided in **Appendix C** (**Tables C1-C90**, one table per species). A synthesis of these results for selected species is presented in **Table 11**. For ease of interpretation, CREEL CPUE values are expressed as the expected time a party of four persons would need to fish (or dive) to land (capture and keep) one animal of a given species. Shorter fishing times thus reflect higher stock abundance and longer fishing times reflect lower stock abundance. The fishery-dependent CREEL and fishery-independent RVC abundance indices corresponded quite well for the recent 1995-1998 period, showing the same rank order of reef fish species abundance with the exception of bluestriped grunt. The restricted sampling domain of the RVC survey compared to the more expansive capture regions of the CREEL census may somewhat account for this discrepancy. Comparing CREEL estimates between the periods 1995-1998 and 1985-1988 sheds some light on stock abundance trends over the past 10-15 years in BNP (**Table 11**). Lobster diving in BNP appears to have improved from the late 1980s to the late 1990s, as measured by the decrease in capture time and thus increase in CPUE. It is interesting to note that establishment of the spiny lobster sanctuary, which eliminated lobster fishing in the coastal bay portion of BNP, occurred in 1984. Hook-and-line fishing for dolphin in the pelagic zone, and for grunts (white and bluestriped) in bay-reef environments, has remained steady or improved slightly in the past 10-15 years. In contrast, reef fishing for snappers and groupers seems to have worsened to a lesser (gray and yellowtail snapper) or greater (mutton snapper and red grouper) degree over this time frame. Exploited phase black groupers have apparently been quite rare in BNP for some time.

Table 10.- CREEL survey sampling (number of recreational fishing trip interviews) by year, gear type (hook and line, spearfishing, and lobster diving) and region (bay, reef tract, and pelagic zone) from 1976 to 1998. The Bay portion of BNP was declared a lobster sanctuary in 1983.

	Hook & Line			**Spearfishing**	**Lobster Diving**	
Year	**Bay**	**Reef**	**Pelagic**	**Reef**	**Bay**	**Reef**
1976	411	424	314	112	56	71
1977	574	714	446	324	139	176
1978	767	793	546	391	158	190
1979	861	713	511	340	106	168
1980	798	627	262	278	167	194
1981	505	653	340	335	53	212
1982	874	975	497	395	67	353
1983	999	795	387	304	51	150
1984	196	148	37	40	1	113
1985	339	455	236	100	1	60
1986	346	328	249	76	3	144
1987	282	282	167	60	4	132
1988	116	225	113	56	0	99
1989	119	217	130	46	0	123
1990	100	236	143	52	3	203
1991	79	257	195	45	2	119
1992	180	279	187	36	0	21
1993	173	231	134	45	0	37
1994	244	277	190	89	0	44
1995	103	122	60	34	2	45
1996	174	167	107	58	1	34
1997	118	137	98	37	1	26
1998	98	150	82	37	0	29

Table 11.- Comparison of CREEL and RVC exploited phase (actual) CPUE estimates for selected species. Units for the CREEL census are expressed as the expected time a party of four persons would need to fish (or dive) to land one animal. RVC survey CPUE units are number observed per diver station. Values are 4-year averages for the time period indicated.

Species	CREEL 90's 1995-1998	CREEL 80's 1985-1988	RVC 90's 1995-1998
spiny lobster	10 min	20 min	—
dolphin	1 h	1 h	—
white grunt	1 h	1 h	0.689
gray snapper	2.5 h	1.5 h	0.227
bluestriped grunt	3.5 h	4.5 h	0.605
yellowtail snapper	7 h	5.5 h	0.157
red grouper	23 h	11 h	0.016
mutton snapper	26 h	15 h	0.010
black grouper	71 h	100 h	0.000

4.4.2 Average Size in Exploited Phase $\bar{L}$

To describe baseline status for a fish population in multispecies community settings, a robust population dynamic variable is required to relate current trends in human and environmental stressors to expected future condition of the stocks over relatively broad spatial and temporal scales. A powerful choice is the metabolic-based pool variable average size of animals (in either length or weight) in the exploited phase of the stock (Beverton and Holt 1957, Gulland 1983, Ault 1988, Ault and Ehrhardt 1991, Ehrhardt and Ault 1992). 'Average size', denoted as $\bar{L}$, is a physiologically-based variable that is a very sensitive indicator of direct and indirect stress on marine ecosystems (Ault et al. 1997a, 1998, Quinn and Deriso 1999). The $\bar{L}$ of a reef fish stock (or population if closed intra-breeding unit) is strongly correlated with population size in both numbers and biomass, and thus can be used as an indicator variable of population health. The formal definition of $\bar{L}(t)$ is

$$\bar{L}(t) = \frac{F(t) \int_{t_c}^{t_\lambda} N(a,t) L(a,t)\, da}{F(t) \int_{t_c}^{t_\lambda} N(a,t)\, da}$$

where t_c is minimum age at first capture, t_g is oldest age in the stock, $N(a,t)$ is abundance for age class a, $L(a,t)$ is length, and $F(t)$ is the instantaneous fishing mortality rate at time t.

The use of $\bar{L}$ in stock assessment has deep roots in traditional fisheries management (Beverton and Holt 1956, 1957, Ricker 1975). In general, it is well-known that $\bar{L}$ is highly correlated with average population size, and so reflects the rate of fishing mortality operating in the fishery. As fishing mortality rate increases, $\bar{L}$ decreases at a rate proportional to the population-dynamic tolerance of a stock. Minimally, average size is greatest when fishing mortality is lowest (or near zero), and decreases as the rate increases (**Figure 26**). Assuming that mortality occurs proportionally to stock age-size spatial distributions, $\bar{L}$ will continue to decrease until at high exploitation rates it will be nearly equal to the minimum size of first capture regulated by fishery management. Secondly, there exists a value of $\bar{L}$ corresponding to a population size that produces maximum sustainable yields on a continuing basis.

We computed 'average length' for each of the principal data sources available for BNP. Estimates of the mean, variance, and 95% confidence interval followed Sokal and Rohlf (1969). The complete time series of annual estimates of average length for the RVC and CREEL surveys for the period 1976 to 1999 are provided in **Appendix C** for 90 species. To understand the status of stocks in BNP relative to the greater Florida Keys ecosystem, we also computed $\bar{L}$ from several region-wide survey databases, both fishery-independent (RVC surveys in the Florida Keys and Dry Tortugas) and fishery-dependent (headboat surveys in the Keys, Tortugas). The time series of $\bar{L}$ estimates for six different types of survey data are plotted in **Figure 27** for three primary and representative exploited species. We first note that species' estimates of average size (e.g., black grouper, gray snapper, and yellowtail snapper) have been relatively constant for the past 25 years. This constant "average size" has been very close to the minimum size of first capture. Secondly, the estimates of average size have been lowest in BNP relative to the Keys and Dry Tortugas. The third item to note that reflects the effectiveness of traditional fishery management methods is that many species have had extremely low sizes of average length in the past, and that very little recovery of average length has occurred, even as minimum size limits were imposed.

Estimates of average length for fishery-dependent CREEL surveys and fishery-independent RVC surveys are extremely close for each of the three example species of **Figure 27**, which is characteristic of the other 90+ species analyzed **(Appendix C)**. This would indicate that the two data sources are producing similar estimates of the effects of mortality on these stocks. An important factor in the use of the $\bar{L}$ statistic to measure population mortality rates and to assess the effects of exploitation is that it can be reliably computed from both fishery-dependent and fishery-independent data sources. Theoretically, the average size of fish in the exploited phase landed for any given exploited species should be equal to the average size in the exploited phase of the remaining population in the sea just after fishing. The greater the correlation between the two independent estimates of $\bar{L}$, the more robust 'average length' should be as an indicator of stock status subject to exploitation. This is a powerful conclusion in that it allows several independent observations of 'average length' to be computed and compared for consistency and reliability. Our results for BNP corroborate previous research which demonstrated close agreement between fishery-independent RVC estimates of average length and fishery-dependent headboat survey $\bar{L}$ estimates for Florida

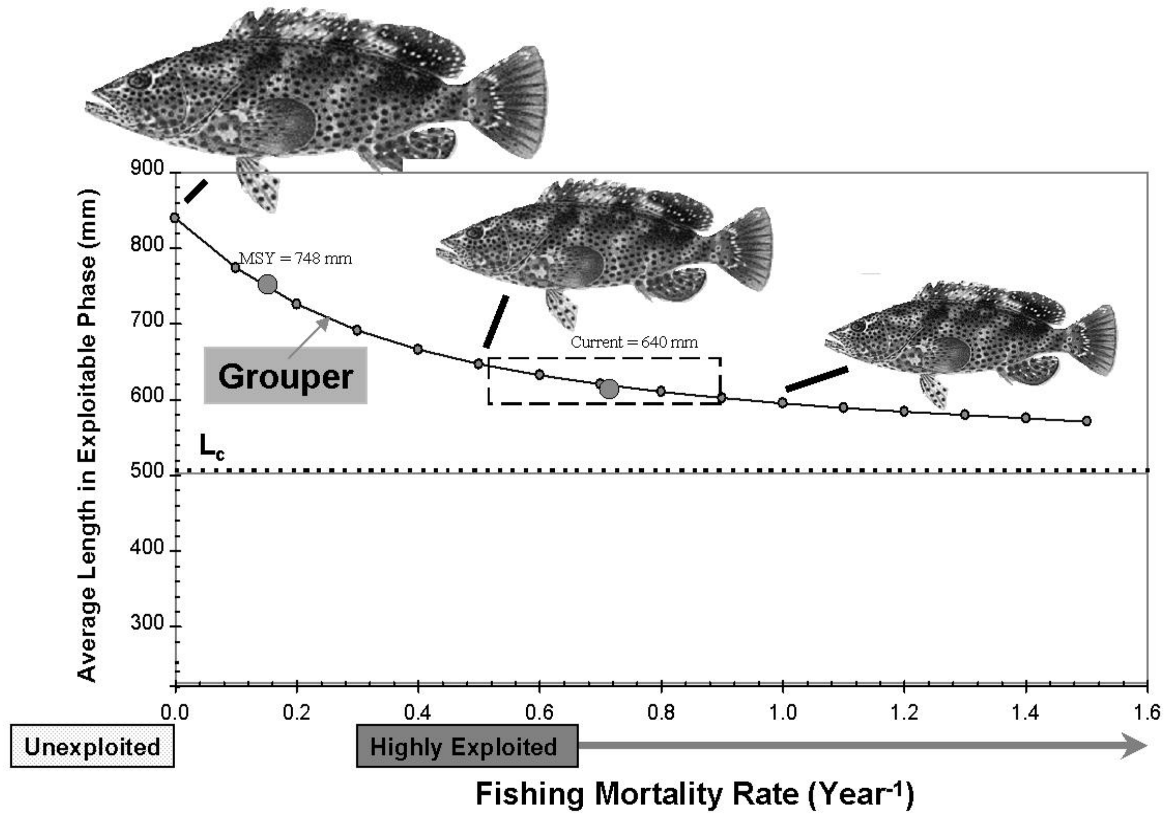


Figure 26. - Theory of reduction of average length in the exploited phase with increasing fishing mortality for black grouper.

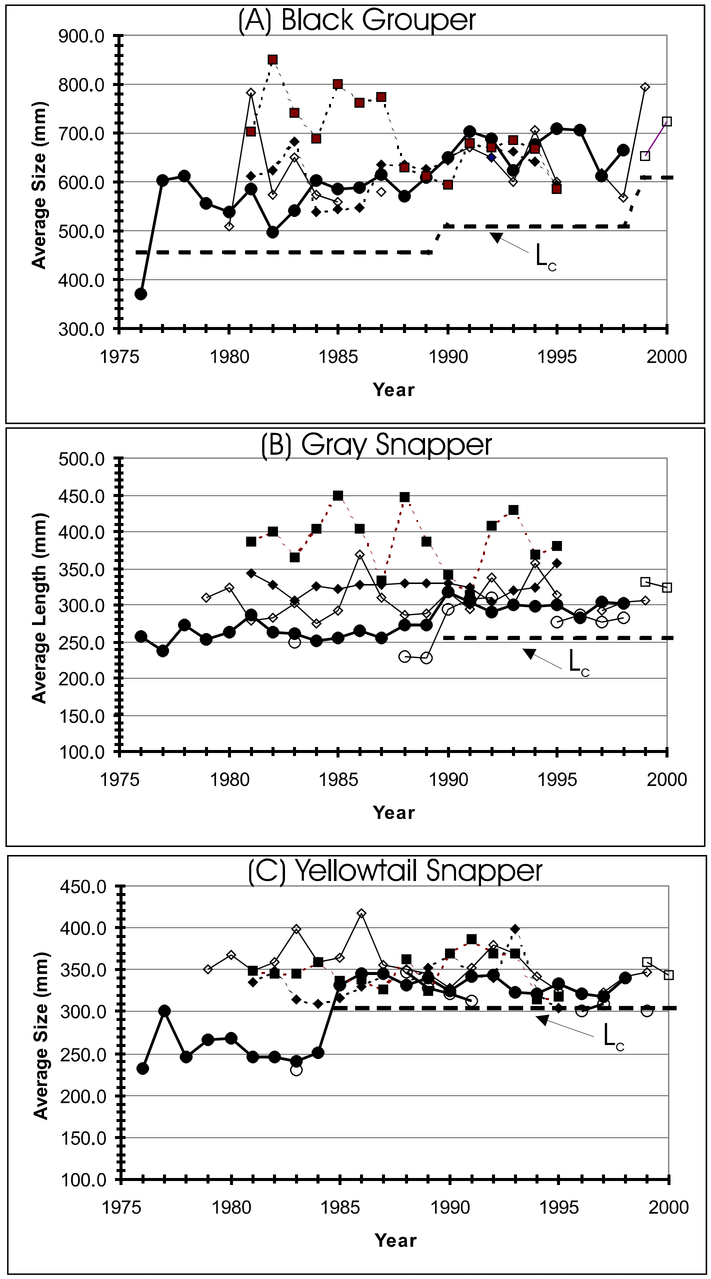


Figure 27.- Time series of average length estimates derived from fishery-dependent and fishery independent survey data taken from BNP, the Florida Keys coral reef tract, and the Dry Tortugas region from 1976 to 1999 for: (A) Black grouper; (B) Gray snapper; and, (C) Yellowtail snapper. The six data types are: BNP CREEL (black circles); BNP RVC (open circles); Keys-wide RVC (open diamonds); Keys-wide headboats (black diamonds); Dry Tortugas RVC (open squares); Dry Tortugas (black squares). The dashed horizontal line is the minimum size of first capture.

Keys reef fishes (Ault et al. 1997a, 1998).

4.5 Non-Compliance with Fishery Minimum Size Regulations

In computation of 'average size' statistics for further assessment of fishery management benchmarks, an alarming observation we noted in analysis of the CREEL database was that a fairly high proportion of the catches returned to the BNP ramp by recreational fishermen contained fishes that were smaller than the minimum size of first capture regulated by regional fishery management. This was particularly evident for several snapper species, e.g., mutton snapper, in which more than 70% of the fish landed were below minimum size (**Figure 28a,b**), but was also evident for hogfish (**Figure 28c**), gray triggerfish (**Figure 28d**), and a number of groupers and grunts.

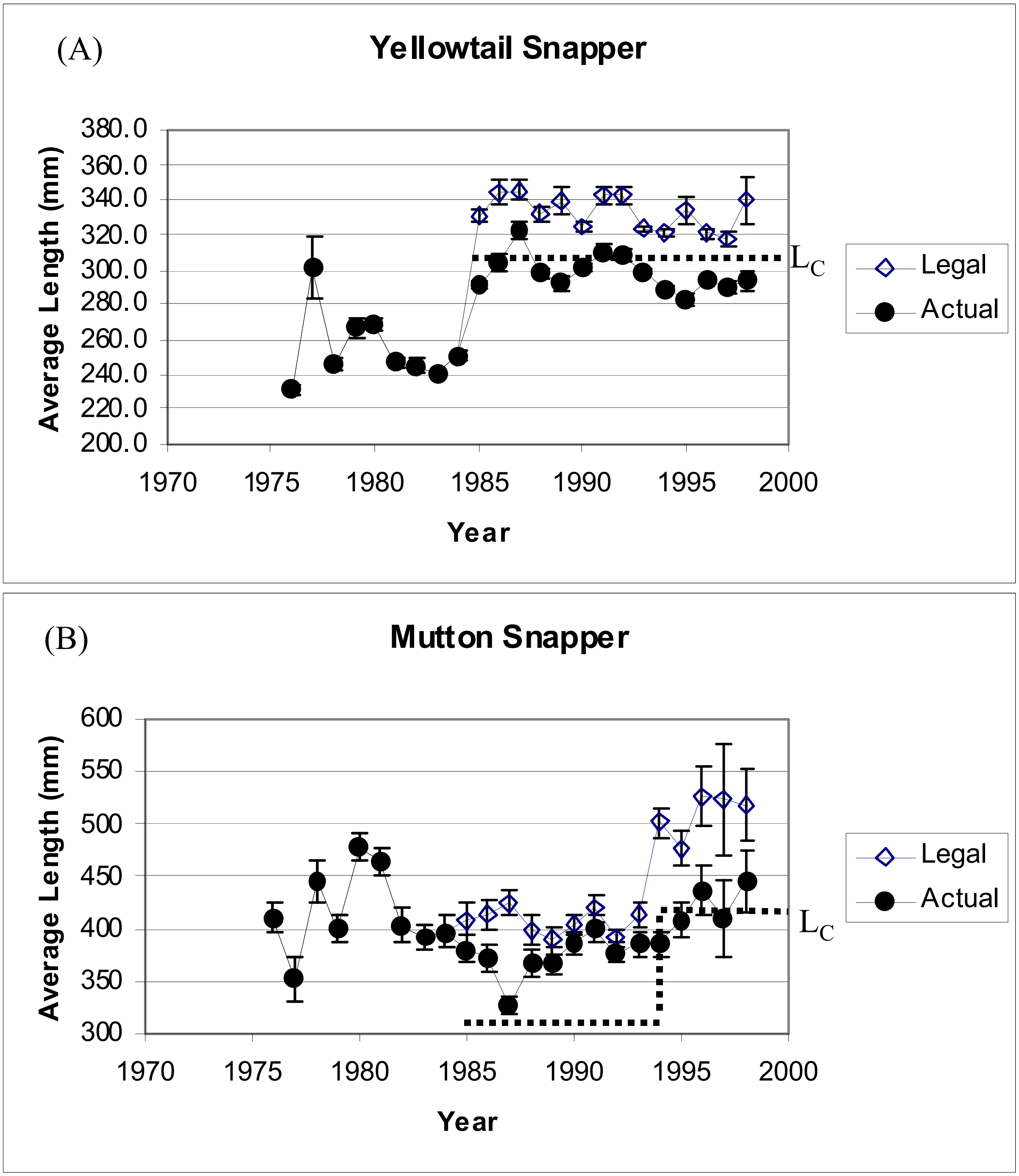
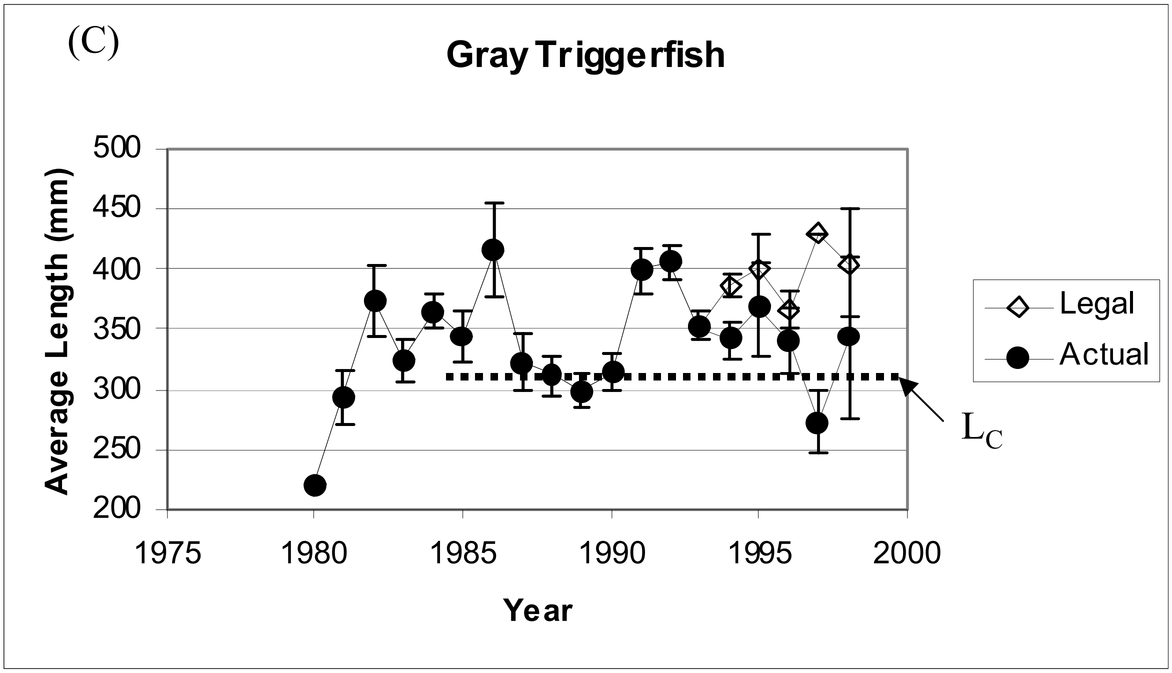


Figure 28. - Impacts of non-compliance with regulated minimum size L_c (dashed line) restrictions. The 'average length' in the exploitable phase estimated from the CREEL data is shown for: (A) yellowtail snapper; (B) mutton snapper; (C) gray triggerfish; and, (D) hogfish. The actual statistic L'_c includes many individuals that are below L_c, resulting in much lower estimates of average size(and higher fishing mortality rates) than if the law were enforced or received full compliance from recreational fishermen.



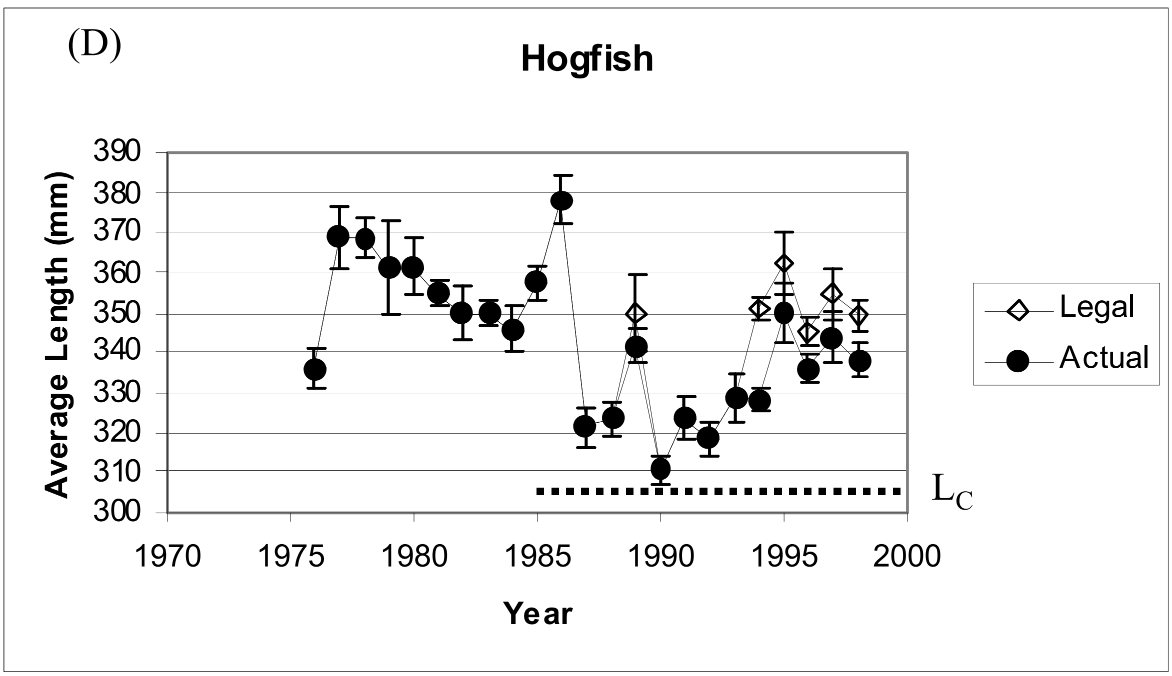


Figure 28.- (continued)

5.0 Multispecies Fishery Stock Assessments

In this section, we conduct a formal quantitative assessment of exploited fish stocks in BNP and evaluate their current status with respect to established fishery management benchmarks. An overview of the general assessment procedure, comprised of 8 separate steps, is summarized in the flow diagram of **Figure 29**. Steps 1 to 3 of the procedure were described in previous sections. This section details Steps 4 through 8.

5.1 Synthesis of Population Dynamics Parameters

To facilitate assessment of the multispecies fisheries resources in BNP, we conducted a thorough search of the scientific and technical literature (c.f., Claro 1994; FISHBASE, Froese and Pauly 2000) and our own databases to assemble a comprehensive suite of biological and population dynamic information that contains key rate parameters necessary for computing the relevant fishery management benchmarks for sustainability of resources. These parameters included age-growth, weight-length and weight-fecundity relationships, size-age at first recruitment, minimum size-age at first sexual maturity, maximum size-age, sex ratios and age (size) class distributions, natural mortality rates, and other key fisheries indices (**Tables 12 and 13**). These data were required to run our suite of multispecies fishery stock assessment computer models (Ehrhardt and Ault 1992; FAO 1997, Ault et al. 1996, 1997a, 1998). Of the 91 exploited and/or ecologically-important species we identified within the BNP databases, we found that the available population dynamics parameters varied widely in breadth and statistical quality. Therefore, we classified each species' parameter set according to a 'parameter confidence' rating that ranged from no data available (scored 0) to high confidence (scored 3). Given the disparity in quality between data sets available for various stocks, and in some cases the complete lack of critical population dynamic data, we feel some additional refinement of these critical data will be necessary in the longer run, as these data are required to assess exploitation effects and to determine the appropriate management strategies to achieve Park goals. Nonetheless, these data were essential to producing a baseline assessment of BNP multispecies fisheries resources.

5.2 Estimation of Total Mortality Rate from 'Average Size' Statistics

While persistent heavy fishing reduces the average fishable population size over time, it also leaves a distinguishing size-age structure signature on the exploited population, which provides a robust basis for mortality estimation (**Figure 30**). We capitalized on this aspect of demographic theory by using the $\bar{L}$ statistic to assess the current levels of exploitation of the multispecies fishery community in BNP. To estimate the total instantaneous mortality rate $Z(t)$ given an estimate of $\bar{L}(t)$, we used the following equation (Ault and Ehrhardt 1991; Ehrhardt and Ault 1992):

$$\left[\frac{L_\infty - L_\lambda}{L_\infty - L_c}\right]^{\frac{Z(t)}{K}} = \frac{Z(t)\left(L_c - \bar{L}(t)\right) + K\left(L_\infty - \bar{L}(t)\right)}{Z(t)\left(L_\lambda - \bar{L}(t)\right) + K\left(L_\infty - \bar{L}(t)\right)}$$

where L_c is size at first capture, L_8 is maximum size in the stock, K and L_4 are parameters of the von Bertalanffy equation, and t is year. While no explicit formula exists for analytical estimation of $Z(t)$,

Figure 29.- Flow chart showing the steps used in the multispecies reef fish assessment. See Ault et al. (1998) for additional details.

Begin Multispecies Assessment

↓

Step 1: Conduct fishery surveys (RVC, CREEL, TRAWL, etc.) for fish community in year *t* and intercalibrate sampling efficiency by species, site, and year.

↓

Begin Management Analyses for species s

↓

Step 2: Using intercalibrated survey data, compute annual estimates of $\bar{L}$ and associated 95% confidence intervals from size and abundance data integrated over the range of exploitable sizes.

↓

Step 3: Compute CPUE by species by lifestage by year t for each data type.

↓

Step 4: Use population dynamics parameters (**Table 10**) to parameterize the LBAR (Ault et al., 1996) and REEFS (Ault et al. 1998) computer algorithms.

↓

Step 5: Use $\bar{L}(t)$ estimate in LBAR computer algorithm to estimate fishing mortality rates as $\hat{F}(t) = \hat{Z}(t) - M$ for each species by year for the several data sources, i.e., time series of RVC, CREEL and headboat data.

↓

Step 6: Use the REEFS numerical model to: (1) compute expected $\bar{L}(t)$ given the reported population dynamics and $\hat{F}$ parameter values; (2) compute yield per recruit (YPR) and assess growth overfishing; and, (3) compute spawning stock biomass (SSB) for the fishery in unexploited and (for maximum sustainable yield and current) exploited states (i.e., F=0, F=F_{msy}, *and* F=$\hat{F}(t)$, respectively) and evaluate spawning potential ratio (SPR) to assess recruitment overfishing.

↓

Step 7: Use REEFS to compute $\hat{B}_0$, B_{msy}, $\hat{B}(t)$ and assess limit control rules.

↓

Step 8: From these results make specific fishery management recommendations on control strategies of F and L_c consistent with eumetric fishing principles and the precautionary approach of the MSFMCA that minimize the potential for overfishing.

↓

Conduct next species analyses?

STOP

Table 12.- Parameters, definitions and units for life table variables common to the LBAR and REEFS numerical models used in simulation analysis of Florida Keys reef fish population dynamics. See **Tables 13** for parameter values.

Parameter	Definition	Units
s	Reef fish species (s=1,ğ,n)	
a	Cohort age class (a=1,…,t_8)	
t_r	Age of recruitment	months
L_r	Size at recruitment	mm
t_m	Minimum age of maturity	months
L_m	Minimum size of maturity	mm
t_c	Minimum age of first capture	months
L_c	Minimum size of first capture	mm
t_8	Oldest (largest) age	years
L_8	Largest (oldest) size	mm
W_4	Ultimate weight	kg
L_4	Ultimate length	mm
K	Brody growth coefficient	$year^{-1}$
t_0	Age at which size equals 0	years
$"_{WL}$	Scalar coefficient of weight-length function	dimensionless
$ß_{WL}$	Power coefficient of weight-length function	dimensionless
W(a,t)	Weight at age *a* at time *t*	g
L(a,t)	Length at age *a* at time *t*	mm
N(a,t)	Numbers at age *a* at time *t*	number of fish
M(a,t)	Natural mortality rate at age *a* at time *t*	$year^{-1}$
F(a,t)	Fishing mortality rate at age *a* at time *t*	$year^{-1}$
S(a)	Survivorship to age *a*	dimensionless
Z(t)	Total mortality rate in year *t*	dimensionless
1(a)	Sex ratio at age *a*	dimensionless
B(a,t)	Biomass at age *a* in year *t*	kg
$Y_w(t)$	Yield in weight in year t	mt
SSB(t)	Spawning stock biomass in year *t*	mt
SPR(t)	Spawning potential ratio in year *t*	mt

Table 13. - Population dynamics parameters for exploited fishes in Biscayne National Park necessary to LBAR and REEFS assessment and management models

	Common Name	Scientific Name	Population Dynamics Rate Parameters													Parameter
			M(a,t)	τ_λ	L_∞	W_∞	K	t_0	L_m	t_m	L_c	t_c	α_{WL}	β_{WL}	L_λ	Confidence
	Groupers															
1	**Rock Hind**	*Epinephelus adscensionis*	0.25	12	486.1	2.27	0.191	-2.16	336	48	200	7	6.00E-06	3.193	453.3	3
2	**Graysby**	*Epinephelus cruentatus*	0.37	8.1	340	0.62	0.35	-0.46	198	24	200	25	1.22E-05	3.044	350	3
3	**Speckled Hind**	*Epinephelus drummondhayi*	0.20	15	967	16.58	0.13	-1.01	463	48	290	21	1.11E-05	3.073	861	3
4	**Yellowedge Grouper**	*Epinephelus flavolimbatus*	0.12	26	1180	40.22	0.11	-1.07	606	66	240	12	2.82E-05	2.980	1150	1
5	**Coney**	*Epinephelus fulvus*	0.67	4.5	340	0.68	0.63	-0.25	198	13	220	17	1.74E-05	3.000	340	1
6	**Red Hind**	*Epinephelus guttatus*	0.18	17	392.7	1.01	0.207	-0.831	251	49	180	26	8.55E-06	3.112	382.9	3
7	**Marbled Grouper**	*Epinephelus inermis*	0.18	17	937	11.83	0.17	-0.7	493	44	200	9	1.13E-05	3.035	910	1
8	**Goliath Grouper**	*Epinephelus itajara*	0.13	22.3	2010	180.72	0.13	-0.13	978	52	**Closed**		1.04E-05	3.100	2500	3
9	**Red Grouper**	*Epinephelus morio*	0.18	17	938	11.86	0.153	-0.099	437	48	**508**	60	1.13E-05	3.035	869	3
10	**Misty Grouper**	*Epinephelus mystacinus*	0.19	16	1633	63.56	0.18	0	811	38			2.45E-05	2.930	1600	1
11	**Warsaw Grouper**	*Epinephelus nigritus*	0.07	41	2394	244.86	0.054	-3.616	807	48			2.09E-05	2.980	2328	3
12	**Snowy Grouper**	*Epinephelus niveatus*	0.20	15	1091.3	19.51	0.113	-0.915	465	48			2.45E-05	2.930	909	3
13	**Nassau Grouper**	*Epinephelus striatus*	0.18	17	698.9	5.87	0.145	-1.08	480	83	**Closed**		3.83E-06	3.229	648.2	3
14	**Black Grouper**	*Mycteroperca bonaci*	0.15	20	1200	31.59	0.16	-0.3	597	48	**609.6**	50	4.27E-06	3.205	1153.1	3
15	**Yellowmouth Grouper**	*Mycteroperca interstitialis*	0.18	17	881.8	8.60	0.063	-9.03	469	36	**508**	55	2.58E-05	2.894	710.7	3
16	**Gag Grouper**	*Mycteroperca microlepis*	0.23	13	1187.2	25.14	0.149	-0.802	687	60	**609.6**	48	1.21E-05	3.031	1034.4	3
17	**Scamp**	*Mycteroperca phenax*	0.14	21	999.7	19.26	0.126	-1.357	491	48	**508**	51	2.02E-05	2.993	932.2	3
18	**Yellowfin Grouper**	*Mycteroperca venenosa*	0.20	15	860	15.67	0.17	0	527	67	**508**	63	2.82E-05	2.980	960	3
	Snappers															
19	**Mutton Snapper**	*Lutjanus analis*	0.21	14	938.7	14.15	0.129	-0.738	279	24	**406.4**	44	1.57E-05	3.012	797.8	3
20	**Schoolmaster**	*Lutjanus apodus*	0.25	12	570	3.28	0.18	0	148	20	**254**	39	2.04E-05	2.978	503.8	3
21	**Blackfin Snapper**	*Lutjanus buccanella*	0.33	9	729.7	2.41	0.084	-2.896	232	20	**304.8**	43	7.40E-06	2.974	458.8	3
22	**Red Snapper**	*Lutjanus campechanus*	0.19	16	975	13.68	0.162	-0.01	308	28	**508**	54	2.04E-05	2.953	955	3
23	**Yellowtail Snapper**	*Lutjanus chrysurus*	0.21	14	454.7	1.30	0.209	-0.712	197	24	**304.8**	55	7.75E-05	2.718	433.4	3
24	**Cubera Snapper**	*Lutjanus cyanopterus*	0.15	20	1633	89.57	0.14	-0.71	819	50	**304.8**	9	1.32E-05	3.060	1600	1
25	**Gray Snapper**	*Lutjanus griseus*	0.30	10	722.3	5.25	0.136	-0.863	233	24	**254**	28	3.05E-05	2.881	556.2	3
26	**Dog Snapper**	*Lutjanus jocu*	0.33	9	854	10.19	0.1	-2	300	28	**304.8**	29	4.28E-05	2.857	790	3
27	**Mahogony Snapper**	*Lutjanus mahogoni*	0.30	10	499	1.77	0.29	-0.48	280	29	**304.8**	33	8.18E-05	2.719	480	1
28	**Lane Snapper**	*Lutjanus synagris*	0.30	10	618.3	3.24	0.097	-1.728	205	29	**203.2**	29	4.52E-05	2.815	418.4	3
29	**Silk Snapper**	*Lutjanus vivanus*	0.33	9	781.1	9.28	0.092	-2.309	305	37	**304.8**	37	1.00E-05	3.100	512	3
30	**Black Snapper**	*Apsilus dentatus*	0.68	4.4	638	3.87	0.65	-0.2	349	12			1.49E-05	3.000	650	2
31	**Vermillion Snapper**	*Rhomboplites aurorubens*	0.30	10	613.6	9.19	0.206	0.111	314	43	**254**	32	3.01E-05	3.044	541.6	3
32	**Hogfish**	*Lachnolaimus maximus*	0.25	12	566	3.51	0.19	-0.776	199	18	**304.8**	40	2.09E-05	2.988	439	3
	Grunts															
33	**Black Margate**	*Anisotremus surinamensis*	0.37	8	673	9.33	0.36	-0.35	366	22	220	10	2.39E-06	3.392	639.2	1
34	**Porkfish**	*Anisotremus virginicus*	0.43	7	397	1.72	0.41	-0.35	228	21	160	11	1.01E-05	3.167	380	1
35	**Margate**	*Haemulon album*	0.37	8	752.6	8.57	0.174	-0.45	426	52	200	16	1.52E-05	3.042	710	2
36	**Tomtate**	*Haemulon aurolineatum*	0.33	9	310	0.61	0.22	-1.28	130	14	150	21	6.19E-06	3.208	250	3
37	**Caesar Grunt**	*Haemulon carbonarium*	0.43	7	376	0.96	0.1	0	217	103	160	67	1.29E-05	3.056	360	1
38	**Smallmouth Grunt**	*Haemulon chrysargyreum*	0.50	6	242	0.38	0.47	-0.35	146	19			2.77E-03	2.157	230	1
39	**French Grunt**	*Haemulon flavolineatum*	0.50	6	294.31	0.57	0.179	0	176	18	160	53	9.06E-06	3.158	300	2
40	**Spanish Grunt**	*Haemulon macrostomum*	0.50	6	448	2.46	0.48	-0.29	254	17	200	11	2.28E-05	3.030	430	1
41	**Cottonwick**	*Haemulon melanurum*	0.33	9	350	0.82	0.32	-0.5	203	26			2.52E-05	2.953	330	2
42	**Sailors Choice**	*Haemulon parrai*	0.43	7	400.2	1.24	0.22	-0.355	103	12	200	34	2.02E-05	2.993	320.1	1
43	**White Grunt**	*Haemulon plumieri*	0.37	8	511.9	3.06	0.186	-0.776	177	18	170	17	8.35E-06	3.161	410.3	3
44	**Bluestriped Grunt**	*Haemulon sciurus*	0.50	6	412.7	1.36	0.3	0	205	24	180	23	1.94E-05	3.000	460	3
45	**Striped Grunt**	*Haemulon striatum*	0.50	6	294	0.62	0.47	-0.33	174	19	170	18	1.39E-05	3.099	280	1
46	**Pigfish**	*Orthopristis chrysoptera*									170		9.71E-06	3.189		0

Table 13. - Biscayne National Park, Exploited Species List (continued)

	Common Name	Scientific Name	Population Dynamics Rate Parameters													Parameter
			M(a,t)	t_λ	L_∞	W_∞	K	t_0	L_m	t_m	L_c	t_c	α_{WL}	β_{WL}	L_λ	Confidence
	Other Reef Fishes															
47	**Great Barracuda**	*Sphyraena barracuda*	0.09	32	1780	42.95	0.09	-1.19	877	77	350	15	4.11E-06	3.083	2000	2
48	**Jolthead Porgy**	*Calamus bajonado*	0.23	13	704	7.03	0.22	-0.58	381	36	200	11	6.67E-05	2.818	680	1
49	**Saucereye Porgy**	*Calamus calamus*	0.43	7	581	3.75	0.41	-0.32	321	20	200	9	6.78E-05	2.801	560	1
50	**Yellow Jack**	*Caranx bartholomaei*	0.20	15	1028	18.41	0.19	-0.6	450	40	250	10	3.20E-05	2.909	1000	1
51	**Blue Runner**	*Caranx crysos*	0.27	11	724	5.28	0.26	-0.48	391	30	160	6	1.07E-04	2.690	700	2
52	**Crevalle Jack**	*Caranx hippos*	0.17	18	1271	29.37	0.16	-0.69	648	45	200	5	9.55E-05	2.734	1240	1
53	**Horse-eye Jack**	*Caranx latus*	0.25	12	826	20.12	0.24	-0.51	440	31	240	11	4.76E-06	3.300	800	1
54	**Bar Jack**	*Caranx ruber*	0.15	20	520	2.65	0.24	0	240	31	240	31	4.28E-06	3.237	520	3
55	**Bermuda Chub**	*Kyphosus sectatrix*	0.37	8	785	11.93	0.36	-0.34	420	21	180	5	1.45E-05	3.080	760	1
56	**Gray Angelfish**	*Pomacanthus arcuatus*	0.43	7	622	7.26	0.41	-0.31	341	19			3.71E-05	2.968	600	1
57	**Bicolor Damselfish**	*Pomacentrus partitus*											1.28E-05	3.152		0
58	**Threespot Damselfish**	*Pomacentrus planifrons*											5.27E-05	2.857		0
59	**Blue Parrotfish**	*Scarus coeruleus*	0.25	12	1231	39.56	0.24	-0.45	629	30			9.63E-06	3.111	1200	1
60	**Striped Parrotfish**	*Scarus croicensis*											1.29E-05	3.055		0
61	**Rainbow Parrotfish**	*Scarus guacamaia*	0.30	10	1231	39.16	0.29	-0.38	629	25			1.34E-05	3.063	1200	1
62	**Princess Parrotfish**	*Scarus taeniopterus*	0.50	6	366	0.58	0.48	-0.31	212	18			6.55E-05	2.709	350	1
63	**Queen Parrotfish**	*Scarus vetula*	0.60	5	551	2.26	0.6	-0.23	306	13			1.35E-05	3.000	610	1
64	**Greenblotch Parrotfish**	*Sparisoma atomarium*	0.60	5	263	0.21	0.57	-0.28	157	16			1.14E-05	3.000	250	1
65	**Redband Parrotfish**	*Sparisoma aurofrenatum*	0.60	5	294	0.41	0.57	-0.27	174	16			1.62E-05	3.000	280	1
66	**Redtail Parrotfish**	*Sparisoma chrysopterum*	0.83	3.6	418	1.43	0.79	-0.19	239	11			1.07E-05	3.100	460	2
67	**Bucktooth Parrotfish**	*Sparisoma radians*	0.60	5	211	0.11	0.57	-0.3	129	17			1.14E-05	3.000	200	2
68	**Redfin Parrotfish**	*Sparisoma rubripinne*	0.60	5	505	2.50	0.58	-0.24	283	14			1.94E-05	3.000	478	1
69	**Stoplight Parrotfish**	*Sparisoma viride*	0.30	10	663	5.78	0.29	-0.45	361	28			3.80E-05	2.900	640	2
70	**Gray Triggerfish**	*Balistes capriscus*	0.37	8	600	4.15	0.38	-0.36	330	20	**304.8**	18	2.91E-05	2.935	600	3
71	**Queen Triggerfish**	*Balistes vetula*	0.23	13	759	11.19	0.23	-0.57	408	33	240	13	2.73E-05	2.990	600	3
72	**Ocean Triggerfish**	*Cantherhines sufflamen*	0.33	9	673	6.78	0.32	-0.4	366	25	250	13	1.55E-05	3.055	650	1
73	**Foureye Butterflyfish**	*Chaetodon capistratus*											1.42E-05	3.190		0
74	**Doctorfish**	*Acanthurus chirurgus*	0.27	11	332	0.96	0.254	-0.63	194	32	200	36	1.19E-06	3.533	350	3
	Inshore Gamefishes															
75	**Spotted Seatrout**	*Cynoscion nebulosus*	0.16	19	794		0.15	-0.87	425	50	350	36			910	2
76	**Permit**	*Trachinotus falcatus*	0.18	17	1170	6.64	0.17	-0.66	601	4	**254-508**	9	1.01E-06	3.200	1140	1
77	**African Pompano**	*Alectis ciliaris*	0.20	15	1530	89.23	0.19	-0.54	767	37	**609.6**	26	5.19E-05	2.900	1500	1
	Pelagics															
78	**Dolphin**	*Coryphaena hippurus*	0.94	3.2	2340	215.18	0.92	-0.1	1121	7	300	1	7.93E-05	2.800	2100	2
79	**Atlantic bonito**	*Sarda sarda*	0.71	4.2	640	24.83	0.69	-0.19	350	12	300	9	2.60E-05	3.200	914	2
80	**Little Tunny**	*Euthynnus alletteratus*	0.20	15.2	1150	19.77	0.19	-0.62	592	38	290	11	1.30E-05	3.000	1220	2
81																
81	**Sailfish**	*Istiophorus platypterus*	0.45	6.6	3410	167.75	0.44	-0.19	1571	14			1.10E-04	2.600	3400	3
82	**Skipjack Tuna**	*Katsuwonus pelamis*	0.67	4.5	791	10.46	0.64	-0.19	423	12	500	16	2.86E-06	3.300	1080	2
83	**Blackfin Tuna**	*Thunnus atlanticus*	0.34	8.7	780	11.29	0.33	-0.39	418	22	320	15	1.22E-05	3.100	1000	2
84	**King Mackerel**	*Scomberomorus cavalla*	0.16	19.3	1370	18.71	0.15	-0.75	693	47	**609.6**	38	8.83E-06	2.973	1840	2
85	**Spanish Mackerel**	*Scomberomorus maculatus*	0.21	14.4	964	7.30	0.2	-0.61	505	37	**304.8**	15	9.21E-06	2.982	830	2
86	**Cero**	*Scomberomorus regalis*	0.18	17	1864	45.99	0.17	-0.58	914	41	350	8	3.20E-05	2.800	1830	1
87	**Greater Amberjack**	*Seriola dumerili*	0.26	11.6	1581	48.71	0.25	-0.42	788	28	**711.2**	24	5.03E-05	2.809	1900	2
88																
88	**Tripletail**	*Lobotes surinamensis*	0.20	15	1130	23.99	0.19	-0.59	583	38	**381**	19	6.78E-05	2.800	1110	1
89	**Wahoo**	*Acanthocybium solandri*	0.15	20	2534	123.26	0.15	-0.63	1204	44	**600**	14	1.58E-06	3.200	2500	1
	Macroinvertebrates															
90	**Spiny Lobster**	*Panulirus argus*									**76.2**					0
91	**Pink shrimp**	*Farfantapaneus duorarum*														

Parameter Confidence:

0	No Data Available
1	Based on Max Size
2	Max Size, but mixed
3	Relatively High Confidence

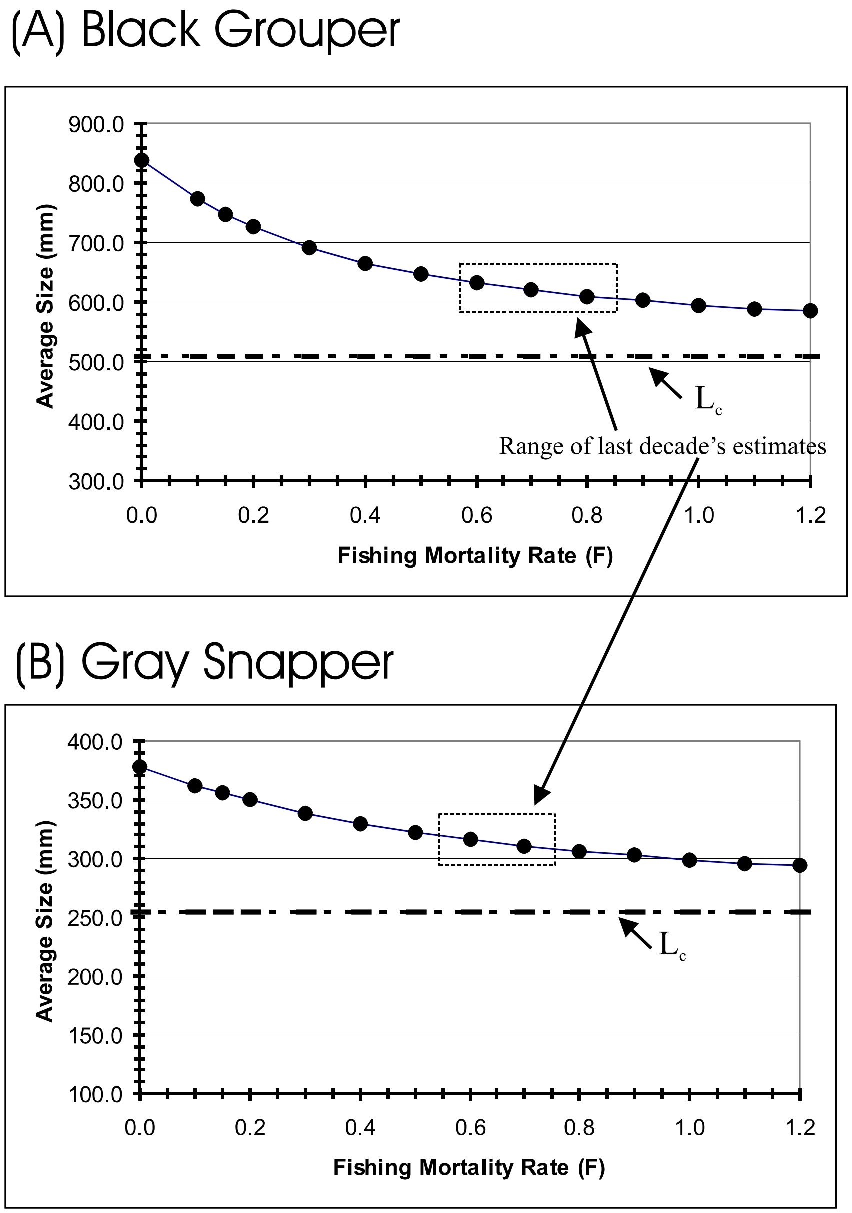


Figure 30.- Expected distribution of average size on fishing mortality rates for: (A) Black grouper; and, (B) Gray snapper. Horizontal dashed line shows the minimum size of first capture. Stipled box indicates the range of fishing mortality estimated over the last decade.

this can be achieved fairly easily using an iterative numerical algorithm called LBAR (**Appendix F**) developed by Ault et al. (1996) (also found in the FAO stock assessment library, FAO 1997). The algorithm provides a means to an unbiased estimator of total instantaneous population mortality rate *Z(t)* (Quinn and Deriso 1999). Estimation of instantaneous fishing mortality rate *F(t)* is accomplished by subtracting the rate of natural mortality *M* from the $\hat{Z}(t)$ estimate. The $\hat{Z}(t)$ statistic is robust to any population survey measure (i.e., visual census, creel, or headboat survey data). Iterative application of the mortality estimation method using annual estimates of $\bar{L}$ provided time-series information on fishing mortality rates, and thus abundance, for all key species included in the analysis (see **Appendix C**). This estimation procedure is explained in detail in Ault et al. (1998). Current estimates of $\hat{F}$ are given in **Table 14**.

5.3 Management Benchmarks Analyses

To assess the status of the multispecies fishery based on the estimated rates of fishing mortality, we employed a population computer simulation model called REEFS (reef-fish equilibrium exploitation fishery simulator) (**Appendix F**). The model was applied to 35 reef fish species in 5 families: groupers, Serranidae; snappers, Lutjanidae; grunts, Haemulidae; the hogfish, Lachnolaimus maximus, Labridae; and, the great barracuda, Sphyraena barracuda, Sphyraenidae. These are among the primary fishery targets of the recreational and commercial fishing fleets in the south Florida coral reef ecosystem. Other species (e.g., bonefish, tarpon, spiny lobster, etc.) lacked sufficient indices of population status (**Appendix C**) and/or population dynamics data (**Table 13**) necessary for comprehensive quantitative stock assessments in BNP. The hogfish (or hog snapper) was grouped with snappers for analytical purposes.

The REEFS model is a size-based algorithm that embodies a stochastic age-independent model for ensemble number at a given length ($\bar{N}_\gamma(L_\gamma,t)$) for the entire population (Ault and Rothschild 1991, Ault and Olson 1996, Ault 2001)

$$\bar{N}_\gamma(L_\gamma,t) = \int_{t_r}^{t_\lambda} R(\tau - a)\; S(a)\; \Theta(a)\; P(L_\gamma \mid a)\; da$$

where *R(J-a)* is recruitment, *S(a)* is survivorship at age a, *1(a)* is sex ratio at age, and P(L*a) is the probability of being length *L* given the fish is age *a* (Ault 1988, Ault and Rothschild 1992, Ault et al. 1997, 1998). The modeled fishing mortality rate of recreational and commercial fishers (or 'viewing power' of divers) was assumed to remove (sight) fish with a 'knife-edged selectivity pattern' (see Gulland, 1983) over the range of exploitable sizes

$$F(t) = \begin{cases} 0 & if \quad L|a < L_c \\ \hat{F}(t) & if \quad L|a \geq L_c \end{cases}$$

where the size of first capture L_c is that regulated by regional fishery management. Species-specific population dynamics parameters (**Table 13**) were used as model inputs.

The REEFS model was configured to assess several fishery management decision making reference points, or benchmarks, including yield-per-recruit (YPR) and spawning potential ratio (SPR). These two reference points are relatively robust measures of potential yields and recruitment,

Table 14.- Full fishery management benchmark analysis for 35 reef fish stocks in Biscayne National Park showing current estimates. Species with dashed boxes indicate current minimum size regulations are at or set lower than the minimum sexual maturity.

Taxa		Common name	Ave. L	F	M	K	M/K	L_m	L_c	L_λ	SPR	F/F_{msy}	B/B_{msy}	B_0	B_{msy}	B_{now}
Groupers	**1**	Rock Hind	260.00	0.510	0.250	0.191	1.31	336.0	203.2	453.3	5.78	2.04	0.26	18367	4053	1061
	2	Graysby	250.00	0.275	0.200	0.350	0.57	108.0	203.2	362.7	40.14	1.37	0.83	8824	4286	3542
	3	Speckled Hind	442.95	0.269	0.200	0.130	1.54	460.1	290.0	845.7	18.45	1.34	0.68	120668	32620	22265
	4	Yellowedge	509.58	**2.000**	0.200	0.170	1.17	524.8	240.0	792.4	3.19	10.02	0.07	126653	58387	4037
	5	Coney	280.00	0.645	0.180	0.145	1.24	185.1	203.2	647.8	8.41	3.58	0.25	22919	7859	1927
	6	Red Hind	279.14	0.146	0.180	0.207	0.87	247.0	203.2	382.8	44.25	0.81	1.18	19520	7350	8638
	7	Goliath	691.26	0.430	0.130	0.130	1.00	978.0	508.0	2178.3	1.27	3.31	0.05	5827829	1548036	73923
	8	Red	560.00	1.065	0.180	0.153	1.18	433.8	508.0	869.0	14.71	5.91	0.30	125310	60588	18434
	9	Warsaw	691.26	0.431	0.080	0.054	1.48	940.5	508.0	2178.3	1.17	5.39	0.05	6322926	1609331	73970
	10	Snowy	493.07	**2.000**	0.130	0.113	1.15	462.1	508.0	909.8	6.97	15.38	0.13	228770	125243	15937
	11	Nassau	551.86	0.313	0.180	0.145	1.24	480.0	508.0	648.2	46.49	1.74	0.77	48595	29247	22590
	12	Black	628.78	0.625	0.150	0.160	0.94	597.0	508.0	1153.4	5.91	4.17	0.16	532994	191373	31476
	13	Yellowmouth	545.40	0.423	0.180	0.063	2.86	468.0	508.0	710.7	21.32	2.35	0.48	170878	76345	36427
	14	Gag	569.84	1.258	0.230	0.149	1.54	657.0	508.0	1034.4	0.92	5.47	0.03	133456	41421	1234
	15	Scamp	470.25	**2.000**	0.143	0.126	1.13	491.0	508.0	932.2	4.09	13.99	0.09	319185	138084	13065
	16	Yellowfin	520.00	**2.000**	0.180	0.170	1.06	524.8	508.0	792.4	3.99	11.11	0.08	151123	74204	6024
Snappers	**17**	Mutton	450.00	1.249	0.214	0.129	1.66	275.8	406.4	797.8	14.59	5.84	0.32	91558	42117	13355
	18	Schoolmaster	280.00	**2.037**	0.250	0.180	1.39	144.6	254.0	503.8	12.44	8.15	0.27	20614	9563	2565
	19	Blackfin	350.00	0.447	0.230	0.084	2.75	233.4	304.8	459.2	50.65	1.94	0.77	7317	4837	3706
	20	Red	356.00	1.898	0.190	0.162	1.17	303.5	508.0	901.6	1.78	9.99	0.05	146407	49553	2609
	21	Yellowtail	330.00	0.795	0.210	0.209	1.00	194.3	304.8	433.4	35.99	3.78	0.59	17173	10438	6181
	22	Cubera	488.65	0.495	0.150	0.140	1.07	407.3	304.8	1153.1	5.83	3.30	0.19	639420	196466	37284
	23	Gray	300.00	0.966	0.300	0.136	2.21	230.2	254.0	556.5	14.70	3.22	0.36	17396	7077	2558
	24	Dog	358.71	0.588	0.330	0.100	3.30	298.0	304.8	568.5	27.91	1.78	0.64	19922	8627	5560
	25	Lane	245.00	0.573	0.300	0.097	3.09	202.3	203.2	418.3	23.26	1.91	0.57	7396	2998	1720
	26	Silk	260.00	**2.000**	0.230	0.092	2.50	303.7	304.8	512.0	7.10	8.70	0.13	23033	12217	1636
	27	Black	250.00	0.478	0.300	0.650	0.46	203.0	203.4	650.0	27.61	1.59	0.68	7356	2984	2031
	28	Vermillion	279.21	**2.000**	0.300	0.206	1.45	310.9	254.0	532.9	0.50	6.68	0.01	11330	4081	57
	29	Hogfish	330.00	1.639	0.250	0.190	1.32	195.5	304.8	515.4	19.86	6.56	0.38	32515	16857	6456
Grunts	**30**	Margate	270.00	0.995	0.374	0.174	2.15	324.4	203.2	578.4	4.72	2.66	0.18	17222	4550	813
	31	Tomtate	206.39	**2.000**	0.330	0.220	1.50	136.1	203.2	250.0	47.10	6.06	0.65	2533	1845	1193
	32	Sailors choice	235.00	0.760	0.430	0.220	1.95	100.4	203.2	320.1	48.81	1.77	0.80	3139	1926	1532
	33	Bluestriped	226.90	0.762	0.500	0.484	1.03	108.4	203.2	273.5	56.54	1.52	0.87	2269	1481	1283
	34	White	216.50	**2.000**	0.370	0.186	1.99	174.0	203.2	410.9	11.64	5.41	0.27	8676	3695	1010
Others	**35**	Great barracuda	590.00	1.291	0.200	0.172	1.16	625.1	508.0	1151.0	1.81	6.46	0.05	140803	48491	2543

respectively. As such, they help to focus on biological (size) and fishing (intensity) controls for managing current and future fishery production. We also used the REEFS stochastic simulation model to assess population risks relative to 'limit control rules' (e.g., NMFS 1999). Taken together, these management benchmarks characterize the status of stocks under exploitation relative to Federal fishery management standards. These analyses thus provide the basis for the assessment of the entire reef fish community, and indicate the efficacy of current fishery management practices and their sufficiency to provide sustainable fisheries now and into the future.

5.3.1 Fishery Yields and YPR

Since biomass *B(a,t)* is the product of numbers-at-age times weight-at-age, yield in weight Y_w from a given species *s* was calculated as

$$Y_w(F,L_c,t) = F(t)\int_{L_c}^{L_\lambda} B(L|a,t)\,dL = F(t)\int_{L_c}^{L_\lambda} N(L|a,t)W(L|a,t)\,dL$$

Yield-per-recruit (YPR), or the lifetime yield expected from a single recruited individual, can then calculated by scaling yield to average recruitment.

5.3.2 Spawning Potential Ratios (SPR)

Mature or spawning stock biomass *SSB(t)* is a measure of the stock's reproductive potential or capacity to produce newborn, ultimately realized at the population level as successful cohorts or year classes. Spawning stock biomass is obtained by integrating over individuals between the minimum size of first maturity (L_m) and maximum reproductive size (here assumed to be the maximum size L_8) in the stock

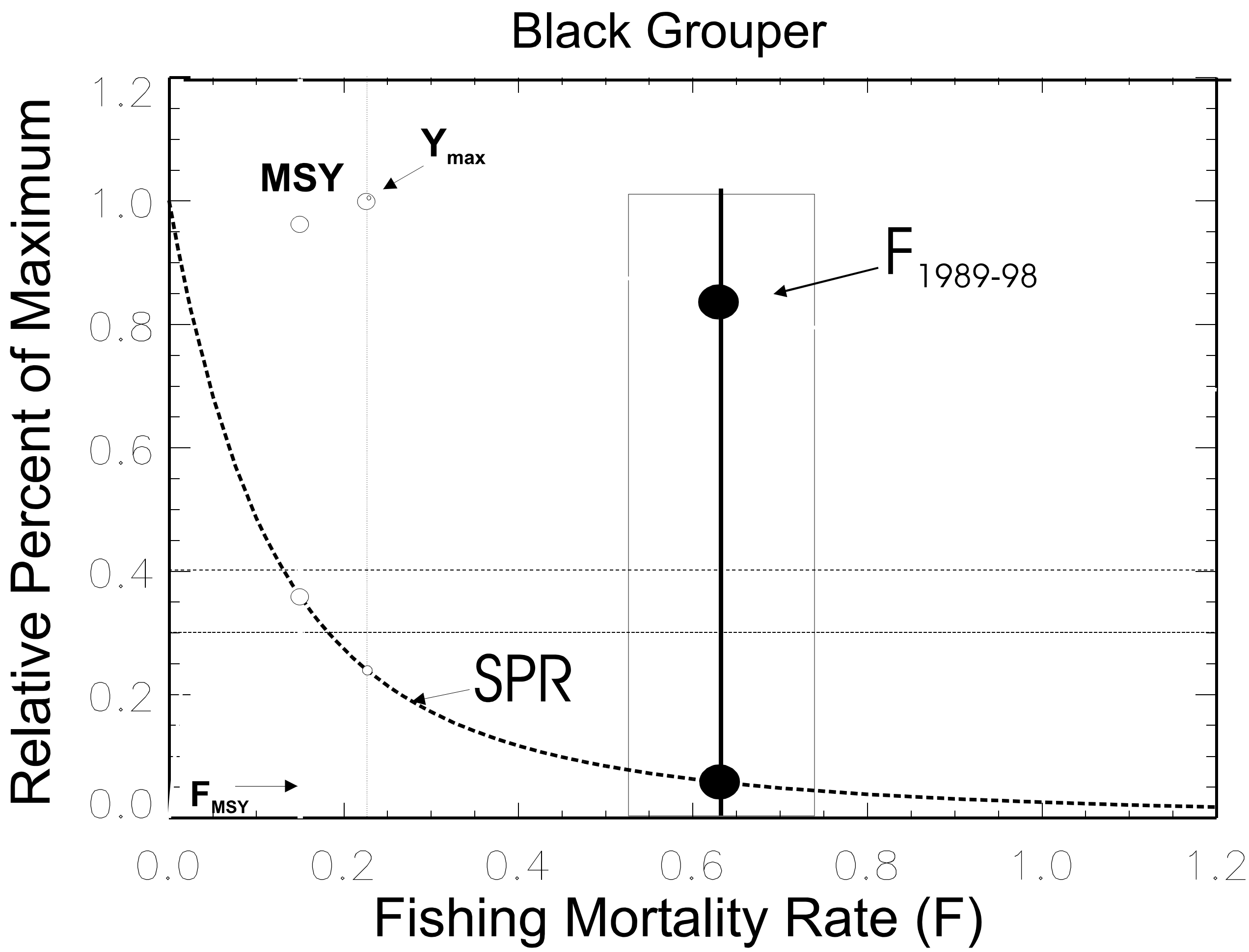
$$SSB(t) = \int_{L_m}^{L_\lambda} B(L|a,t)\,dL$$

Spawning potential ratio (SPR) is a contemporaneous management reference point that measures the stock's potential capacity to produce optimum yields on a sustainable basis. SPR is a fraction expressed as the ratio of exploited spawning stock biomass relative to the equilibrium unexploited SSB

$$SPR = \frac{SSB_{exploited}}{SSB_{unexploited}}$$

Resultant estimated SPRs are then compared to the U.S. Federal standards which define 30% SPR as the "overfishing" threshold (Rosenberg et al., 1996).

The relationship between YPR and SPR with respect to fishing mortality rate is shown for black grouper in **Figure 31**. Note that the current estimates of *F* for black grouper place SPR and YPR well below optimal levels for sustainability of the fishery resource. An important attribute of the progression of average size as fishing mortality increases is shown in **Figure 32** for black grouper. Increasing exploitation successively eliminates older, more fecund size classes through a process known as "juvenescence", which ultimately produces an overall younger stock (Ricker 1963, Ault 1988). This fact is extremely important in the context of stock and recruitment, since the fecundity potential of individuals increases exponentially with size. Such a phenomenon will be reflected by reductions of



igure 31.- Example of the response of relative spawning potential ratio SPR and yield-per-recruit YPR theory for Black grouper ith increasing exploitation using the REEFS model. Graph shows position of MSY and F_{msy} and estimated fishing mortality rate ›r the last decade derived from average size analyses with LBAR in shaded box.

the stock's spawning capacity, which itself is related to the expectation of new recruits to sustain the population over the longer run. For black grouper, fishing at the rate of mortality that produces "maximum sustainable yield" reduces the spawning potential ratio (the proportion of the virgin spawning biomass available) to about 36% (**Figure 31**). Remarkably, the current estimated rate of fishing mortality has reduced the spawning potential ratio to less than 5% of its historical maximum. From the perspective of ecological theory, this is an ominous result in terms of black grouper population stability and resilience. From the perspective of fishers, a current 5% SPR implies that the average size of black grouper (**Figure 32**) is 60% of what it once was (circa 1940).

The summary of the SPRs for the Biscayne National Park exploited reef fish complex in **Figure 33** shows that 13 of 16 groupers, 11 of 13 snappers, barracuda, and 2 of 5 grunts for which there are population dynamics data are below the SPR that constitutes overfishing by Federal definitions. Overall, 77% of the 35 stocks that could be analyzed were overfished.

5.3.3 Limit Control Rules

The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) contains a set of National Standards for fishery conservation and management, the first of which states:

> *"Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry."*

The MSFCMA also required the Secretary of Commerce to "establish advisory guidelines (which shall not have the force and effect of law), based on the national standards, to assist in the development of fishery management plans". These Guidelines (or national standard guidelines or NSGs) were published as a final rule in May 1998. Following the NSGs, Technical Guidelines were developed (NMFS 1999, Restrepo and Powers 1999) to translate the NSGs into usable scientific criteria so that scientific advice could be offered to the regional Fishery Management Councils to assist in implementing the MSFMCA. Key points arising were: (1) that maximum sustainable yield (MSY) is to be viewed as a limit (i.e., a threshold **NOT** to be exceeded); (2) that two measures were to be used to determine a fish stock's management status, (a) the current fishing mortality rate relative to the fishing mortality rate that would produce MSY (denoted as F/F_{msy}), and (b) the current amount of spawning biomass relative to the spawning biomass at MSY (denoted as B/B_{msy}); (3) that there should be maximum standards of fishing mortality rates which should not be exceeded, called Maximum Fishing Mortality Threshold (MFMT); (4) that there should be a Minimum Stock Size Threshold (MSST) under which a stock's spawning biomass would be considered as depleted; and (5) that these criteria and measures should be linked together through "control rules" which specify actions to be taken (i.e., changes in management measures to alter fishing mortality rates) depending upon the status of current spawning biomass relative to B_{msy} and MSST and the status of the fishing mortality rate relative to F_{msy} and MFMT.

To address these emerging fishery management benchmark criteria for BNP multispecies resources, we conducted a new cutting-edge analysis that established fishery limit control rules consistent with the "precautionary approach" (NMFS 1999, Restrepo and Powers 1999, Darcy and Matlock 1999, Butterworth and Punt 1999). Criteria used to set target catch levels as explained above are explicitly *risk averse*. A risk averse Precautionary Approach would set OY (optimum yield) below MSY as a function of uncertainty. Thus, the greater the uncertainty, the greater the distance between the two. The *precautionary approach* to fisheries management requires avoidance of overfishing, restoration of already overfished stocks, explicit specification of management objectives including

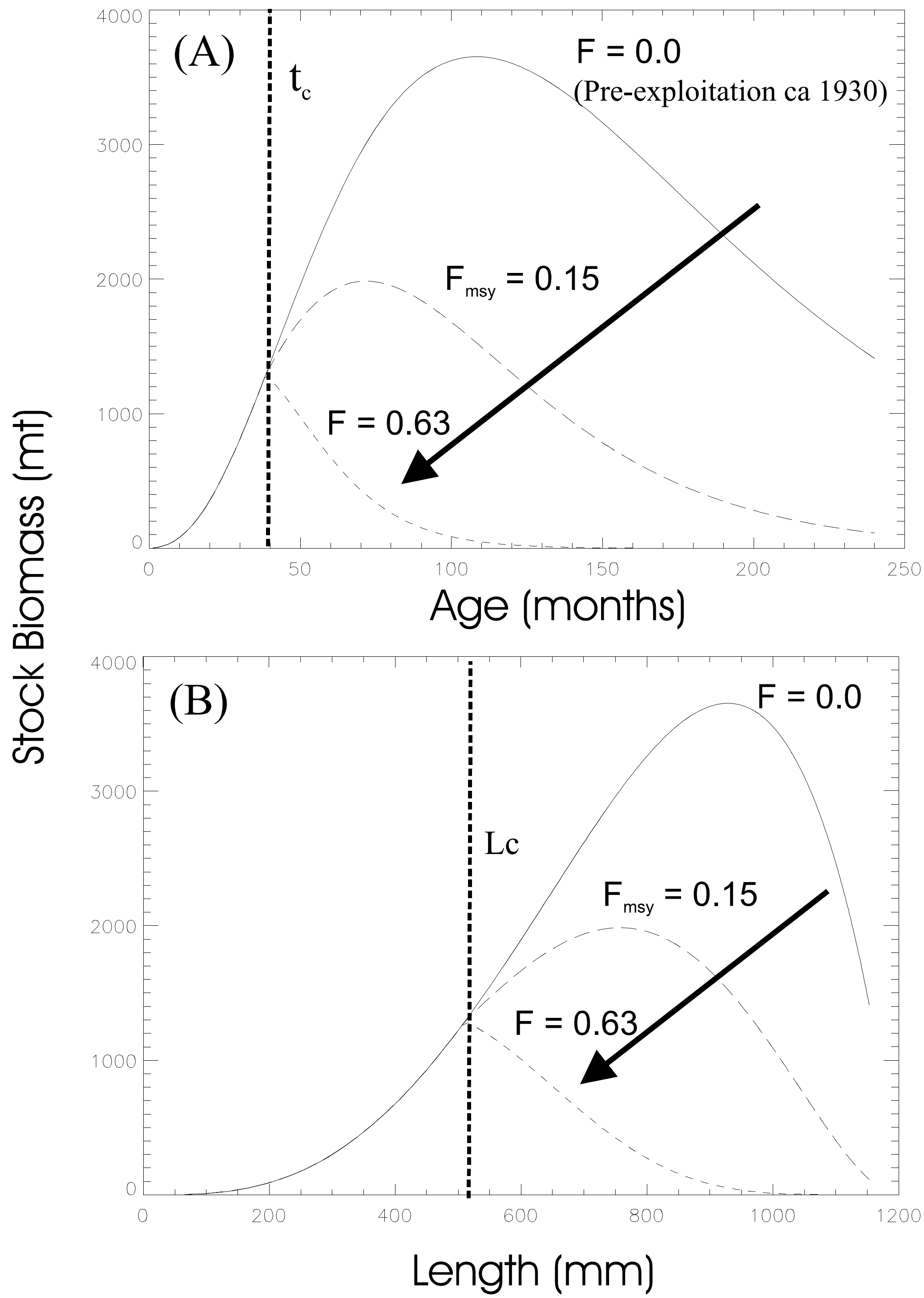


Figure 32.- Graphical theory of juvenescence. Comparison of simulations of equilibrium relationships of 'average length in the exploitable phase' dependent on fishing mortality rate *F* using the REEFS model for Black grouper: (A) cohort biomass on age; and, (B) cohort biomass on length.

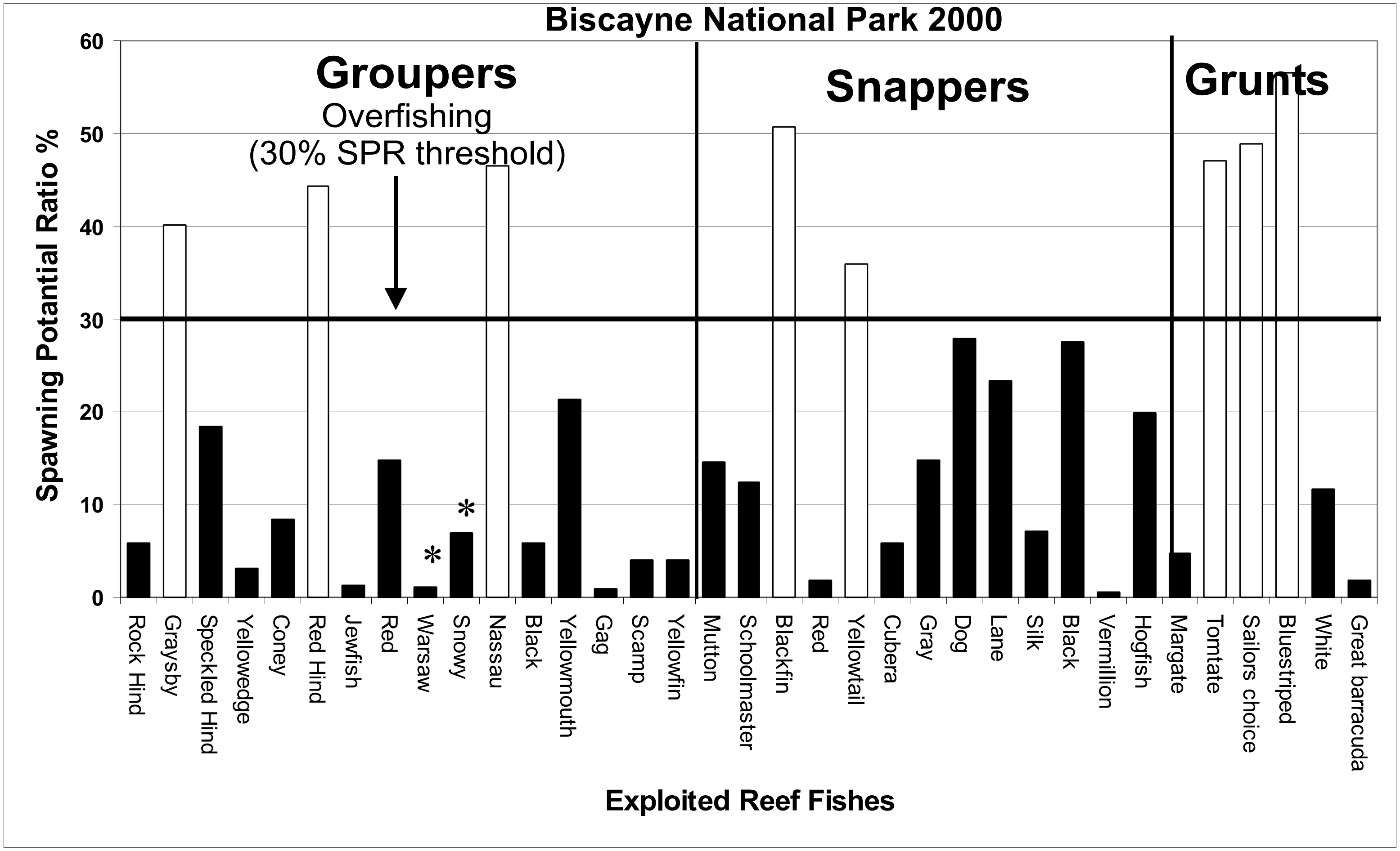


Figure 33.- Fishery management benchmark spawning potential ratio SPR annalyses for 35 exploited species of BNP-Florida Keys reef fish comprising groupers, snappers and hogfish, grunts and great barracuda. Darkened bars indicate stock “overfishing” and open bars indicate the stock is above the 30% SPR U.S. Federal Standard. Asterisk indicates estimate from headboat data outside BNP. The high SPR estimate for Nassau grouper is dubious.

operational targets and constraints (e.g., target and limit reference points), taking account of uncertainty by being more conservative, and avoidance of excess harvest capacity. In addition, this approach requires formulation of decision rules that stipulate in advance what actions will be taken to prevent overfishing and promote stock rebuilding.

Limit reference points are designed to constrain exploitation within safe biological limits so that stocks retain the ability to produce maximum sustainable yield. Overfishing is a level or rate of fishing mortality that jeopardizes the long-term capacity of a stock or stock complex to produce MSY on a continuing basis. In this arrangement, the fishing mortality rate which generates MSY should be regarded as the minimum standard for limit reference points. The limit MSST, minimum stock size threshold, is used to decide what level of fishing mortality indicates "overfishing", and when the stock is in an "overfished" condition. If spawning biomass drops below MSST, then the regional fishery management councils MUST take remedial actions to end overfishing and rebuild overfished stocks to MSY levels very rapidly (generally in 10 years or less).

A graphical application of limit control rule theory is shown in **Figure 34** for black grouper in BNP. The region defined by (A) represents a developing fishery where fishing mortality rates are below the level required to achieve MSY, and the stock biomass is greater than the biomass at MSY. The (B) region defines an area where overfishing is occurring and passes up to the threshold rate that will lead to an overfished stock. The (C) region formally defines an overfished stock that violates principles of sustainability and that requires strong intervention by fishery management. The (D) region defines a stock under recovery where the current fishing mortality rate has been reduced to a level that promotes rebuilding of the resource over a 10 year time horizon. We used the natural mortality rate as a proxy for F_{msy} (e.g., Gulland 1983). These estimates of F_{msy} were then input to REEFS to estimate $\hat{B}_{msy}(t)$. We note that all the yearly estimates of the black grouper fishery show that substantial overfishing has occurred in BNP, and that most recent estimates place the level of overfishing at 3-5 times the level of fishing required to produce maximum sustainable yield under Federal definitions (note that the 1981 estimate is dubious). Minimally, this means that fleet effort would need to be reduced by some 80% to achieve the longer-term sustainability goals under these standards. However, it should be noted that the National Park Service standards may be even more conservative than those established under the MSFMCA, and thus effort reductions would have to be even more severe to achieve NPS goals for BNP.

The limit control rule technique is demonstrated for black grouper (**Figure 34**); but the process is reflective of the analyses for every fish stock or community member (groupers, snappers, grunts, etc.). Fishing mortality rates were estimated to be from 2 to 10 times higher than F_{msy} for 71% (i.e., 25/35) of the exploited species analyzed (**Figure 35**). Moreover, the current levels of stock biomass are critically low for more than 70% of the key targeted species. The most current estimates and results are summarized in **Table 14.**

5.4 Baseline Status of BNP Exploited Fish Stocks

Our results indicate that BNP reef fish populations are currently heavily fished (**Figures 33 and 35, Table 14**). Despite using conservative assumptions, the estimated fishery exploitation rates we estimated suggest that many BNP and Florida Keys reef fish stocks are overfished according to definitions for U.S. fisheries (Rosenberg et al., 1996). Many desirable grouper and snapper stocks have extremely low spawning potential ratios (SPRs). Moreover, our analysis indicates that these stocks have experienced high rates of exploitation over <u>at least</u> the last two decades (see also Ault et al. 1998). The estimated average lengths in the exploitable phase from statistically independent data sources were

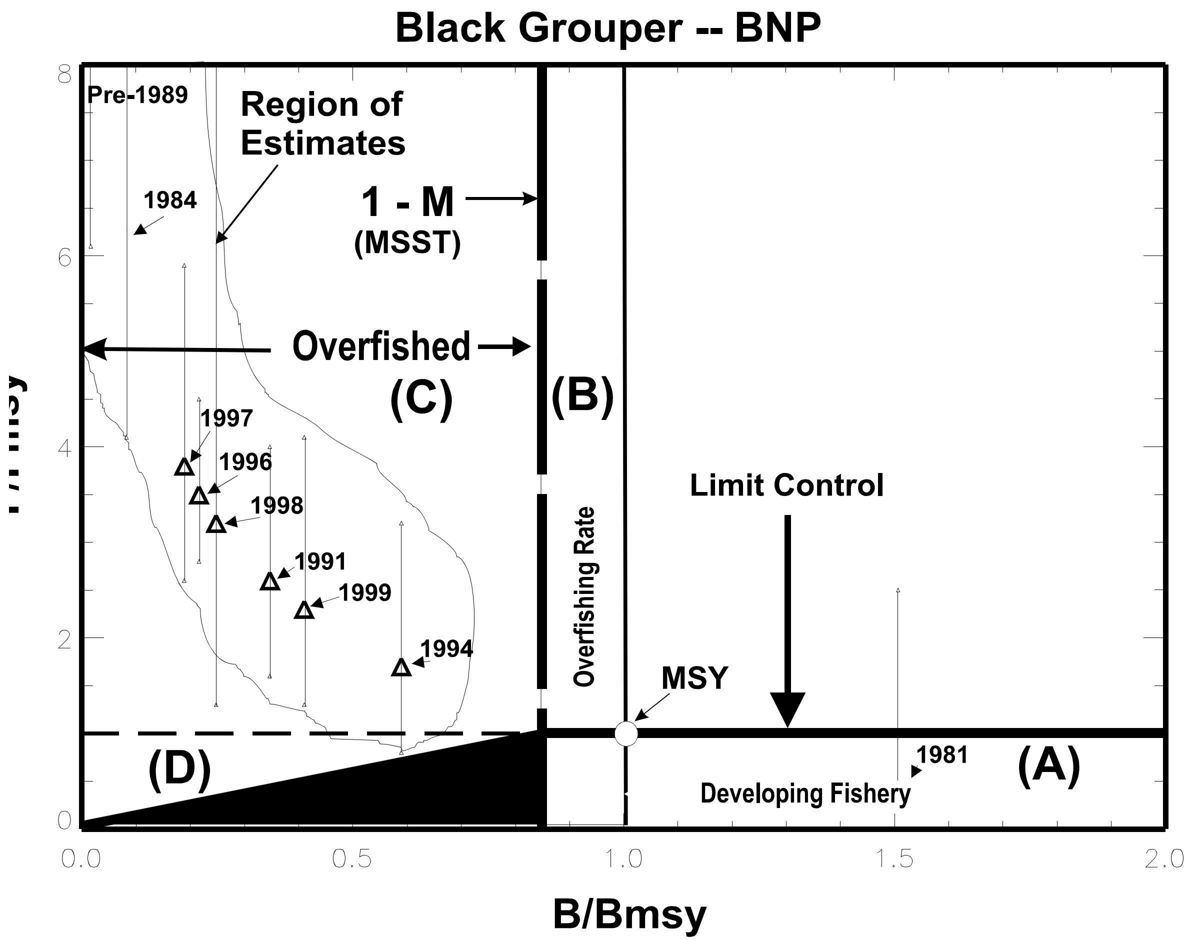


Figure 34.- An example of Limit Control Theory applied to BNP Black grouper. Note the highly "overfished" condition of the stock according to U.S. Federal Standards under the MSFMCA.

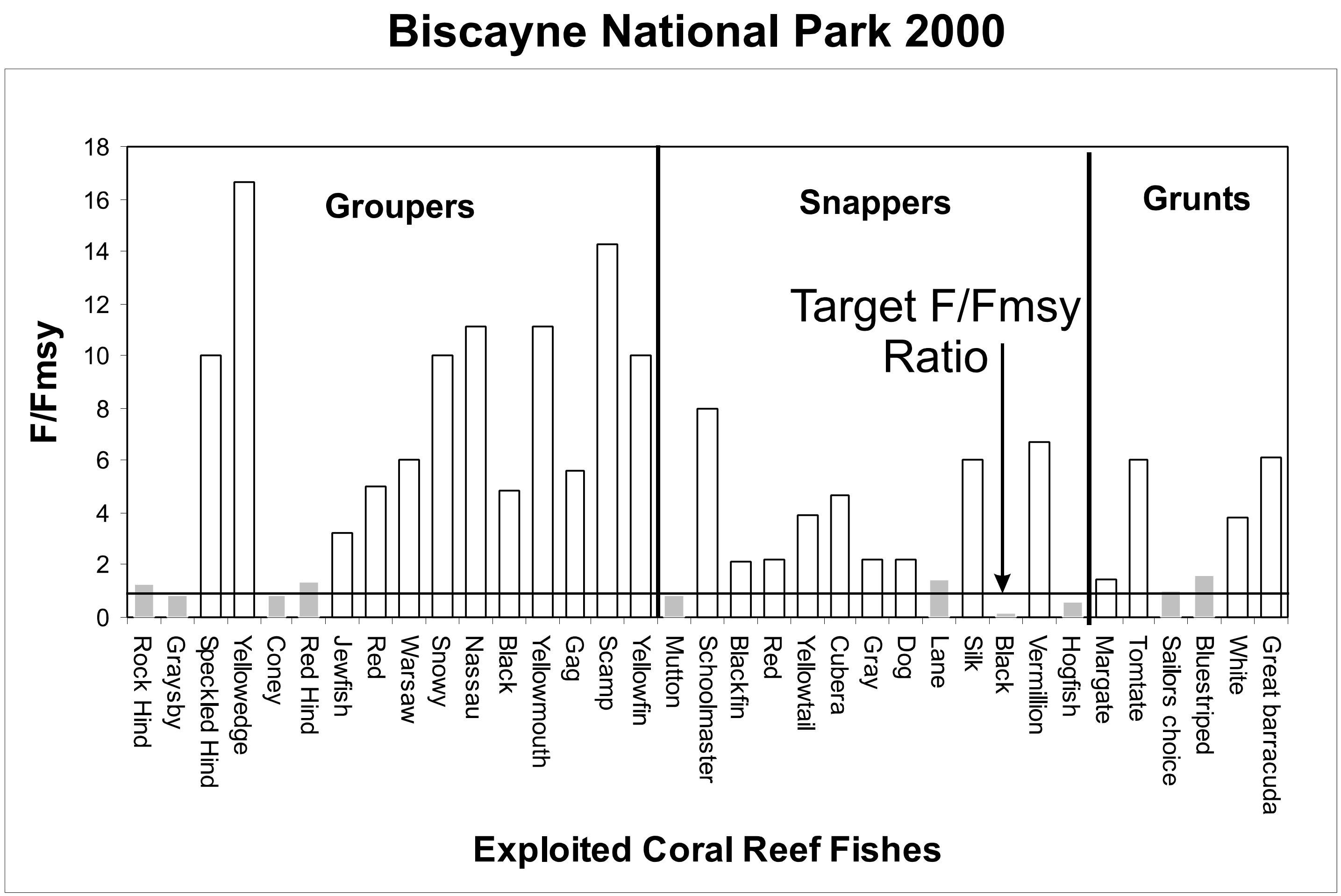


Figure 35.- Fishery management control rule benchmark analyses for 35 exploited species of BNP Florida Keys reef fish comprising groupers, snappers and hogfish, grunts, and great barracuda. The F/F_{msy} criterion is the current fishing mortality rate relative to the fishing mortality rate that would produce MSY. A value of 1.0 is the maximum allowed under Federal Standards according the precautionary approach of the MSFMCA. Values above 1.0 indicate stock "overfishing" and give the magnitude of fleet overcapitalization above and beyond U.S. Federal Standards.

highly comparable for groupers, snappers, and grunts, which supports their use in the multispecies assessment. The trends in average size for grouper, snapper and grunt stocks was relatively flat over the last 25 yr and close to the minimum exploitable length. The flatness is explained by considering expected $\bar{L}$ from a modeled range of F in an analytical model, given knowledge about current values of $\hat{F}$. The slope of $\bar{L}$ on F is very shallow in the range of the analytical model, corroborating empirical estimates. Some stocks appear to have been chronically overfished since at least the late 1970's.

There is also substantial corroborating evidence of these trends from our fishing effort and CPUE analyses. Total fishing effort has increased substantially because of greater average fishing power per vessel and a much larger recreational fishery fleet The arithmetic increase of recreational fishing vessels is an extremely important factor for any future assessments. However, absolute magnitude of the recreational fishing effect on reef fish stocks is poorly known because the recreational fleet is heterogeneously distributed across south Florida and the Keys seascape, and has been poorly sampled or studied to date. Inverse relationships between increased fishing effort (particularly by the recreational sector) and the long-term decreased average size and stock biomass of the most desirable species (e.g., groupers and snappers) are of particular concern. Declining CPUE trends observed in CREEL data also support our overfishing conclusions.

We also noted similarities in key relationships within various taxa that separate out into somewhat discrete clusters when plotting maximum size versus maximum age by species. This pattern suggests that species within the various taxa groupings will likely respond to exploitation in a similar manner. The sensitivity to exploitation is highest for groupers, followed by snappers and then grunts. The Florida Keys reef fishery shows the classic pattern of serial overfishing, in which the more vulnerable species are progressively depleted (Munro and Williams, 1985; Russ and Alcala, 1989). The longest lived, latest maturing, and lowest mortality (M) stocks (i.e., groupers) are those first to experience significant declines in population biomass, followed in sequence by intermediate-lived (snappers), and finally by short-lived stocks (grunts). Within families, the inverse relationships between the spawning potential ratio and ex-vessel market price is consistent with serial overfishing (Ault et al. 1998). As expected, the most valuable snappers and groupers also tend to have the lowest spawning potentials.

The process of serial overfishing has decimated the grouper stocks and current levels of fishing mortality range from 3 to more than 10 times the exploitation level that would achieve MSY. The only stocks at about the Federal target are rock hind, graysby, coney and red hind. This is because these species rarely reach a maximum size greater than about 16 inches in total length, and thus are not generally targeted by fishermen. However, given the current extremely POOR status of the snapper-grouper fishery in the Florida Keys and BNP, these species too are now becoming targets. The serial overfishing phenomenon is clearly reflected in the fact that snappers, and now grunts, stock sizes are falling below federal target levels under the precautionary approach of the MSFMCA. Now there are hardly any fish big enough or mature enough to support the waning resources, or to affect any hopes of system recovery given the pervasive increases in fishers and fleet fishing power. This is particularly distressing scenario when coupled with pervasive trends in increased coastal development, habitat degradation, and coastal pollution in south Florida.

Our data suggest that there may have been substantial changes in the composition of the biomass and abundance of the reef fish community over the past several decades. While many groupers and snappers have apparently declined in response to growing fishing effort, some grunts have increased in relative abundance. Claro (1991) noted a similar process in the Golfo de Batabano, Cuba, and hypothesized that chronic over-harvesting of snappers resulted in community shifts in favor of grunts. Another indication of significant change shown by Ault et al. (1998) is the explosive growth of barracuda which may be explained by several factors. First, there is little directed commercial or recreational fishing for barracuda as food Keys-wide due to health concerns. Second, growth of catch-and-release fishing by sport anglers and reduced emphasis on spearfishing may have substantially lowered barracuda mortality. Third, other top predators such as groupers, snappers and sharks have been intensively fished which appears to have lowered competition while barracuda still retain a large and possibly increasing prey base of grunts and other small fishes. Increased abundance and biomass of a top predator like barracuda could be a management concern if barracuda substantially impact reef fish community dynamics. For example, excessive predation on popular sport fishes like snappers could counteract potential reductions in fishing mortality sought by traditional management.

During the time frame of this study, numerous measures have been taken to reduce fishing mortality in state and federal waters. Fish traps were progressively eliminated between 1980 and 1992 and numerous bag limits and minimum size limits were imposed. Fisheries were closed for queen conch (Strombus gigas), Goliath grouper (Epinephelus itajara), and Nassau grouper (E. striatus). These actions are evidence of trends reported in this study. These management measures have been largely ineffectual to reduce the observed declining trends in stock sizes and productivity. The patterns of fishery size regulations in south Florida have followed those characteristic of fisheries under stress, and reflect too little action too late. Ault et al. (1998) have shown the Florida Keys multispecies reef fisheries to have been seriously overfished since at least the late 1970s.

Adjusting minimum sizes of first capture (L_c) and fishing mortality rates (F) may mitigate the apparent growth and recruitment overfishing conditions in the fishery. A striking result we discovered, however, was that 13 of 35 species we closely analyzed have the minimum size of first capture by the fishery set lower than the minimum size of first sexual maturity (**Table 14**)! However, traditional management actions alone are unlikely to be sufficient because they can be circumvented and habitually fail to effectively control fishing effort, particularly in an open access fishery (Bohnsack and Ault 1996, Ault et al. 1998). For example, bycatch mortality and high fishing effort from the expanding fleets can make size limits ineffective. In theory, every fish can be caught once it reaches minimum legal size resulting in insufficient mature adult survival. The problems we have identified have been compounded by a clear lack of compliance of fishery regulations by sportfishers, and the apparent lack of enforcement of existing regulations. Surprisingly, there has been little to no follow-up plan to evaluate whether regulations and policies invoked are achieving their intended results. What is needed is clear plan of action to ameliorate these trends in declining and to build sustainable fisheries and conserve marine biodiversity in the face of ecosystem changes and regional human population growth.

6.0 Conclusions and Recommendations

In the report we conducted a baseline characterization and fishery management analyses using a new systems methodology comprised of advanced methods in fish population dynamics, mathematical, and statistical modeling to provide a quantitative baseline assessment of the distribution and status of fishery resources and their essential habitats in BNP. We focused on explicit modeling of linkages between fish community distribution, abundance and size structure in relation to key "habitat" characteristics. As a result, precise estimates of the essential parameters are required to provide critical guidance for future cost-effective sampling and resource assessment efforts. A principal key to our ability to assess the multispecies reef fish stocks in BNP was the strategic use of 'average size' (in length) of fish in the exploitable phase of the population ($\bar{L}$) as a quantitative indicator of stock status and response to exploitation. The average length statistic is extremely robust to the data source from which the population estimation measure is made (i.e., RVC, CREEL or head boat survey data). In addition, by providing an enhanced and rigorous baseline reference point of reef fish stock status and spatial abundance for the multispecies community, this research will greatly facilitate the assessment of natural system variability versus regional changes that may result from proposed fishery and spatial ecological management strategies. Our principal findings with respect to problems with overfishing, habitat degradation, and fishery management were:

- An analysis of the Spawning Potential Ratios (SPR) of exploited reef fish shows that 13 of 16 grouper species,11 of 13 snapper species, barracuda, and 2 of 5 grunt species for which there are reliable population dynamics data are below the SPR that constitutes overfishing by Federal definitions (Magnusson-Stevens Fishery Management Conservation Act).

- For example, the average size of black grouper is now 60% of what it was in 1940 and the spawning stock is now less than 5% of its historical unfished maximum.

- Overall, 77% of the 35 individual stocks that could be analyzed are overfished.

- The current level of fishing mortality for grouper stocks range from 3 to 10 times the exploitation level that would achieve Maximum Sustainable Yield (MSY).

- Stock biomass is critically low for more than 70% of the key targeted species within the recreational fishery.

- Some stocks appear to have been chronically overfished since at least the late 1970's.

- For all of the harvested species analyzed, the average sized fish within these exploited populations for the last 25 years has remained relatively constant and is very close to minimum harvest sizes (for 77% of those analyzed), not natural historical unfished population size.

- Many species with extremely low average length in the past have had very little change in average length even though new minimum size limits were imposed.

- The recreational fishing fleet in South Florida has grown at a near exponential rate since 1964 (a 444% increase in recreational boats from 1964 to 1998) with no limits on the number of boats allowed to fish.

- C The relative effective vessel "fishing power" of the recreational fleet has quadrupled due to depth indicators and fish finders, global positioning systems, improved vessel designs, larger motors, and two-way radio communications.

- C Exceptionally high and sustained exploitation pressures have precipitated "serial overfishing" of key fishery resources. Smaller and less desirable species have consistently increased in the catch as larger more vulnerable species are eliminated.

The following outlines critical habitat-animal relationships, fishery management, policy alternatives and planning, survey design analysis, and fishery statistics that underlie the portent of future problems:

Bay-to-Reef Dynamics.- Biscayne Bay and BNP is a very important nursery environment. There are more than 325 fish and macroinvertebrate species in BNP, of these more than 150 of these species are under direct assault or subject to some form of fishing pressure from recreational commercial fishing activities that can have long-term deleterious social, economic and ecological consequences. More than 30 of these species are seen in all three existing survey mechanisms (RVC, creel and trawl surveys), but substantial size differences exist between species and areas of BNP. The species captured by all three gears use the entire seascape on their ontogenetic migrations from the bay-to-reef, making them excellent candidates for "key" indicator species that can assist evaluation of the impacts and successes of Everglades restoration on the sensitive and dynamic coastal environments of BNP. However, many species that are known to occur in the Bay are rarely, if ever, found in the samples. This fact requires innovations in gear deployments, new technologies, and directed efforts to sample fringe environments like mangroves, channels, canals, tidal creeks, etc., to detect species such as pink shrimp (we know they use ALL habitats, as do bonefish, tarpon, snook, permit, black and silver mullet, jack crevalle and yellow jacks, anchovies and sardines, black- and white-tipped sharks, nurse sharks, bonnetheads, sheepshead, red and black drum, etc.). Florida waters have produced 13 of 16 standing world records for bonefish, and they may be one of the most lucrative fisheries in BNP. However, there is little or no information system available to document the status or sustainability of many of these economic and ecologically important resources (i.e., bonefish-tarpon-permit).

The Everglades restoration includes a comprehensive effort to understand and model the physical and biological processes of Florida Bay and it's connectivity to the coral reef tract. As the restoration enters the implementation phase, it is essential to have effective monitoring programs to assess system changes and to run predictive models that guide decision making. Ensuring the sustained function and productivity of this unique environment through prudent use and strategic management decision making will result in substantial biological, ecological and economic benefits to the scientific, commercial fishing and public communities. Concern about overfishing, habitat degradation and progressively escalating resource use resulted in the establishment of the FKNMS in 1990. It is imperative that BNP management link up with the larger regional efforts of NOAA, NPS and the State of Florida decision-making entities on the resource management and sustainability issues critical to the Florida Keys. Fishes are extremely important to monitor with high precision, because in terms of the species composition, size/age structure, and fishery catch and economic productivity, they are a direct public concern and an obvious measure of management success (Bohnsack and Ault 1996, Ault et al. 1998, Meester et al. 1999).

Fishery Management Problems.- The history of fishery management actions by the State and Federal Fishery Management Council for BNP waters clearly reflects the characteristics of trying to manage fisheries under increasing stress with conventional approaches. Actions have been taken only after declines have already occurred and were finally acknowledged. Actions are then usually only minimal and not at a level that ensures recovery will take place. (Note: The history of increasingly more restrictive size limits placed on several grouper species until the fishery for some was eventually closed is a prime example of failure in conventional management approaches).

- A proportion of the fish in catches observed at the Biscayne NP boat ramps during creel surveys are **smaller** than the minimum size limit for legal harvest. This is as high as 70% for yellowtail and mutton snapper!

- 13 of 35 species closely analyzed have their minimum legal harvest size set lower than the minimum size of first sexual maturity.

In this way, our baseline computations allow BNP resource managers to determine and understand the current status of the fishery resources and habitats prior to consideration and implementation of fishery management alternatives (e.g., spatial protection zones (RNAs), catch and release only zones, etc.) that build sustainable fisheries. These baseline computations will also allow efficacy assessment of any fishery management alternatives applied in the short- or longer-term. As a result, this study forms the precursor to more intensive analyses of the multi species fish community in Biscayne National Park (BNP), and their connections with the broader south Florida coastal ocean ecosystem. Some particular recommendations for research and fishery management are:

Formulation of Policy Alternatives.- The tradition of open-access management systems coupled with risk-prone management decisions remains a principal obstacle to achieving renewable resource sustainability (Rosenberg et al., 1993). Reversing adverse trends in the reef fishery are likely to require other innovative approaches to controlling exploitation rates. Rothschild et al. (1996) recommended that fishery management maintain a systems view of the resources, emphasizing strategy over tactics. With this in mind, we recommend consideration of management alternatives that couple traditional management measures with a spatial network of "no take" marine reserves (Fogarty et al. 2001). Marine reserves provide an ecosystem management strategy for achieving long-term goals of protecting biodiversity while maintaining sustainable fisheries. The establishment of a network of small no-take reserves may be a first step. A key to the success of this effort is a conscientious, continuous assessment program using integrated fishery-independent and fishery-dependent data to evaluate their effectiveness (Bohnsack and Ault, 1996, Ault et al. 1998). With adaptive management (e.g., Walters, 1986), improvements can be implemented over time.

Fishery Management Planning.- Fisheries in Florida were loosely managed prior to the formation of the Florida Marine Fisheries Commission in 1983. The Magnuson-Stevens Conservation and Fishery Management Act explicitly defines a process for managing sustainable resources in the U.S. EEZ. The planning must be based in a ecosystem perspective. However, NPS preferred alternatives for Park status may likely be more conservative that the MSFMCA standards. In addition, management changes have been recently made as part of the Florida Keys National Marine Sanctuary (FKNMS) and Dry Tortugas National Park (DTNP) management plans. The most important change is the use of spatial protection including the establishment of 'no-take' marine protected areas or research natural areas initiatives (NPS 2000; www.coralreef.gov), and these strategies may be appropriate for Biscayne National Park resource management.

Survey Design Analysis.- This report also presents the quantitative bases required for future preparation of an optimal sampling design analysis that produces precise statistics required for future implementation of a robust fishery management plan for BNP. This research will lead to subsequent development of an efficient survey and monitoring design that optimizes in a cost-effective way the precision of estimates for key management variables to assess resource status and to evaluate management system efficacy. We recommend:

- Increasing the resolution and precision of base "habitat" maps for key environmental variables (i.e., salinity, benthic substrates, bathymetry, etc.).

- Developing "statistical" fish-habitat suitability models for individual populations, taxa, and community of inshore and reef fishes and macroinvertebrates. Use these models to optimize sampling survey designs for monitoring of trends with implementation of spatial management measures (Ault et al. 1999a, Ault and Luo 1998, Rubec et al. 1999, 2001).

- Conducting and analyzing broad sampling design issues such as key habitats presently not monitored (e.g., baywide, mangroves, reef fish (RVC and CREEL), pelagic environment) but which may provide critical signals for management.

An additional important attribute of this technology is that fishery-independent measures of stock status become even more important when spatial management strategies (i.e., such as marine protected areas or "no-take" marine reserves) are implemented, because these methods are capable of addressing estimation of population mortality rates from both within the "closed" reserve areas and areas outside under exploitation without reliance on estimation of fishery catch data, and does so in a non-intrusive and non-destructive way.

Fishery-dependent versus Fishery-independent Statistics.- Over time there will be an increasing need to rely on fishery-independent data because fishery-dependent data will become less available and less useful as larger size limits, closed seasons, closed fishing areas, and prohibitions on species are imposed. Also, the shifting emphasis from commercial to recreational fishing in the Florida Keys makes collecting fishery-dependent data much more difficult and expensive. Fishery-dependent data has the potential to be biased by under-reporting and lack of cooperation on the part of the fishery itself. Although fishery-independent assessments can provide reliable measures of reef fish abundance, population dynamics and community composition (Gunderson, 1993), there have been few applications of the approach for optimizing the performance of multispecies fisheries in tropical coral reefs. We have therefore developed techniques and methods for the extraction of a useful indicator of reef fish stock health from fishery-independent and fishery-dependent monitoring and assessment surveys.

As a result, the quantitative multispecies stock assessment methods presented here should help provide a backbone for the future use of fishery-independent and fishery-dependent assessment surveys in management decisions regarding fish stocks at broader levels. This could lead to development of spatial models of multicohort-multistock dynamics for BNP and the Florida Keys coral reef ecosystem following Ault and Olson (1996), Ault et al. (1999b), and Cosner et al. (1999). These estimates and models are then the precursors to more exacting management analyses like multispecies stock assessments and modeling of spatial management alternatives. Furthermore, once determined these fundamental relationships could be embedded in a biophysical spatial simulation model (e.g., REEFS model has been generalized to incorporate space as well as time Ault et al. 1999b, 2000; Meester 2000) to assess the consequences of preferred management alternatives for the Park, or to provide quantitative insights into the longer-term goals of maintaining ecosystem integrity, building sustainable fisheries, and conserving marine biodiversity that meet management targets and goals.

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List of Appendices

Appendix A.- Biscayne National Park regional databases used in the site characterization.

Appendix B.- Species list comprised of 325 species for Biscayne National Park, ordered by family and Latin name. The number of each species within the three surveys (reef fish visual surveys (RVC), CREEL survey, and TRAWL surveys) used to compute average length estimates is given under the appropriate column, a number greater than 0 indicates that the species is present in the survey. A 1* indicates that the species was present in the survey, but no lengths were available. Highlighted rows indicate species for which further fisheries assessment is conducted.

Appendix C.- Indicators of stock status for BNP exploited fisheries resources (about 90 species) for the period 1976 to 1999 as determined by the BNP Creel survey and the RVC survey databases: *n* is the number of survey samples; legal is $\bar{L}$ computed using the minimum size of first capture regulated by fishery management. SE is the standard error of the mean estimate of $\bar{L}$; Actual is $\bar{L}$ computed from the minimum size of first capture determined from Creel survey catches; *CPUE* is catch (number of fish) per person-hours fishing. CPUE for the RVC survey is: *IM* computed between the integral limits of L_r 6 L_m; *MAT* is between L_m 6 L_8; and, *Legal* is L_c 6 L_8.

Appendix D(1).- SAS programs used for processing reef fish visual census (RVC) data and estimating average length in the exploited phase and catch per unit effort.

Appendix D(2).- SAS programs used for processing recreational creel survey (CREEL) data and estimating average length in the exploited phase and catch per unit effort.

Appendix E.- LBAR FORTRAN computer programs, users guide, and data input files.

Appendix F.- REEFS FORTRAN computer programs, users guide, and data input files.

Appendix A
Biscayne National Park Region Databases

(A) Benthic Habitat Databases

[1] NOAA/NOS Hydrographic Surveys

Source: NOAA Silver Spring, MD; NOS, Boulder, Colorado.
Description: Depth soundings, NOS Hydrographic Survey Data Vol. 1, Ver. 4;
Spatial Coverage: Depth soundings, Florida coast.
Variables: Latitude, Longitude, Depth

[2] FMRI Florida Keys Benthic Habitats Survey

Source: Chris Friel and Frank Sargeant, FMRI St. Petersburg
Description: Benthic habitat characterization interpreted from aerial photographic surveys.
Spatial Coverage: Entire Florida Keys region, including Biscayne National Park.
Overview: GIS layers of bottom substrate classifications, generally limited to depths shallower than 30 feet.
Variables: Multiple categories of coral reef, seagrass, hardbottom, and sand/rock benthic substrates; land and shoreline coverages.

(B) Water Quality Databases

[3] SFWMD Water Quality Sampling

Source: South Florida Water Quality Management District, DBHYDRO Database
Description: Point samples of surface, mid-water and bottom water quality parameters.
Time Frame: 1995-1998
Spatial Coverage: 54 sampling stations within southern Biscayne Bay.
Variables: Station ID, Date, Latitude, Longitude, Depth, Temperature, Salinity, Nutrients.

[4] RSMAS / Wang Biscayne Bay Hydrodynamic Model

Source: John Wang, RSMAS
Description: 2D finite element numerical model of water currents and salinity.
Time Frame: 1995-1998
Spatial Coverage: South Biscayne Bay, Card Sound, Barnes Sound.
Input Data: Information on winds, tides, water currents, canal discharges, salinities, rainfall, evaporation, overland water flow, groundwater flow.
Model Outputs: Water current vectors and salinity, horizontal spatial grid resolution 150-1000 m.

(C) Animals—Fishery Independent Databases

[5] NMFS / Bohnsack Reef Fishes Visual Census

Source: James Bohnsack, SEFSC, and Jerald Ault, RSMAS
Description: Fishery-independent diver survey of reef fish population abundance and size structure using the Bohnsack and Bannerot (1986) stationary visual census technique.
Time Frame: 1983-1992, 1995-1999
Spatial Coverage: 17 reef locations in the Biscayne National Park region.
Sampling Overview: 863 total diver samples; 182 species; 47 families.
Variables: Sample ID, Date, Reef ID, Latitude, Longitude, Depth, Bottom type, Reef habitat, Species, Abundance (number observed), Length (cm).

[6] RSMAS/ Ault Roller Frame Trawl Survey

Source: Jerald Ault, RSMAS
Description: Stratified random fishery-independent roller frame trawl survey of macroinvertebrate and fish population abundance and size structure (Ault et al. 1999).
Time Frame: 1996-1997, 1999-2000
Spatial Coverage: 983 station locations in southern Biscayne Bay.
Sampling Overview: 983 total trawl samples; 155 species; 49 families.
Variables: Sample ID, Date, Latitude, Longitude, Tow area, Depth, Temperature, Salinity, Dissolved Oxygen, Habitat Type, Species, Catch, Length (mm).

(D) Animals—Fishery Dependent Databases

[7] BNP Recreational Creel Census

Source: Doug Harper, NOAA Fisheries SEFSC; Brian Lockwood, NPS BNP
Description: Fishery-dependent dockside sampling survey conducted by BNP personnel of recreational fishing effort, species landings and size composition.
Time Frame: 1976-1998
Spatial Coverage: BNP and surrounding area.
Sampling Overview: 29,940 total interviews; 143 species; 45 families.
Variables: Record ID, Date, Area, Gear, Effort, Species, Number landed, Length, Number released.

[8] NMFS Recreational Headboat Landings

Source: NMFS, Beaufort
Description: Fishery-dependent sampling survey conducted by NMFS personnel of the species and size composition of the recreational headboat catch.

Time Frame: 1981-1995
Spatial Coverage: Florida Keys, including BNP region.
Sampling Overview: 853 total trip samples; 275 species categories.
Variables: Trip ID, Date, Area, Number of Anglers, Species, Catch in Numbers, Catch in Weight, Sex, Length, Weight.

[9] NMFS General Canvas Commercial Landings

Source: Pamela Eyo, NOAA SEFSC
Description: Commercial sector landings data collected by NMFS Port Agents and the State of Florida trip-ticket system for harvested species.
Time Frame: 1986-1999
Spatial Coverage: Water body code #944.2, encompassing Biscayne Bay, Card Sound, and Barnes Sound.
Overview: 57 species categories.
Variables: Year, Species, Total Catch (lbs.), Dockside Value (1997-99 only).

Appendix B. - Species list comprised of 325 species for Biscayne National Park, ordered by family and Latin name. The number of each species within the three surveys (reef fish visual surveys (RVC), CREEL survey, and TRAWL surveys) used to compute average length estimates is given under the appropriate column, a number greater than 0 indicates that the species is present in the survey. A 1* indicates that the species was present in the survey, but no lengths were available. Highlighted rows indicate species for which further fisheries assessment is conducted.

			Survey		
FAMILY	**LATIN**	**COMMON**	**RVC**	**CREEL**	**TRAWL**
Acanthuridae	*Acanthurus bahianus*	ocean surgeon	5897	2	1
Acanthuridae	*Acanthurus chirurgus*	doctorfish	1553	34	20
Acanthuridae	*Acanthurus coeruleus*	blue tang	4595	2	0
Albulidae	*Albula vulpes*	bonefish	0	7	0
Antennariidae	*Histrio histrio*	sargassumfish	0	0	1
Apogonidae	*Apogon planifrons*	pale cardinalfish	0	0	1
Apogonidae	*Astrapogon alutus*	bronze cardinalfish	0	0	1637
Apogonidae	*Astrapogon puncticulatus*	blackfin cardinalfish	0	0	220
Apogonidae	*Astrapogon stellatus*	conchfish	0	0	2
Apogonidae	*Phaeoptyx pigmentaria*	dusky cardinalfish	0	0	1
Atherinidae	*Atherinomorus stipes*	hardhead silverside	0	0	8
Atherinidae	*Hypoatherina harringtonensis*	reef silverside	17500	0	0
Atherinidae	*Membras martinica*	rough silverside	0	0	11
Aulostomidae	*Aulostomus maculatus*	trumpetfish	285	0	0
Balistidae	*Aluterus monocerus*	unicorn filefish	0	0	1
Balistidae	*Aluterus schoepfi*	orange filefish	14	2	0
Balistidae	*Aluterus scriptus*	scrawled filefish	114	11	18
Balistidae	*Balistes capriscus*	gray triggerfish	24	208	2
Balistidae	*Balistes vetula*	queen triggerfish	40	73	0
Balistidae	*Cantherhines macrocerus*	whitespotted filefish	15	0	0
Balistidae	*Cantherhines pullus*	orangespotted filefish	37	0	0
Balistidae	*Cantherhines sufflamen*	ocean triggerfish	25	321	2
Balistidae	*Melicthys niger*	black durgon	2	0	0
Balistidae	*Monacanthus ciliatus*	fringed filefish	0	0	2665
Balistidae	*Monacanthus hispidus*	planehead filefish	15	0	739
Balistidae	*Monacanthus tuckeri*	slender filefish	6	0	12
Batrachoididae	*Opsanus beta*	gulf toadfish	0	0	4480
Belonidae	*Tylosurus acus*	agujon (needlefish)	0	0	1
Belonidae	*Tylosurus crocodilus*	houndfish	0	42	0
Blenniidae	*Hypsobennius ionthas*	freckled blenny	0	0	1
Blenniidae	*Ophioblennius atlanticus*	redlip blenny	5	0	0
Blenniidae	*Scartella cristata*	molly miller	1	0	1
Bothidae	*Bothus lunatus*	peacock flounder	1	0	46
Bothidae	*Bothus ocellatus*	eyed flounder	2	0	47
Bothidae	*Bothus robinsi*	twospot flounder	0	0	8
Bothidae	*Citharichthys arenaceus*	sand whiff	0	0	2
Bothidae	*Citharichthys macrops*	spotted whiff	0	0	20
Bothidae	*Citharichthys spilopterus*	bay whiff	0	0	1
Bothidae	*Paralichthys albigutta*	gulf flounder	0	1	4
Bythitidae	*Ogilbia cayorum*	key brotula	0	0	1
Bythitidae	*Petrotyx sanguineus*	redfin brotula	0	0	1
Callionymidae	*Diplogrammus pauciradiatus*	spotted dragonet	0	0	44
Carangidae	*Alectis ciliaris*	african pompano	0	24	0
Carangidae	*Caranx bartholomaei*	yellow jack	478	524	0
Carangidae	*Caranx crysos*	blue runner	474	1954	2
Carangidae	*Caranx hippos*	crevalle jack	0	80	0
Carangidae	*Caranx latus*	horse-eye jack	0	19	0
Carangidae	*Caranx ruber*	bar jack	3637	97	0
Carangidae	*Decapterus macarellus*	mackerel scad	1	32	0
Carangidae	*Elagatis bipinnulata*	rainbow runner	0	15	0
Carangidae	*Oligoplites saurus*	leatherjack	0	24	0
Carangidae	*Selar crumenophthalmus*	bigeye scad	0	15	0
Carangidae	*Selene vomer*	lookdown	0	44	0
Carangidae	*Seriola dumerili*	greater amberjack	2	107	0
Carangidae	*Seriola fasciata*	lesser amberjack	0	4	0
Carangidae	*Seriola rivoliana*	almaco jack	0	10	0
Carangidae	*Trachinotus carolinus*	Florida pompano	0	2	0
Carangidae	*Trachinotus falcatus*	permit	2	24	0

Appendix B.- (Continued)

FAMILY	LATIN	COMMON	Survey RVC	CREEL	TRAWL
Carapidae	*Carapus bermudensis*	pearfish	0	0	1
Carcharhinidae	*Carcharhinus brevipinna*	spinner shark	0	1	0
Carcharhinidae	*Carcharhinus falciformis*	silky shark	0	1	0
Carcharhinidae	*Carcharhinus limbatus*	blacktip shark	0	7	0
Carcharhinidae	*Negaprion brevirostris*	lemon shark	0	3	0
Centropomidae	*Centropomus ensiferus*	swordspine snook	0	1	0
Centropomidae	*Centropomus undecimalis*	common snook	0	1*	0
Chaetodontidae	*Chaetodon capistratus*	foureye butterflyfish	809	0	3
Chaetodontidae	*Chaetodon ocellatus*	spotfin butterflyfish	495	0	0
Chaetodontidae	*Chaetodon sedentarius*	reef butterflyfish	353	0	0
Chaetodontidae	*Chaetodon striatus*	banded butterflyfish	154	0	0
Cirrhitidae	*Amblycirrhitus pinos*	redspotted hawkfish	4	0	0
Clinidae	*Malacoctenus macropus*	rosy blenny	1	0	0
Clinidae	*Malacoctenus triangulatus*	saddled blenny	1	0	0
Clinidae	*Paraclinus marmoratus*	marbled blenny	0	0	44
Clupeidae	*Harengula jaguana*	scaled sardine	10600	0	0
Clupeidae	*Jenkinsia majua*	little-eye herring	0	0	2
Coryphaenidae	*Coryphaena equisetis*	pompano dolphin	0	2	0
Coryphaenidae	*Coryphaena hippurus*	dolphin	0	6993	0
Cyprinodontidae	*Cyprinodon variegatus*	sheepshead minnow	0	0	2
Cyprinodontidae	*Floridichthys carpio*	goldspotted killifish	0	0	3
Cyprinodontidae	*Lucania parva*	rainwater killifish	0	0	61
Dasyatidae	*Dasyatis americana*	southern stingray	11	0	0
Echeneidae	*Echeneis naucrates*	sharksucker	13	1	0
Echeneidae	*Remora remora*	remora	0	5	0
Elopidae	*Elops saurus*	ladyfish	0	27	0
Elopidae	*Megalops atlanticus*	tarpon	0	1*	0
Ephippidae	*Chaetodipterus faber*	atlantic spadefish	276	36	3
Exocoetidae	*Chriodorus atherinoides*	hardhead halfbeak	0	0	4
Exocoetidae	*Hemiramphus balao*	balao	0	0	1
Exocoetidae	*Hemiramphus brasiliensis*	ballyhoo	547	38	1
Exocoetidae	*Hyporhamphus unifasciatus*	silverstripe halfbeak	0	0	10
Fistularidae	*Fistularia petimba*	red cornetfish	0	0	2
Fistularidae	*Fistularia tabacaria*	bluespotted cornetfish	1	0	0
Gadidae	*Urophycis regia*	spotted hake	0	0	2
Gasterosteidae	*Pungitius pungitius*	ninespine stickleback	0	0	1
Gerreidae	*Eucinostomus argenteus*	spotfin mojarra	0	0	232
Gerreidae	*Eucinostomus gula*	silver jenny	0	0	3160
Gerreidae	*Eucinostomus jonesi*	slender mojarra	0	0	50
Gerreidae	*Gerres cinereus*	yellowfin mojarra	32	18	5
Gobiidae	*Bathigobius curacao*	notchtongue goby	0	0	1
Gobiidae	*Coryphopterus dicrus*	colon goby	32	0	2
Gobiidae	*Coryphopterus glaucofraenum*	bridled goby	1294	0	24
Gobiidae	*Coryphopterus personatus*	masked goby	653	0	0
Gobiidae	*Coryphopterus punctipectophorus*	spotted goby	0	0	12
Gobiidae	*Gnatholepis thompsoni*	goldspot goby	92	0	0
Gobiidae	*Gobionellus saepepallens*	dash goby	0	0	1
Gobiidae	*Gobionellus shufeldti*	freshwater goby	0	0	1
Gobiidae	*Gobionellus stigmalophius*	spotfin goby	0	0	32
Gobiidae	*Gobionellus stigmaturus*	spottail goby	0	0	5
Gobiidae	*Gobiosoma bosc*	naked goby	0	0	1
Gobiidae	*Gobiosoma evelynae*	sharknose goby	1	0	0
Gobiidae	*Gobiosoma oceanops*	neon goby	96	0	0
Gobiidae	*Gobiosoma randalli*	yellownose goby	0	1	0
Gobiidae	*Gobiosoma robustum*	code goby	0	0	1
Gobiidae	*Ioglossus calliurus*	blue goby	12	0	0
Gobiidae	*Ioglossus helenae*	hovering goby	1	0	0
Gobiidae	*Microgobius microlepis*	banner goby	0	0	87
Gobiidae	*Nes longus*	orangespotted goby	0	0	2
Haemulidae	*Anisotremus surinamensis*	black margate	75	207	0
Haemulidae	*Anisotremus virginicus*	porkfish	1113	200	9

Appendix B.- (Continued)

FAMILY	LATIN	COMMON	Survey RVC	CREEL	TRAWL
Haemulidae	*Haemulon album*	margate	19	269	0
Haemulidae	*Haemulon aurolineatum*	tomtate	26483	97	73
Haemulidae	*Haemulon carbonarium*	ceasar grunt	354	81	0
Haemulidae	*Haemulon chrysargyreum*	smallmouth grunt	2104	4	0
Haemulidae	*Haemulon flavolineatum*	french grunt	5975	113	76
Haemulidae	*Haemulon macrostomium*	spanish grunt	113	35	0
Haemulidae	*Haemulon melanurum*	cottonwick	106	0	0
Haemulidae	*Haemulon parra*	sailors choice	187	594	61
Haemulidae	*Haemulon plumieri*	white grunt	10179	14499	3855
Haemulidae	*Haemulon sciurus*	bluestriped grunt	3628	4569	2350
Haemulidae	*Haemulon striatum*	striped grunt	5	78	0
Haemulidae	*Orthopristis chrysoptera*	pigfish	0	33	57
Holocentridae	*Holocentrus adscensionis*	squirrelfish	53	57	0
Holocentridae	*Holocentrus rufus*	longspine squirrelfish	58	0	0
Holocentridae	*Holocentrus vexillarius*	dusky squirrelfish	8	0	0
Inermiidae	*Inermia vittata*	boga	180	0	0
Istiophoridae	*Istiophorus platypterus*	sailfish	0	38	0
Istiophoridae	*Makaira nigricans*	blue marlin	0	1	0
Istiophoridae	*Tetrapturus albidus*	white marlin	0	2	0
Kyphosidae	*Kyphosus incisor*	yellow chub	0	44	0
Kyphosidae	*Kyphosus sectatrix*	bermuda chub	1472	176	0
Labridae	*Bodianus pulchellus*	spotfin hogfish	5	0	0
Labridae	*Bodianus rufus*	spanish hogfish	188	39	0
Labridae	*Clepticus parrae*	creole wrasse	1148	0	0
Labridae	*Halichoeres bivittatus*	slippery dick	3200	14	0
Labridae	*Halichoeres garnoti*	yellowhead wrasse	4382	0	0
Labridae	*Halichoeres maculipinna*	clown wrasse	3150	0	0
Labridae	*Halichoeres pictus*	rainbow wrasse	6	0	0
Labridae	*Halichoeres poeyi*	blackear wrasse	6	0	0
Labridae	*Halichoeres radiatus*	puddingwife	318	66	0
Labridae	*Hemipteronotus martinicensis*	rosy razorfish	226	0	0
Labridae	*Hemipteronotus novacula*	pearly razorfish	13	0	0
Labridae	*Hemipteronotus splendins*	green razorfish	28	0	0
Labridae	*Lachnolaimus maximus*	hogfish	333	6510	163
Labridae	*Thalassoma bifasciatum*	bluehead	41819	0	0
Lobotidae	*Lobotes surinamensis*	tripletail	0	50	0
Lutjanidae	*Etelis oculatus*	queen snapper	0	9	0
Lutjanidae	*Lutjanus analis*	mutton snapper	22	1966	65
Lutjanidae	*Lutjanus apodus*	schoolmaster	1940	597	8
Lutjanidae	*Lutjanus buccanella*	blackfin snapper	0	16	0
Lutjanidae	*Lutjanus campechanus*	red snapper	0	25	0
Lutjanidae	*Lutjanus cyanopterus*	cubera snapper	0	11	0
Lutjanidae	*Lutjanus griseus*	gray snapper	2314	10688	594
Lutjanidae	*Lutjanus jocu*	dog snapper	11	58	2
Lutjanidae	*Lutjanus mahogoni*	mahogony snapper	16	32	0
Lutjanidae	*Lutjanus synagris*	lane snapper	82	409	242
Lutjanidae	*Lutjanus vivanus*	silk snapper	0	7	0
Lutjanidae	*Ocyurus chrysurus*	yellowtail snapper	3861	5243	142
Lutjanidae	*Rhomboplites aurorubens*	vermilion snapper	0	23	0
Malacanthidae	*Malacanthus plumieri*	sand tilefish	46	77	0
Mullidae	*Mulloidichthys martinicus*	yellow goatfish	580	5	0
Mullidae	*Pseudupeneus maculatus*	spotted goatfish	435	4	0
Muraenidae	*Gymnothorax funebris*	green moray	5	1	0
Muraenidae	*Gymnothorax miliaris*	goldentail moray	2	0	0
Muraenidae	*Gymnothorax moringa*	spotted moray	8	0	2
Muraenidae	*Gymnothorax nigromarginatus*	blackedge moray	0	0	10
Muraenidae	*Gymnothorax saxicola*	honeycomb moray	1	0	7
Muraenidae	*Gymnothorax vicinus*	purplemouth moray	1	0	0
Myliobatidae	*Aetobatus narinari*	spotted eagle ray	1	0	0
Ogcocephalidae	*Ogcocephalus corniger*	longnose batfish	0	0	2
Opistognathidae	*Opistognathus aurifrons*	yellowhead jawfish	26	0	0

Appendix B.- (Continued)

FAMILY	LATIN	COMMON	Survey RVC	CREEL	TRAWL
Ostraciidae	*Lactophrys bicaudalis*	spotted trunkfish	13	0	4
Ostraciidae	*Lactophrys polygonia*	honeycomb cowfish	3	0	5
Ostraciidae	*Lactophrys quadricornis*	scrawled cowfish	15	0	784
Ostraciidae	*Lactophrys trigonus*	trunkfish	6	8	85
Ostraciidae	*Lactophrys triqueter*	smooth trunkfish	132	10	0
Palinuridae	*Panulirus argus*	Caribbean spiny lobster	1*	16764	1*
Palinuridae	*Panulirus guttatus*	spotted spiny lobster	0	28	0
Pempheridae	*Pempheris schomburgki*	glassy sweeper	686	0	0
Penaeidae	*Penaeus duorarum*	pink shrimp	0	0	103896
Pomacanthidae	*Centropyge argi*	cherubfish	1	0	0
Pomacanthidae	*Holacanthus bermudensis*	blue angelfish	172	0	0
Pomacanthidae	*Holacanthus ciliaris*	queen angelfish	174	2	0
Pomacanthidae	*Holacanthus tricolor*	rock beauty	697	0	0
Pomacanthidae	*Pomacanthus arcuatus*	gray angelfish	899	2	11
Pomacanthidae	*Pomacanthus paru*	french angelfish	194	0	0
Pomacentridae	*Abudefduf saxatilis*	sergeant major	7819	0	0
Pomacentridae	*Chromis cyanea*	blue chromis	1844	0	0
Pomacentridae	*Chromis insolata*	sunshinefish	6	0	0
Pomacentridae	*Chromis multilineata*	brown chromis	797	0	0
Pomacentridae	*Chromis scotti*	purple reeffish	18	0	0
Pomacentridae	*Microspathodon chrysurus*	yellowtail damselfish	1057	0	0
Pomacentridae	*Pomacentrus diencaeus*	longfin damselfish	89	0	0
Pomacentridae	*Pomacentrus fuscus*	dusky damselfish	720	0	0
Pomacentridae	*Pomacentrus leucostictus*	beaugregory	296	0	1
Pomacentridae	*Pomacentrus partitus*	bicolor damselfish	30183	0	1
Pomacentridae	*Pomacentrus planifrons*	threespot damselfish	1702	0	1
Pomacentridae	*Pomacentrus variabilis*	cocoa damselfish	700	0	1
Pomatomidae	*Pomatomus saltatrix*	bluefish	0	72	0
Portunidae	*Callinectes sapidus*	blue crab	0	4	0
Priacanthidae	*Priacanthus arenatus*	bigeye	4	84	0
Prosobranchia	*Strombus gigas*	queen conch	0	1*	0
Rachycentridae	*Rachycentron canadum*	cobia	0	12	0
Rhincodontidae	*Ginglymostoma cirratum*	nurse shark	8	15	0
Scaridae	*Cryptotomus roseus*	bluelip parrotfish	145	0	8
Scaridae	*Nicholsina usta*	emerald parrotfish	0	0	593
Scaridae	*Scarus coelestinus*	midnight parrotfish	108	0	3
Scaridae	*Scarus coeruleus*	blue parrotfish	214	13	0
Scaridae	*Scarus croicensis*	striped parrotfish	8476	0	24
Scaridae	*Scarus guacamaia*	rainbow parrotfish	148	0	3
Scaridae	*Scarus taeniopterus*	princess parrotfish	3329	0	3
Scaridae	*Scarus vetula*	queen parrotfish	414	0	0
Scaridae	*Sparisoma atomarium*	greenblotch parrotfish	223	0	12
Scaridae	*Sparisoma aurofrenatum*	redband parrotfish	8321	0	1
Scaridae	*Sparisoma chrysopterum*	redtail parrotfish	317	0	629
Scaridae	*Sparisoma radians*	bucktooth parrotfish	31	0	128
Scaridae	*Sparisoma rubripinne*	redfin parrotfish	396	0	20
Scaridae	*Sparisoma viride*	stoplight parrotfish	3361	0	6
Sciaenidae	*Bairdiella chrysoura*	silver perch	0	0	2
Sciaenidae	*Cynoscion nebulosus*	spotted seatrout	0	565	34
Sciaenidae	*Equetus acuminatus*	high-hat	55	0	26
Sciaenidae	*Equetus lanceolatus*	jackknife-fish	0	0	4
Sciaenidae	*Equetus punctatus*	spotted drum	13	0	0
Sciaenidae	*Equetus umbrosus*	cubbyu	3	0	0
Sciaenidae	*Odontoscion dentex*	reef croaker	18	0	0
Scombridae	*Acanthocybium solandri*	wahoo	0	111	0
Scombridae	*Auxis rochei*	bullet mackerel	0	2	0
Scombridae	*Euthynnus alletteratus*	little tunny	0	140	0
Scombridae	*Katsuwonus pelamis*	skipjack tuna	0	41	0
Scombridae	*Sarda sarda*	atlantic bonito	0	87	0
Scombridae	*Scomberomorus cavalla*	king mackerel	0	198	0
Scombridae	*Scomberomorus maculatus*	spanish mackerel	1	132	0

Appendix B.- (Continued)

FAMILY	LATIN	COMMON	Survey RVC	CREEL	TRAWL
Scombridae	*Scomberomorus regalis*	cero	60	586	0
Scombridae	*Thunnus albacares*	yellowfin tuna	0	1	0
Scombridae	*Thunnus atlanticus*	blackfin tuna	0	27	0
Scorpaenidae	*Neomerinthe hemingwayi*	spinycheek scorpionfish	0	0	1
Scorpaenidae	*Scorpaena brasiliensis*	barbfish	0	0	296
Scorpaenidae	*Scorpaena dispar*	hunchback scorpionfish	0	0	1
Scorpaenidae	*Scorpaena grandicornus*	plumed scorpionfish	0	0	16
Scorpaenidae	*Scorpaena inermis*	mushroom scorpionfish	0	0	3
Scorpaenidae	*Scorpaena plumieri*	spotted scorpionfish	7	0	6
Scyllaridae	*Scyllarides aequinoctialis*	spanish (shovelnose) lobster	0	33	0
Serranidae	*Diplectrum bivittatum*	dward sand perch	0	0	12
Serranidae	*Diplectrum formosum*	sand perch	2	160	94
Serranidae	*Epinephelus adscensionis*	rock hind	7	84	0
Serranidae	*Epinephelus cruentatus*	graysby	567	522	0
Serranidae	*Epinephelus drummondhayi*	speckled hind	0	5	0
Serranidae	*Epinephelus flavolimbatus*	yellowedge grouper	0	12	0
Serranidae	*Epinephelus fulvus*	coney	13	28	0
Serranidae	*Epinephelus guttatus*	red hind	15	234	0
Serranidae	*Epinephelus inermis*	marbled grouper	0	1	0
Serranidae	*Epinephelus itajara*	Goliath grouper	0	4	0
Serranidae	*Epinephelus morio*	red grouper	42	2093	0
Serranidae	*Epinephelus striatus*	nassau grouper	10	739	0
Serranidae	*Hypoplectrus chlorurus*	yellowtail hamlet	1	0	0
Serranidae	*Hypoplectrus gemma*	blue hamlet	100	0	0
Serranidae	*Hypoplectrus guttavarius*	shy hamlet	3	0	0
Serranidae	*Hypoplectrus indigo*	indigo hamlet	11	0	0
Serranidae	*Hypoplectrus nigricans*	black hamlet	15	0	0
Serranidae	*Hypoplectrus puella*	barred hamlet	50	0	0
Serranidae	*Hypoplectrus unicolor*	butter hamlet	320	0	0
Serranidae	*Liopropoma eukrines*	wrasse bass	1	0	0
Serranidae	*Mycteroperca bonaci*	black grouper	22	618	1
Serranidae	*Mycteroperca interstitialis*	yellowmouth grouper	2	48	0
Serranidae	*Mycteroperca microlepis*	gag	1	327	0
Serranidae	*Mycteroperca phenax*	scamp	2	13	0
Serranidae	*Mycteroperca venenosa*	yellowfin grouper	1	26	0
Serranidae	*Paranthias furcifer*	creole-fish	0	2	0
Serranidae	*Rypticus saponaceus*	greater soapfish	4	3	0
Serranidae	*Serranus baldwini*	lantern bass	5	0	1
Serranidae	*Serranus tabacarius*	tobaccofish	123	0	0
Serranidae	*Serranus tigrinus*	harlequin bass	464	0	0
Soleidae	*Achirus lineatus*	lined sole	0	0	39
Soleidae	*Gymnachirus melas*	naked sole	0	0	1
Soleidae	*Symphurus diomedianus*	spottedfin tonguefish	0	0	1
Soleidae	*Symphurus plagiusa*	blackcheek tonguefish	0	0	21
Soleidae	*Symphurus urospilus*	spottail tonguefish	0	0	1
Soleidae	*Trinectes inscriptus*	scrawled sole	0	0	2
Sparidae	*Archosargus rhomboidalis*	sea bream	3	113	42
Sparidae	*Calamus arctifrons*	grass porgy	0	64	65
Sparidae	*Calamus bajonado*	jolthead porgy	37	1642	0
Sparidae	*Calamus calamus*	saucereye porgy	159	725	0
Sparidae	*Calamus nodosus*	knobbed porgy	0	18	0
Sparidae	*Calamus penna*	sheepshead porgy	0	9	3
Sparidae	*Calamus proridens*	littlehead porgy	5	66	2
Sparidae	*Lagodon rhomboides*	pinfish	0	346	8163
Sphyraenidae	*Sphyraena barracuda*	great barracuda	418	1841	2
Sphyraenidae	*Sphyraena picudilla*	southern sennet	0	0	1*
Sphyrnidae	*Sphyrna lewini*	scalloped hammerhead	2	0	0
Sphyrnidae	*Sphyrna mokarran*	great hammerhead	0	4	0
Sphyrnidae	*Sphyrna tiburo*	bonnethead shark	0	28	0
Stromateidae	*Psenes maculatus*	silver driftfish	0	0	5
Syngnathidae	*Cosmocampus albirostris*	whitenose pipefish	0	0	180

Appendix B.- (Continued)

FAMILY	LATIN	COMMON	Survey RVC	Survey CREEL	Survey TRAWL
Syngnathidae	*Hippocampus erectus*	lined seahorse	0	0	253
Syngnathidae	*Hippocampus reidi*	longsnout seahorse	0	0	37
Syngnathidae	*Hippocampus zosterae*	dwarf seahorse	0	0	12
Syngnathidae	*Syngnathus floridae*	dusky pipefish	0	0	145
Syngnathidae	*Syngnathus louisianae*	chain pipefish	0	0	3
Syngnathidae	*Syngnathus pelagicus*	sargassum pipefish	0	0	1
Syngnathidae	*Syngnathus scovelli*	gulf pipefish	0	0	27
Synodontidae	*Synodus foetens*	inshore lizardfish	1	0	69
Synodontidae	*Synodus intermedius*	sand diver	10	0	0
Synodontidae	*Trachinocephalus myops*	snakefish	0	0	1
Tetraodontidae	*Canthigaster rostrata*	sharpnose puffer	618	0	3
Tetraodontidae	*Chilomycterus antennatus*	bridled burrfish	1	0	1
Tetraodontidae	*Chilomycterus schoepfi*	striped burrfish	1	0	71
Tetraodontidae	*Diodon holocanthus*	balloonfish	31	0	6
Tetraodontidae	*Diodon hystrix*	porcupinefish	12	0	1
Tetraodontidae	*Sphoeroides maculatus*	northern puffer	0	0	7
Tetraodontidae	*Sphoeroides nephelus*	southern puffer	0	0	1
Tetraodontidae	*Sphoeroides spengleri*	bandtail puffer	12	0	325
Tetraodontidae	*Sphoeroides testudineus*	checkered puffer	0	0	2
Triglidae	*Prionotus scitulus*	leopard searobin	0	0	27
Uranoscopidae	*Dactyloscopus tridigitatus*	sand stargazer	0	0	2
Urolophidae	*Urolophus jamaicensis*	yellow stingray	69	0	4
Xanthidae	*Menippe mercenaria*	Florida stone crab	0	2	0

Appendix C1.-

rock hind
Epinephelus adscensionis

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				0			0.001										
1979				1	300.0	0.0	0.004		NO RVC SURVEY CONDUCTED								
1980				3	400.0	57.7	0.001										
1981				5	342.0	42.1	0.002										
1982				11	303.6	23.2	0.005										
1983				12	330.8	31.4	0.001				0			0.000	0.000		0.000
1984				0			0.000				0			0.000	0.000		0.000
1985				10	312.0	24.1	0.002				0			0.000	0.000		0.000
1986				5	394.0	44.5	0.001		FIXED-		0			0.000	0.000		0.000
1987				1	300.0	0.0	0.000		SITE		0			0.000	0.000		0.000
1988				3	346.7	14.5	0.001		DESIGN		0			0.003	0.000		0.000
1989				4	342.5	48.7	0.001				0			0.000	0.000		0.000
1990				2	295.0	25.0	0.001				1	320.0	0.0	0.005	0.000		0.000
1991				5	276.0	44.5	0.001				0			0.000	0.000		0.000
1992				11	260.0	15.4	0.005				0			0.000	0.000		0.000
1993				3	350.0	26.5	0.001				.			.	.		.
1994				2	325.0	25.0	0.001				.			.	.		.
1995				0			0.000		KEYS-WIDE		0			0.000	0.000		0.000
1996				1	310.0	0.0	0.001		HABITAT		0			0.000	0.000		0.000
1997				0			0.000		STRATIFICATION		0			0.000	0.000		0.000
1998				4	242.5	19.3	0.001		DESIGN		0			0.000	0.000		0.000
1999											1	210.0	0.0	0.064	0.000		0.050

Appendix C2.-

graysby
Epinephelus cruentatus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				5	242.0	11.1	0.002										
1979				10	277.0	14.6	0.007										
1980				19	252.6	8.3	0.009										
1981				48	256.7	5.8	0.011										
1982				8	242.5	10.8	0.007										
1983				52	251.2	5.2	0.010				7.0	221.4	0.9	0.194	0.194		0.194
1984				6	253.3	16.3	0.002				0.0			0.000	0.000		0.000
1985				35	260.6	6.1	0.006				0.0			0.000	0.000		0.000
1986				15	268.0	6.3	0.005				0.0			0.000	0.000		0.000
1987				26	248.5	5.0	0.005				6.0	251.7	1.5	0.351	0.162		0.162
1988				59	256.6	4.1	0.017				13.0	226.2	0.9	0.206	0.070		0.070
1989				20	264.0	6.0	0.008				45.8	226.7	0.4	0.284	0.161		0.161
1990				50	248.6	4.5	0.019				32.0	227.2	0.8	0.376	0.133		0.133
1991				9	255.6	9.6	0.002				9.0	210.0	0.5	0.507	0.108		0.108
1992				7	267.1	14.1	0.002				6.0	231.7	2.8	0.387	0.062		0.062
1993				19	250.0	8.3	0.010				.			.	.		.
1994				24	248.3	4.7	0.010				.			.	.		.
1995				9	242.2	12.3	0.008				5.0	216.0	1.1	0.245	0.042		0.042
1996				15	250.0	7.7	0.012				4.0	250.0	3.5	0.208	0.056		0.056
1997				50	236.8	3.9	0.023				4.0	211.3	1.1	0.321	0.056		0.056
1998				6	236.7	9.2	0.002				3.5	248.6	2.9	0.140	0.053		0.053
1999											0.5	250.0	0.0	0.356	0.017		0.017

Appendix C3.-

speckled hind
Epinephelus drummondhayi

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				0			0.000										
1979				0			0.000										
1980				0			0.000										
1981				0			0.000										
1982				0			0.000										
1983				0			0.000										
1984				0			0.000										
1985				1	300.0	0.0	0.000										
1986				1	550.0	0.0	0.000										
1987				0			0.000										
1988				1	410.0	0.0	0.000										
1989				0			0.000										
1990				0			0.000										
1991				0			0.000										
1992				0			0.000										
1993				0			0.000										
1994				0			0.000										
1995				0			0.000										
1996				1	500.0	0.0	0.002										
1997				0			0.000										
1998				1	290.0	0.0	0.001										
1999																	

Appendix C4.-

yellowedge grouper
Epinephelus flavolimbatus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				0			0.000										
1979				0			0.000										
1980				0			0.000										
1981				0			0.000										
1982				3	256.7	6.7	0.000										
1983				7	497.1	23.8	0.003										
1984				0			0.000										
1985				0			0.000										
1986				0			0.000										
1987				0			0.000										
1988				0			0.000										
1989				0			0.000										
1990				0			0.000										
1991				0			0.000										
1992				1	240.0	0.0	0.000										
1993				1	630.0	0.0	0.000										
1994				0			0.000										
1995				0			0.000										
1996				0			0.000										
1997				0			0.000										
1998				0			0.000										
1999																	

Appendix C5.-

coney
Epinephelus fulvus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				0			0.000										
1979				0			0.000										
1980				1	250.0	0.0	0.000										
1981				0			0.000										
1982				3	253.3	14.5	0.001										
1983				1	220.0	0.0	0.001				0			0.000	0.000		0.000
1984				0			0.000				0			0.000	0.000		0.000
1985				0			0.000				0			0.000	0.000		0.000
1986				0			0.000				0			0.000	0.000		0.000
1987				4	312.5	34.2	0.001				2	250.0	2.0	0.000	0.081		0.054
1988				3	246.7	3.3	0.001				0			0.003	0.000		0.000
1989				0			0.000				1	350.0	0.0	0.000	0.004		0.004
1990				0			0.000				0			0.009	0.000		0.000
1991				0			0.000				0			0.040	0.000		0.000
1992				8	250.0	9.6	0.002				2	250.0	0.0	0.000	0.018		0.018
1993				2	255.0	15.0	0.001				.			.	.		.
1994				1	280.0	0.0	0.000				.			.	.		.
1995				1	300.0	0.0	0.001				0			0.000	0.005		0.000
1996				0			0.000				0			0.000	0.000		0.000
1997				1	270.0	0.0	0.001				0			0.000	0.000		0.000
1998				1	280.0	0.0	0.001				0			0.000	0.000		0.000
1999											0			0.000	0.000		0.000

Appendix C6.-

red hind
Epinephelus guttatus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				2	280.0	10.0	0.004										
1979				6	358.3	26.4	0.012										
1980				21	309.5	10.1	0.009										
1981				28	328.6	11.8	0.006										
1982				25	308.8	14.4	0.015										
1983				13	313.8	21.8	0.003				1	200.0	0.0	0.028	0.000		0.028
1984				6	345.0	27.7	0.004				0			0.000	0.000		0.000
1985				43	224.0	11.2	0.005				0			0.000	0.000		0.000
1986				9	280.0	16.2	0.002				0			0.000	0.000		0.000
1987				11	302.7	13.1	0.002				0			0.000	0.000		0.000
1988				20	302.0	8.7	0.009				0			0.007	0.000		0.000
1989				2	360.0	70.0	0.000				2	260.0	6.0	0.004	0.002		0.006
1990				3	320.0	17.3	0.001				2	250.0	0.0	0.010	0.000		0.010
1991				7	264.3	15.1	0.008				0			0.000	0.000		0.000
1992				9	273.3	12.7	0.005				0			0.000	0.000		0.000
1993				3	310.0	11.5	0.001				.			.	.		.
1994				4	295.0	32.8	0.001				.			.	.		.
1995				5	290.0	9.5	0.005				2	290.0	1.0	0.031	0.005		0.005
1996				5	302.0	17.7	0.002				0			0.000	0.000		0.000
1997				2	300.0	20.0	0.001				0			0.000	0.000		0.000
1998				10	347.0	21.8	0.002				1	200.0	0.0	0.008	0.000		0.008
1999											1	340.0	0.0	0.014	0.029		0.029

Appendix C7.-

marbled grouper
Epinephelus inermis

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0													
1977				0													
1978				0													
1979				0													
1980				0													
1981				0													
1982				0													
1983				1	440.0	0.0											
1984				0													
1985				0													
1986				0													
1987				0													
1988				0													
1989				0													
1990				0													
1991				0													
1992				0													
1993				0													
1994				0													
1995				0													
1996				0													
1997				0													
1998				0													
1999																	

Appendix C8.-

Goliath grouper
Epinephelus itajara

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	0			0			0.000										
1977	0			0			0.000										
1978	0			0			0.000										
1979	0			0			0.001										
1980	0			0			0.000										
1981	3	1170.0	225.0	3	1170.0	225.0	0.001										
1982	0			0			0.000										
1983	1	1010.0	0.0	1	1010.0	0.0	0.001										
1984	0			0			0.000										
1985	0			0			0.000										
1986	0			0			0.000										
1987	0			0			0.000										
1988	0			0			0.000										
1989	0			0			0.000										
1990	0			0			0.000										
1991	0			0			0.005										
1992	0			0			0.000										
1993	0			0			0.000										
1994	0			0			0.000										
1995	0			0			0.000										
1996	0			0			0.000										
1997	0			0			0.000										
1998	0			0			0.000										
1999																	

Appendix C9.-

red grouper
Epinephelus morio

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	**n**	**Legal**	**S.E.**	**n**	**Actual**	**S.E.**	**Actual**	**n**	**Legal**	**S.E.**	**n**	**Actual**	**S.E.**	**IM**	**Mat**	**Legal**	**Actual**
1976	307	347.6	6.1	307	347.6	6.1	0.004										
1977	91	402.1	13.0	91	402.1	13.0	0.000										
1978	115	431.1	8.5	115	431.1	8.5	0.009										
1979	87	446.3	11.8	87	446.3	11.8	0.043										
1980	133	434.6	9.2	133	434.6	9.2	0.025										
1981	227	426.5	6.0	227	426.5	6.0	0.034										
1982	80	413.8	12.9	80	413.8	12.9	0.019										
1983	232	382.2	6.0	232	382.2	6.0	0.043	0			0			0.000	0.000	0.000	0.000
1984	66	382.7	9.5	66	382.7	9.5	0.031	0			0			0.000	0.000	0.000	0.000
1985	42	511.0	6.8	188	388.0	5.7	0.036	0			0			0.000	0.000	0.000	0.000
1986	25	528.8	15.5	48	450.2	15.1	0.013	0			0			0.000	0.000	0.000	0.000
1987	29	498.6	6.6	69	422.3	9.3	0.024	0			0			0.027	0.000	0.000	0.000
1988	32	503.8	8.0	70	437.4	9.1	0.016	0			0			0.020	0.000	0.000	0.000
1989	22	525.9	11.6	63	428.6	10.8	0.016	0			2	350.0	0.0	0.000	0.000	0.000	0.000
1990	12	556.7	10.8	24	515.0	10.5	0.006	1	700.0	0.0	3	533.3	8.3	0.013	0.000	0.000	0.000
1991	10	559.0	9.9	13	543.1	11.5	0.006	0			0			0.010	0.000	0.000	0.000
1992	30	592.3	14.4	36	576.1	13.4	0.012	0			1	450.0	0.0	0.000	0.000	0.000	0.000
1993	14	555.7	9.1	32	513.1	8.2	0.020	.			.			.	.	.	.
1994	31	563.9	8.0	39	547.9	8.2	0.011	.			.			.	.	.	.
1995	9	544.4	12.8	13	525.4	12.1	0.008	0			0			0.030	0.000	0.000	0.000
1996	10	562.0	8.7	12	551.7	10.0	0.017	0			1	450.0	0.0	0.015	0.015	0.000	0.015
1997	13	530.0	7.3	23	508.7	7.0	0.009	0			0			0.063	0.000	0.000	0.000
1998	23	539.1	7.3	29	529.7	6.8	0.009	0			0			0.008	0.000	0.000	0.000
1999								0			1	460.0	0.0	0.048	0.050	0.000	0.050

Appendix C13.-

nassau grouper
Epinephelus striatus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	**n**	**Legal**	**S.E.**	**n**	**Actual**	**S.E.**	**Actual**	**n**	**Legal**	**S.E.**	**n**	**Actual**	**S.E.**	**IM**	**Mat**	**Legal**	**Actual**
1976	99	439.7	13.2	99	439.7	13.2	0.001										
1977	67	462.1	23.7	67	462.1	23.7	0.000										
1978	98	444.6	8.8	98	444.6	8.8	0.001										
1979	64	450.2	11.4	64	450.2	11.4	0.014										
1980	91	427.0	8.9	91	427.0	8.9	0.012										
1981	120	468.4	6.3	120	468.4	6.3	0.004										
1982	26	450.8	22.5	26	450.8	22.5	0.007										
1983	26	418.8	18.8	26	418.8	18.8	0.002	0			0			0.000	0.000	0.000	0.000
1984	5	398.0	10.2	5	398.0	10.2	0.002	0			0			0.000	0.000	0.000	0.000
1985	10	546.0	20.8	34	415.0	16.7	0.005	0			0			0.000	0.000	0.000	0.000
1986	7	601.4	9.6	14	489.3	32.2	0.002	0			0			0.000	0.000	0.000	0.000
1987	7	555.7	54.1	11	491.8	43.4	0.001	0			0			0.000	0.000	0.000	0.000
1988	7	512.9	16.0	14	446.4	22.3	0.002	0			0			0.000	0.000	0.000	0.000
1989	9	528.9	15.1	12	496.7	20.6	0.002	1	460.0	0.0	1	460.0	0.0	0.002	0.000	0.002	0.002
1990	7	565.7	16.3	7	565.7	16.3	0.000	1	600.0	0.0	1	600.0	0.0	0.000	0.004	0.004	0.004
1991	1	650.0	0.0	1	650.0	0.0	0.000	0			0			0.000	0.000	0.000	0.000
1992	2	515.0	5.0	2	515.0	5.0	0.000	1	600.0	0.0	1	600.0	0.0	0.018	0.009	0.009	0.009
1993	0			0			0.000	.			.			.	.	.	.
1994	0			0			0.000	.			.			.	.	.	.
1995	0			0			0.000	0			0			0.036	0.000	0.000	0.000
1996	0			0			0.001	0			0			0.014	0.000	0.000	0.000
1997	0			0			0.000	1	640.0	0.0	1	640.0	0.0	0.000	0.008	0.008	0.008
1998	2	590.0	20.0	2	590.0	20.0	0.001	0			0			0.000	0.000	0.000	0.000
1999								0			0			0.000	0.000	0.000	0.000

Appendix C14.-

black grouper

Mycteroperca bonaci

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	1	370.0	0.0	1	370.0	0.0	0.000										
1977	11	603.6	51.5	11	603.6	51.5	0.000										
1978	25	612.0	39.7	25	612.0	39.7	0.002										
1979	59	555.9	19.7	59	555.9	19.7	0.007										
1980	72	536.8	16.3	72	536.8	16.3	0.006										
1981	93	585.2	17.6	93	585.2	17.6	0.005										
1982	34	497.6	26.6	34	497.6	26.6	0.007										
1983	46	541.5	27.3	46	541.5	27.3	0.002	0			0			0.000	0.000	0.000	0.000
1984	29	602.1	35.2	29	602.1	35.2	0.005	0			0			0.000	0.000	0.000	0.000
1985	20	584.5	23.4	53	450.8	17.5	0.006	0			0			0.000	0.000	0.000	0.000
1986	10	587.0	20.3	14	532.1	28.9	0.001	0			0			0.000	0.000	0.000	0.000
1987	11	613.6	39.0	18	517.2	38.0	0.002	0			0			0.000	0.000	0.000	0.000
1988	9	571.1	50.3	15	501.3	38.5	0.001	0			4	380.0	27.0	0.025	0.000	0.000	0.018
1989	16	607.5	31.7	21	556.7	31.8	0.004	0			0			0.000	0.000	0.000	0.000
1990	12	650.0	33.6	13	638.5	33.0	0.001	1	650.0	0.0	1	650.0	0.0	0.005	0.004	0.004	0.004
1991	4	702.5	79.2	5	662.0	73.5	0.000	0			0			0.024	0.000	0.000	0.000
1992	7	688.6	27.9	7	688.6	27.9	0.000	1	650.0	0.0	1	650.0	0.0	0.010	0.010	0.010	0.010
1993	7	624.3	32.4	7	624.3	32.4	0.001	.			.			.	.	.	.
1994	11	677.3	20.8	11	677.3	20.8	0.002	.			.			.	.	.	.
1995	7	708.6	27.9	7	708.6	27.9	0.005	0			0			0.000	0.000	0.000	0.000
1996	10	706.0	20.7	11	687.3	26.5	0.003	0			0			0.015	0.000	0.000	0.000
1997	12	610.8	15.2	13	602.3	16.4	0.000	0			0			0.000	0.000	0.000	0.000
1998	9	663.3	24.2	9	663.3	24.2	0.006	0			0			0.023	0.000	0.000	0.000
1999								0			0			0.035	0.000	0.000	0.000

Appendix C15.-

yellowmouth grouper

Mycteroperca interstitialis

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	0			0			0.000										
1977	0			0			0.000										
1978	1	530.0	0.0	1	530.0	0.0	0.000										
1979	1	520.0	0.0	1	520.0	0.0	0.000										
1980	5	406.0	24.8	5	406.0	24.8	0.001										
1981	26	545.4	29.5	26	545.4	29.5	0.003										
1982	1	780.0	0.0	1	780.0	0.0	0.000										
1983	1	730.0	0.0	1	730.0	0.0	0.000	0			0			0.000	0.000		0.000
1984	0			0			0.000	0			0			0.000	0.000		0.000
1985	0			0			0.000	0			0			0.000	0.000		0.000
1986	0			0			0.000	0			0			0.000	0.000		0.000
1987	0			0			0.000	0			0			0.000	0.000		0.000
1988	8	582.5	35.7	8	582.5	35.7	0.000	0			0			0.000	0.000		0.000
1989	0			0			0.000	0			0			0.000	0.000		0.000
1990	0			0			0.000	0			0			0.008	0.000		0.000
1991	0			0			0.000	0			0			0.000	0.000		0.000
1992	0			0			0.000	0			0			0.000	0.000		0.000
1993	0			0			0.000	.			.			.	.		.
1994	0			0			0.000	.			.			.	.		.
1995	0			0			0.000	0			0			0.000	0.000		0.000
1996	0			0			0.000	0			0			0.000	0.000		0.000
1997	0			0			0.000	0			0			0.000	0.000		0.000
1998	0			0			0.000	0			0			0.000	0.000		0.000
1999								0			0			0.000	0.000		0.000

Appendix C16.-

gag
Mycteroperca microlepis

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	5	486.0	110.7	5	486.0	110.7	0.000										
1977	9	454.4	45.1	9	454.4	45.1	0.000										
1978	37	566.8	25.8	37	566.8	25.8	0.002										
1979	14	440.7	16.1	14	440.7	16.1	0.005										
1980	34	442.4	13.8	34	442.4	13.8	0.002										
1981	27	532.2	30.9	27	532.2	30.9	0.002										
1982	34	375.0	14.4	34	375.0	14.4	0.008										
1983	46	468.3	20.8	46	468.3	20.8	0.004	0			0			0.000	0.000	0.000	0.000
1984	13	443.8	39.6	13	443.8	39.6	0.004	0			0			0.000	0.000	0.000	0.000
1985	7	644.3	61.7	14	508.6	48.6	0.001	0			0			0.000	0.000	0.000	0.000
1986	4	685.0	33.0	6	580.0	71.9	0.001	0			0			0.000	0.000	0.000	0.000
1987	8	511.3	24.2	19	428.4	20.1	0.003	0			0			0.000	0.000	0.000	0.000
1988	15	560.0	22.1	15	560.0	22.1	0.003	0			0			0.000	0.000	0.000	0.000
1989	1	630.0	0.0	3	423.3	103.5	0.001	0			0			0.000	0.000	0.000	0.000
1990	2	720.0	170.0	3	633.3	130.9	0.000	0			0			0.000	0.000	0.000	0.000
1991	11	603.6	15.4	11	603.6	15.4	0.002	0			0			0.000	0.000	0.000	0.000
1992	1	530.0	0.0	3	510.0	10.0	0.000	0			0			0.000	0.000	0.000	0.000
1993	6	710.0	37.8	6	710.0	37.8	0.001	.			.			.	.	.	.
1994	5	574.0	30.9	8	541.3	24.6	0.005	.			.			.	.	.	.
1995	2	585.0	45.0	5	528.0	27.5	0.001	0			0			0.000	0.000	0.000	0.000
1996	3	633.3	37.6	3	633.3	37.6	0.000	0			0			0.000	0.000	0.000	0.000
1997	0			0			0.000	0			0			0.000	0.000	0.000	0.000
1998	1	570.0	0.0	1	570.0	0.0	0.000	0			0			0.000	0.000	0.000	0.000
1999								0			0			0.000	0.000	0.000	0.000

Appendix C17.-

scamp
Mycteroperca phenax

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	0			0			0.000										
1977	0			0			0.000										
1978	0			0			0.000										
1979	2	320.0	20.0	2	320.0	20.0	0.000										
1980	3	346.7	6.7	3	346.7	6.7	0.000										
1981	4	587.5	47.5	4	587.5	47.5	0.000										
1982	0			0			0.000										
1983	0			0			0.000	0			0			0.000	0.000		0.000
1984	0			0			0.000	0			0			0.000	0.000		0.000
1985	0			0			0.000	0			0			0.000	0.000		0.000
1986	1	350.0	0.0	1	350.0	0.0	0.000	0			0			0.000	0.000		0.000
1987	0			0			0.000	0			0			0.000	0.000		0.000
1988	0			0			0.000	0			0			0.000	0.000		0.000
1989	0			0			0.000	0			0			0.000	0.000		0.000
1990	0			0			0.000	0			0			0.000	0.000		0.000
1991	0			0			0.000	0			0			0.000	0.000		0.000
1992	0			0			0.000	0			0			0.000	0.000		0.000
1993	0			0			0.000	.			.			.	.		.
1994	0			0			0.000	.			.			.	.		.
1995	0			0			0.000	0			0			0.000	0.000		0.000
1996	0			0			0.000	0			0			0.000	0.000		0.000
1997	0			0			0.000	0			0			0.000	0.000		0.000
1998	1	580.0	0.0	1	580.0	0.0	0.000	0			0			0.000	0.000		0.000
1999								0			0			0.050	0.000		0.000

Appendix C18.-

yellowfin grouper
Mycteroperca venenosa

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	0			0			0.000										
1977	0			0			0.000										
1978	5	564.0	52.8	5	564.0	52.8	0.006										
1979	1	450.0	0.0	1	450.0	0.0	0.009										
1980	10	401.0	11.1	10	401.0	11.1	0.002										
1981	1	590.0	0.0	1	590.0	0.0	0.000										
1982	8	640.0	45.5	8	640.0	45.5	0.012										
1983	0			0			0.000	0			0			0.000	0.000	0.000	0.000
1984	0			0			0.000	0			0			0.000	0.000	0.000	0.000
1985	0			0			0.000	0			0			0.000	0.000	0.000	0.000
1986	0			0			0.000	0			0			0.000	0.000	0.000	0.000
1987	0			0			0.000	0			0			0.000	0.000	0.000	0.000
1988	0			0			0.000	0			0			0.000	0.000	0.000	0.000
1989	0			1	300.0	0.0	0.000	0			0			0.000	0.000	0.000	0.000
1990	0			0			0.000	0			0			0.000	0.000	0.000	0.000
1991	0			0			0.000	0			0			0.000	0.000	0.000	0.000
1992	0			0			0.000	0			0			0.000	0.000	0.000	0.000
1993	0			0			0.000	.			.			.	.	.	.
1994	0			0			0.000	.			.			.	.	.	.
1995	0			0			0.000	0			0			0.000	0.000	0.000	0.000
1996	0			0			0.000	0			0			0.000	0.000	0.000	0.000
1997	0			0			0.000	0			0			0.000	0.000	0.000	0.000
1998	0			0			0.000	0			0			0.000	0.000	0.000	0.000
1999								0			0			0.000	0.000	0.000	0.000

Appendix C19.-

mutton snapper
Lutjanus analis

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	134	409.6	13.7	134	409.6	13.7	0.000										
1977	62	351.5	20.8	62	351.5	20.8	0.000										
1978	70	445.3	18.8	70	445.3	18.8	0.004										
1979	62	399.8	14.3	62	399.8	14.3	0.021										
1980	138	477.8	11.9	138	477.8	11.9	0.022										
1981	149	463.9	12.2	149	463.9	12.2	0.019										
1982	64	402.5	17.0	64	402.5	17.0	0.015										
1983	161	392.4	11.9	161	392.4	11.9	0.016	1	300.0	0.0	1	300.0	0.0	0.000	0.028	0.028	0.028
1984	64	396.9	15.4	64	396.9	15.4	0.017	0			0			0.000	0.000	0.000	0.000
1985	55	408.9	14.3	67	381.0	13.8	0.006	0			0			0.000	0.000	0.000	0.000
1986	51	413.5	14.5	69	371.2	13.8	0.012	0			0			0.000	0.000	0.000	0.000
1987	82	424.1	12.8	198	325.1	8.0	0.029	0			0			0.000	0.000	0.000	0.000
1988	62	397.4	14.2	80	367.3	12.7	0.018	4	382.5	69.3	5	364.0	56.8	0.000	0.048	0.044	0.048
1989	65	389.7	13.2	76	368.9	12.7	0.020	2	355.0	25.0	2	355.0	25.0	0.000	0.007	0.007	0.007
1990	67	404.6	10.4	78	385.6	10.4	0.017	3	360.0	20.8	3	360.0	20.8	0.000	0.009	0.009	0.009
1991	56	419.3	12.4	63	400.8	12.9	0.023	3	433.3	33.3	3	433.3	33.3	0.000	0.040	0.040	0.040
1992	82	391.1	9.6	94	376.6	9.3	0.022	1	400.0	0.0	4	292.5	37.3	0.027	0.018	0.009	0.036
1993	78	413.2	11.6	95	385.2	11.4	0.028	.			.			.	.	.	.
1994	36	501.7	14.7	99	385.1	10.8	0.023	.			.			.	.	.	.
1995	15	476.7	16.6	29	408.6	16.8	0.017	0			0			0.000	0.000	0.000	0.000
1996	13	526.9	29.6	26	436.9	23.7	0.007	0			0			0.000	0.000	0.000	0.000
1997	6	523.3	52.8	14	409.3	37.0	0.007	1	400.0	0.0	1	400.0	0.0	0.000	0.013	0.013	0.013
1998	14	517.9	34.5	23	445.2	29.0	0.007	0			0			0.000	0.000	0.000	0.000
1999								1	450.0	0.0	1	450.0	0.0	0.013	0.025	0.025	0.025

Appendix C20.-

schoolmaster
Lutjanus apodus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	0			0			0.000										
1977	0			0			0.000										
1978	4	305.0	26.0	4	305.0	26.0	0.002										
1979	11	286.4	18.4	11	286.4	18.4	0.003										
1980	15	264.7	12.5	15	264.7	12.5	0.004										
1981	51	262.5	6.5	51	262.5	6.5	0.005										
1982	12	267.5	5.2	12	267.5	5.2	0.004										
1983	55	306.9	10.8	55	306.9	10.8	0.003	0			0			0.000	0.000	0.000	0.000
1984	4	272.5	23.9	4	272.5	23.9	0.001	0			0			0.000	0.000	0.000	0.000
1985	10	249.0	9.9	10	249.0	9.9	0.002	0			0			0.000	0.000	0.000	0.000
1986	27	270.4	9.4	27	270.4	9.4	0.002	0			0			0.000	0.000	0.000	0.000
1987	37	264.9	10.5	37	264.9	10.5	0.008	0			0			0.000	0.000	0.000	0.000
1988	30	267.7	5.6	30	267.7	5.6	0.005	177	244.8	3.0	177	244.8	3.0	0.021	1.072	0.887	0.887
1989	45	264.0	4.8	45	264.0	4.8	0.013	123	269.7	3.4	123	269.7	3.4	0.225	0.587	0.403	0.403
1990	26	303.8	10.2	30	295.3	9.7	0.005	277	283.4	2.3	285	282.4	2.3	0.211	3.037	1.176	1.225
1991	15	288.0	11.5	18	280.0	10.4	0.003	9	297.8	12.9	9	297.8	12.9	0.021	0.281	0.094	0.094
1992	38	284.7	5.5	42	280.5	5.4	0.008	9	280.4	11.4	10	276.3	11.0	0.280	0.918	0.086	0.086
1993	17	286.5	7.6	19	281.6	7.5	0.006	.			.			.	.	.	.
1994	57	272.8	3.3	61	270.7	3.2	0.011	.			.			.	.	.	.
1995	14	281.4	9.9	16	276.3	9.3	0.011	33	285.2	5.0	33	285.2	5.0	0.045	0.842	0.379	0.379
1996	9	271.1	9.2	13	261.5	7.5	0.004	110	305.2	3.1	110	305.2	3.1	0.154	1.972	1.521	1.521
1997	16	270.6	4.0	18	267.2	4.3	0.007	61	301.1	4.9	64	298.2	4.9	0.125	1.308	1.021	1.071
1998	24	290.4	3.8	24	290.4	3.8	0.002	1	280.0	0.0	1	280.0	0.0	0.265	0.409	0.008	0.008
1999								0			0			0.013	0.050	0.000	0.000

Appendix C21.-

blackfin snapper
Lutjanus buccanella

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	0			0													
1977	0			0													
1978	0			0													
1979	0			0													
1980	4	315.0	9.6	4	315.0	9.6											
1981	0			0													
1982	0			0													
1983	2	385.0	5.0	2	385.0	5.0											
1984	0			0													
1985	0			0													
1986	0			0													
1987	0			0													
1988	0			0													
1989	0			0													
1990	0			0													
1991	3	360.0	32.1	5	320.0	30.2											
1992	0			3	233.3	3.3											
1993	0			0													
1994	0			0													
1995	0			0													
1996	0			0													
1997	0			0													
1998	0			0													
1999																	

Appendix C22.-

red snapper
Lutjanus campechanus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	0			0													
1977	0			0													
1978	0			0													
1979	0			0													
1980	0			0													
1981	0			0													
1982	0			0													
1983	7	345.7	13.1	7	345.7	13.1											
1984	0			0													
1985	1	740.0	0.0	1	740.0	0.0											
1986	5	356.0	6.0	5	356.0	6.0											
1987	0			0													
1988	0			0													
1989	0			10	210.0	3.0											
1990	0			0													
1991	0			0													
1992	0			0													
1993	0			0													
1994	0			0													
1995	0			0													
1996	0			0													
1997	0			0													
1998	0			0													
1999																	

Appendix C23.-

yellowtail snapper
Ocyurus chrysurus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	237	231.7	2.4	237	231.7	2.4	0.002										
1977	55	300.9	18.1	55	300.9	18.1	0.000										
1978	171	245.7	3.9	171	245.7	3.9	0.032										
1979	104	266.7	5.2	104	266.7	5.2	0.107										
1980	341	268.7	3.7	341	268.7	3.7	0.153										
1981	272	246.3	3.3	272	246.3	3.3	0.125										
1982	175	245.0	3.8	175	245.0	3.8	0.141										
1983	422	241.3	2.4	422	241.3	2.4	0.095	73	230.9	3.4	73	230.9	3.4	2.556	1.750	2.028	2.028
1984	165	251.0	3.1	165	251.0	3.1	0.070	0			0			0.000	0.000	0.000	0.000
1985	137	331.0	3.4	338	290.9	2.3	0.085	0			0			0.000	0.000	0.000	0.000
1986	47	344.5	7.1	98	303.8	5.3	0.021	0			0			0.429	0.143	0.000	0.000
1987	91	345.5	5.4	131	322.9	4.8	0.025	0			3	266.7	8.8	0.324	0.270	0.000	0.081
1988	79	331.6	4.4	179	297.9	3.1	0.047	3	346.7	29.1	10	288.0	15.3	1.837	0.379	0.008	0.040
1989	41	339.5	7.8	118	292.0	4.3	0.043	8	328.8	17.7	153	259.2	1.8	1.059	1.334	0.026	0.419
1990	93	324.6	2.9	174	300.5	2.6	0.040	47	321.0	3.6	171	279.2	2.3	3.085	1.308	0.190	0.683
1991	78	342.4	5.8	137	310.3	4.6	0.043	4	312.5	12.5	12	277.2	8.6	3.845	0.488	0.048	0.136
1992	130	343.3	4.8	250	308.4	3.5	0.046	0			0			1.288	0.109	0.000	0.000
1993	158	323.4	1.8	305	298.9	1.8	0.093	.			.			.	.	.	.
1994	139	321.5	2.5	386	289.3	1.6	0.078	.			.			.	.	.	.
1995	23	333.9	7.9	93	282.8	3.8	0.048	0			2	265.0	5.0	2.141	0.120	0.000	0.016
1996	52	320.8	3.1	122	293.7	2.7	0.030	1	300.0	0.0	36	258.2	2.2	1.669	0.861	0.014	0.500
1997	21	317.1	3.9	54	290.4	3.6	0.019	1	310.0	0.0	5	266.0	11.7	1.321	0.221	0.013	0.077
1998	44	339.8	14.3	118	293.8	6.3	0.048	0			3	250.0	0.0	0.323	0.127	0.000	0.038
1999								1	300.0	0.0	1	300.0	0.0	0.292	0.086	0.013	0.013

Appendix C25.-

gray snapper
Lutjanus griseus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	549	255.9	2.9	549	255.9	2.9	0.008										
1977	209	237.0	3.2	209	237.0	3.2	0.000										
1978	293	271.8	4.1	293	271.8	4.1	0.026										
1979	234	253.3	3.5	234	253.3	3.5	0.285										
1980	496	262.8	2.8	496	262.8	2.8	0.281										
1981	635	285.4	2.9	635	285.4	2.9	0.241										
1982	339	262.9	3.6	339	262.9	3.6	0.197										
1983	1108	260.6	1.9	1108	260.6	1.9	0.254	4	250.0	0.0	4	250.0	0.0	0.000	0.111	0.111	0.111
1984	501	251.2	2.7	501	251.2	2.7	0.298	0			0			0.000	0.000	0.000	0.000
1985	1138	254.5	1.8	1138	254.5	1.8	0.201	0			0			0.000	0.000	0.000	0.000
1986	438	265.0	3.1	438	265.0	3.1	0.114	0			0			0.000	0.000	0.000	0.000
1987	555	254.7	2.1	555	254.7	2.1	0.161	0			0			0.000	0.000	0.000	0.000
1988	335	272.3	3.1	335	272.3	3.1	0.111	35	229.7	5.2	35	229.7	5.2	0.091	0.057	0.106	0.106
1989	440	272.5	2.9	440	272.5	2.9	0.157	135	227.7	2.9	135	227.7	2.9	0.135	0.074	0.120	0.120
1990	179	318.2	4.9	193	312.5	4.7	0.041	163	293.7	3.8	232	277.7	3.1	0.058	0.074	0.074	0.074
1991	175	303.0	4.1	185	299.6	4.0	0.063	4	307.5	7.5	4	307.5	7.5	0.688	0.042	0.042	0.042
1992	321	290.6	2.7	328	289.5	2.7	0.074	24	310.4	12.1	27	302.5	11.5	0.979	0.201	0.187	0.198
1993	366	300.6	2.8	390	296.9	2.8	0.154	.			.			.	.	.	.
1994	539	297.5	2.5	574	294.0	2.4	0.124	.			.			.	.	.	.
1995	221	299.2	3.2	234	295.9	3.2	0.107	12	276.1	9.8	14	271.0	8.7	1.334	0.076	0.031	0.055
1996	301	281.4	2.1	318	279.2	2.0	0.087	6	286.7	5.6	6	286.7	5.6	0.239	0.083	0.083	0.083
1997	199	303.0	4.4	211	299.4	4.3	0.088	73	277.0	3.0	73	276.7	3.0	0.375	0.356	0.348	0.356
1998	258	302.4	3.8	276	298.3	3.7	0.135	29	281.7	5.5	30	281.0	5.5	0.773	0.417	0.409	0.417
1999								0			1	240.0	0.0	0.438	0.050	0.000	0.050

Appendix C26.-

dog snapper
Lutjanus jocu

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	0			0			0.000										
1977	0			0			0.000										
1978	0			0			0.000										
1979	2	600.0	20.0	2	600.0	20.0	0.004										
1980	4	300.0	33.4	4	300.0	33.4	0.004										
1981	16	393.1	46.9	16	393.1	46.9	0.009										
1982	3	226.7	3.3	3	226.7	3.3	0.007										
1983	3	593.3	31.8	3	593.3	31.8	0.001	0			0			0.000	0.000		0.000
1984	8	272.5	26.7	8	272.5	26.7	0.003	0			0			0.000	0.000		0.000
1985	2	470.0	250.0	2	470.0	250.0	0.004	0			0			0.000	0.000		0.000
1986	0			0			0.000	0			0			0.000	0.000		0.000
1987	0			0			0.000	0			0			0.000	0.000		0.000
1988	8	376.3	35.1	8	376.3	35.1	0.001	0			0			0.000	0.000		0.000
1989	2	415.0	175.0	2	415.0	175.0	0.001	2	350.0	0.0	2	350.0	0.0	0.000	0.008		0.008
1990	2	400.0	70.0	2	400.0	70.0	0.001	1	350.0	0.0	1	350.0	0.0	0.000	0.004		0.004
1991	0			0			0.000	0			0			0.000	0.000		0.000
1992	0			0			0.000	1	300.0	0.0	1	300.0	0.0	0.000	0.010		0.010
1993	0			0			0.000	.			.			.	.		.
1994	1	420.0	0.0	1	420.0	0.0	0.002	.			.			.	.		.
1995	0			0			0.000	0			0			0.109	0.000		0.000
1996	1	430.0	0.0	1	430.0	0.0	0.004	0			0			0.000	0.000		0.000
1997	0			0			0.000	0			0			0.000	0.000		0.000
1998	0			0			0.000	0			0			0.000	0.000		0.000
1999								0			0			0.000	0.000		0.000

Appendix C27.-

mahogony snapper
Lutjanus mahogoni

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	0			0			0.000										
1977	0			0			0.000										
1978	0			0			0.000										
1979	0			0			0.000										
1980	0			0			0.000										
1981	0			0			0.000										
1982	2	440.0	10.0	2	440.0	10.0	0.000										
1983	0			0			0.000	0			0			0.000	0.000		0.000
1984	0			0			0.000	0			0			0.000	0.000		0.000
1985	0			0			0.000	0			0			0.000	0.000		0.000
1986	12	213.3	12.3	12	213.3	12.3	0.002	0			0			0.000	0.000		0.000
1987	3	316.7	24.0	3	316.7	24.0	0.000	0			0			0.000	0.000		0.000
1988	0			0			0.000	2	225.0	25.0	2	225.0	25.0	0.008	0.000		0.008
1989	2	380.0	10.0	2	380.0	10.0	0.000	4	257.5	40.5	4	257.5	40.5	0.011	0.008		0.015
1990	2	320.0	10.0	2	320.0	10.0	0.000	1	300.0	0.0	1	300.0	0.0	0.000	0.008		0.004
1991	2	380.0	50.0	2	380.0	50.0	0.000	0			0			0.000	0.000		0.000
1992	0			0			0.000	0			0			0.000	0.000		0.000
1993	0			0			0.000	.			.			.	.		.
1994	4	350.0	24.8	4	350.0	24.8	0.000	.			.			.	.		.
1995	0			0			0.000	0			0			0.000	0.000		0.000
1996	0			0			0.000	0			0			0.028	0.000		0.000
1997	1	370.0	0.0	1	370.0	0.0	0.001	0			0			0.000	0.000		0.000
1998	0			0			0.000	0			0			0.015	0.000		0.000
1999								0			0			0.000	0.000		0.000

Appendix C28.-

lane snapper
Lutjanus synagris

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	0			0			0.000										
1977	0			0			0.000										
1978	9	241.1	13.6	9	241.1	13.6	0.010										
1979	6	300.0	13.4	6	300.0	13.4	0.009										
1980	32	253.4	5.8	32	253.4	5.8	0.016										
1981	35	239.4	8.5	35	239.4	8.5	0.013										
1982	18	225.0	9.4	18	225.0	9.4	0.013										
1983	26	235.0	8.7	26	235.0	8.7	0.011	0			0			0.000	0.000	0.000	0.000
1984	5	202.0	8.6	5	202.0	8.6	0.002	0			0			0.000	0.000	0.000	0.000
1985	49	241.4	9.6	49	241.4	9.6	0.007	0			0			0.000	0.000	0.000	0.000
1986	18	242.2	11.6	18	242.2	11.6	0.005	0			0			0.000	0.000	0.000	0.000
1987	43	242.1	7.7	43	242.1	7.7	0.009	3	230.0	0.0	3	230.0	0.0	0.027	0.081	0.081	0.081
1988	46	229.8	6.2	46	229.8	6.2	0.014	0			0			0.000	0.000	0.000	0.000
1989	21	255.7	11.8	21	255.7	11.8	0.008	15	293.6	12.9	15	293.6	12.9	0.015	0.045	0.056	0.056
1990	13	236.2	5.7	15	230.0	6.5	0.002	0			0			0.012	0.000	0.000	0.000
1991	24	236.7	6.4	26	233.1	6.4	0.009	5	216.8	8.9	5	216.8	8.9	0.028	0.056	0.069	0.069
1992	5	240.0	14.1	6	231.7	14.2	0.001	3	300.0	11.5	3	300.0	11.5	0.000	0.009	0.009	0.009
1993	8	251.3	21.6	9	244.4	20.2	0.001	.			.			.	.	.	.
1994	5	240.0	11.8	5	240.0	11.8	0.002	.			.			.	.	.	.
1995	1	290.0	0.0	1	290.0	0.0	0.009	0			0			0.000	0.000	0.000	0.000
1996	4	207.5	7.5	5	204.0	6.8	0.003	0			0			0.000	0.000	0.000	0.000
1997	0			0			0.000	1	250.0	0.0	1	250.0	0.0	0.006	0.017	0.017	0.017
1998	0			0			0.000	1	255.0	0.0	1	255.0	0.0	0.000	0.008	0.008	0.008
1999								2	273.3	109.1	2	273.3	109.1	0.050	0.075	0.125	0.125

Appendix C29.-

silk snapper
Lutjanus campechanus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	0			0													
1977	0			0													
1978	0			0													
1979	0			0													
1980	0			0													
1981	0			0													
1982	0			0													
1983	0			0													
1984	0			0													
1985	5	244.0	2.4	5	244.0	2.4											
1986	0			0													
1987	0			0													
1988	2	260.0	20.0	2	260.0	20.0											
1989	0			0													
1990	0			0													
1991	0			0													
1992	0			0													
1993	0			0													
1994	0			0													
1995	0			0													
1996	0			0													
1997	0			0													
1998	0			0													
1999																	

Appendix C31.-

vermilion snapper
Rhomboplites aurorubens

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	0			0			0.000										
1977	0			0			0.000										
1978	0			0			0.000										
1979	0			0			0.000										
1980	0			0			0.000										
1981	1	250.0	0.0	1	250.0	0.0	0.001										
1982	13	260.0	14.3	13	260.0	14.3	0.003										
1983	0			0			0.000										
1984	0			0			0.000										
1985	6	208.3	8.3	6	208.3	8.3	0.000										
1986	1	290.0	0.0	1	290.0	0.0	0.000										
1987	1	270.0	0.0	1	270.0	0.0	0.000										
1988	0			0			0.000										
1989	0			0			0.000										
1990	0			0			0.000										
1991	0			0			0.000										
1992	0			0			0.000										
1993	0			0			0.000										
1994	0			0			0.000										
1995	0			0			0.000										
1996	0			0			0.000										
1997	0			0			0.000										
1998	0			0			0.000										
1999																	

Appendix C32.-

hogfish
Lachnolaimus maximus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	389	335.8	4.8	389	335.8	4.8	0.515										
1977	157	369.2	7.8	157	369.2	7.8	0.558										
1978	360	368.7	5.1	360	368.7	5.1	0.663										
1979	84	361.3	11.7	84	361.3	11.7	0.554										
1980	231	361.3	7.0	231	361.3	7.0	0.579										
1981	687	354.8	3.3	687	354.8	3.3	0.719										
1982	189	349.9	6.6	189	349.9	6.6	0.567										
1983	773	349.9	3.1	773	349.9	3.1	0.706	13	227.1	5.6	13	227.1	5.6	0.201	0.354	0.354	0.354
1984	145	345.9	5.9	145	345.9	5.9	0.690	1	250.0	0.0	1	250.0	0.0	0.000	0.250	0.250	0.250
1985	457	357.7	4.2	457	357.7	4.2	0.543	0			0			0.000	0.000	0.000	0.000
1986	310	378.0	6.0	310	378.0	6.0	0.500	0			0			0.143	0.000	0.000	0.000
1987	215	321.4	5.1	215	321.4	5.1	0.546	4	242.5	14.4	4	242.5	14.4	0.027	0.108	0.108	0.108
1988	264	323.2	4.2	264	323.2	4.2	0.497	25	252.0	7.2	25	252.0	7.2	0.028	0.111	0.111	0.111
1989	212	349.8	9.4	211	341.6	4.7	0.615	27	259.6	8.7	27	259.6	8.7	0.045	0.075	0.075	0.075
1990	342	310.9	3.4	342	310.9	3.4	0.666	31	274.8	7.6	31	274.8	7.6	0.039	0.080	0.080	0.080
1991	197	323.4	5.4	197	323.4	5.4	0.404	7	297.1	37.8	7	297.1	37.8	0.135	0.088	0.088	0.088
1992	263	318.6	4.2	263	318.6	4.2	0.648	18	265.0	18.9	18	265.0	18.9	0.235	0.133	0.133	0.133
1993	184	328.9	6.0	184	328.9	6.0	0.882	.			.			.	.	.	.
1994	299	351.0	3.2	426	328.2	2.9	0.887	.			.			.	.	.	.
1995	103	362.7	7.8	121	349.8	7.2	0.579	5	390.0	55.7	8	342.5	40.8	0.073	0.071	0.030	0.050
1996	178	345.1	3.7	205	335.9	3.7	0.792	1	370.0	0.0	3	293.3	39.3	0.000	0.056	0.014	0.042
1997	95	354.6	6.8	109	344.0	6.5	0.510	1	305.0	0.0	7	263.1	8.8	0.198	0.083	0.008	0.054
1998	116	349.1	4.4	138	338.0	4.3	0.389	1	320.0	0.0	3	274.0	19.7	0.043	0.053	0.000	0.023
1999								2	310.0	17.3	4	284.3	20.8	0.231	0.164	0.056	0.102

Appendix C33.-

black margate
Anisotremus surinamensis

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				0			0.001										
1979				4	337.5	37.7	0.006										
1980				9	394.4	29.9	0.006										
1981				20	332.0	15.1	0.020										
1982				3	360.0	50.3	0.013										
1983				10	387.0	23.1	0.010				0			0.000	0.000		0.000
1984				3	383.3	46.7	0.010				0			0.000	0.000		0.000
1985				14	343.6	13.5	0.044				0			0.000	0.000		0.000
1986				17	344.7	25.0	0.013				0			0.000	0.000		0.000
1987				13	430.8	25.6	0.024				0			0.000	0.000		0.000
1988				21	335.7	15.0	0.022				11	338.2	19.2	0.049	0.020		0.061
1989				7	327.1	21.9	0.007				11	289.1	14.7	0.043	0.008		0.051
1990				21	339.5	10.5	0.013				22	332.3	10.6	0.058	0.020		0.078
1991				12	338.3	10.6	0.012				13	314.6	11.2	0.188	0.000		0.135
1992				14	340.0	11.4	0.032				2	295.0	5.0	0.019	0.000		0.019
1993				8	380.0	26.4	0.008				.			.	.		.
1994				12	341.7	15.8	0.006				.			.	.		.
1995				7	350.0	14.5	0.019				7	318.2	11.3	0.104	0.000		0.104
1996				7	361.4	12.0	0.011				1	250.0	0.0	0.014	0.000		0.014
1997				2	310.0	20.0	0.000				0			0.000	0.000		0.000
1998				3	283.3	12.0	0.009				1	290.0	0.0	0.008	0.000		0.008
1999											0			0.000	0.000		0.000

Appendix C34.-

porkfish

Anisotremus virginicus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				31	298.4	9.6	0.000										
1979				1	210.0	0.0	0.001										
1980				1	250.0	0.0	0.005										
1981				14	250.0	16.3	0.002										
1982				5	236.0	6.8	0.001										
1983				12	206.7	8.9	0.003				5	206.0	16.6	0.222	0.028		0.139
1984				0			0.001				2	230.0	0.0	0.000	0.500		0.500
1985				4	250.0	8.2	0.000				0			0.000	0.000		0.000
1986				8	262.5	8.4	0.001				0			0.000	0.000		0.000
1987				12	256.7	18.4	0.002				9	244.4	7.1	0.027	0.216		0.243
1988				3	250.0	20.0	0.001				103	220.6	4.0	0.398	0.171		0.507
1989				6	265.0	27.9	0.001				117	243.1	5.2	0.218	0.338		0.526
1990				12	252.5	6.4	0.003				96	234.3	5.9	0.195	0.140		0.290
1991				8	238.8	14.9	0.002				55	219.4	3.1	0.539	0.270		0.712
1992				20	219.0	7.4	0.004				35	207.7	6.8	0.443	0.131		0.328
1993				1	240.0	0.0	0.000				.			.	.		.
1994				21	220.5	7.0	0.005				.			.	.		.
1995				7	220.0	18.3	0.002				27	207.6	8.1	0.355	0.044		0.220
1996				15	216.0	8.9	0.004				9	206.7	18.3	0.128	0.042		0.126
1997				6	208.3	11.9	0.002				18	244.2	13.1	0.235	0.183		0.256
1998				4	222.5	14.4	0.002				17	230.3	12.3	0.142	0.142		0.225
1999											5	205.6	19.1	0.228	0.050		0.227

Appendix C35.-

margate

Haemulon album

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				21	224.3	5.1	0.001										
1979				6	345.0	47.8	0.003										
1980				8	475.0	36.2	0.002										
1981				12	337.5	26.7	0.002										
1982				44	289.3	11.7	0.006										
1983				18	365.6	29.0	0.002				0			0.000	0.000		0.000
1984				3	236.7	14.5	0.001				0			0.000	0.000		0.000
1985				20	266.0	16.4	0.003				0			0.000	0.000		0.000
1986				21	323.3	22.8	0.006				0			0.000	0.000		0.000
1987				21	316.7	20.8	0.004				0			0.000	0.000		0.000
1988				5	320.0	40.4	0.002				0			0.000	0.000		0.000
1989				7	282.9	28.5	0.001				0			0.000	0.000		0.000
1990				17	270.0	17.2	0.004				7	323.9	46.4	0.026	0.004		0.030
1991				4	380.0	41.0	0.000				0			0.000	0.000		0.000
1992				19	287.4	29.9	0.003				0			0.000	0.000		0.000
1993				7	392.9	20.1	0.001				.			.	.		.
1994				10	249.0	12.6	0.002				.			.	.		.
1995				2	565.0	15.0	0.000				0			0.000	0.000		0.000
1996				0			0.000				0			0.000	0.000		0.000
1997				6	270.0	34.2	0.002				0			0.000	0.000		0.000
1998				3	416.7	26.0	0.000				1	220.0	0.0	0.091	0.000		0.015
1999											0			0.000	0.000		0.000

Appendix C36.-

tomtate

Haemulon aurolineatum

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				0			0.000										
1979				0			0.000										
1980				5	176.0	14.4	0.001										
1981				1	170.0	0.0	0.000										
1982				2	210.0	10.0	0.001										
1983				8	168.8	4.4	0.002				1123	175.9	0.6	29.993	37.674		31.181
1984				0			0.001				0			0.000	3.750		0.000
1985				17	161.2	7.7	0.005				0			0.000	0.000		0.000
1986				0			0.000				2	160.0	0.0	6.536	19.607		0.261
1987				7	171.4	4.6	0.001				988	192.3	0.9	18.904	52.204		26.709
1988				23	169.6	6.2	0.004				642	164.3	0.4	8.267	6.629		2.318
1989				6	176.7	2.1	0.003				1004	176.5	0.8	12.867	7.469		5.595
1990				24	180.8	6.8	0.009				296	152.4	0.6	7.514	3.429		1.203
1991				0			0.000				42	153.5	0.8	0.677	0.677		0.432
1992				0			0.000				20	180.0	0.0	5.745	1.190		0.227
1993				0			0.000				.			.	.		.
1994				0			0.000				.			.	.		.
1995				0			0.000				67	157.7	1.1	4.391	0.760		0.667
1996				0			0.007				66	199.2	0.8	6.482	0.944		0.917
1997				0			0.000				102	195.8	0.8	3.150	1.700		1.692
1998				0			0.000				177	174.6	1.9	3.264	2.521		2.266
1999											5	180.6	6.0	0.000	0.500		0.450

Appendix C37.-

ceasar grunt

Haemulon carbonarium

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				0			0.000										
1979				1	240.0	0.0	0.000										
1980				1	210.0	0.0	0.001										
1981				0			0.000										
1982				0			0.001										
1983				1	200.0	0.0	0.000				0			0.000	0.000		0.000
1984				0			0.000				0			0.000	0.000		0.000
1985				3	313.3	41.8	0.000				0			0.000	0.000		0.000
1986				0			0.000				0			0.000	0.000		0.000
1987				9	217.8	12.4	0.002				0			0.000	0.000		0.000
1988				6	206.7	15.6	0.000				8	202.5	5.6	0.052	0.008		0.037
1989				4	235.0	2.9	0.001				17	210.0	10.2	0.117	0.023		0.063
1990				17	187.6	6.4	0.003				33	208.8	4.3	0.112	0.039		0.138
1991				3	230.0	10.0	0.001				2	230.0	20.0	0.024	0.010		0.024
1992				2	295.0	5.0	0.000				9	173.3	6.3	0.040	0.009		0.018
1993				14	228.6	7.6	0.004				.			.	.		.
1994				4	235.0	6.5	0.001				.			.	.		.
1995				2	200.0	10.0	0.002				3	210.0	20.0	0.587	0.010		0.021
1996				6	233.3	9.9	0.002				4	237.5	19.3	0.278	0.042		0.056
1997				6	250.0	12.6	0.001				18	236.4	5.5	0.233	0.225		0.300
1998				0			0.000				8	207.6	9.9	0.341	0.053		0.117
1999											0			0.000	0.000		0.000

Appendix C39.-

french grunt
Haemulon flavolineatum

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				0			0.000										
1979				0			0.002										
1980				0			0.000										
1981				3	240.0	5.8	0.000										
1982				4	185.0	6.5	0.003										
1983				6	186.7	11.2	0.001				70	183.4	2.4	4.139	1.361		1.944
1984				1	220.0	0.0	0.000				0			0.000	0.000		0.000
1985				42	243.1	5.8	0.009				0			0.000	0.000		0.000
1986				14	226.4	8.4	0.004				34	173.6	0.9	4.821	1.607		4.821
1987				6	191.7	7.9	0.001				49	206.1	3.7	1.216	1.135		1.324
1988				10	172.0	4.4	0.001				78	172.1	2.1	3.322	0.105		0.364
1989				1	280.0	0.0	0.000				269	187.0	1.9	3.239	0.849		1.357
1990				5	184.0	10.3	0.001				165	176.3	1.7	2.363	0.227		0.613
1991				3	246.7	12.0	0.002				20	186.5	5.3	2.865	0.142		0.260
1992				2	185.0	5.0	0.000				15	164.0	2.7	4.280	0.011		0.151
1993				1	170.0	0.0	0.000				.			.	.		.
1994				6	171.7	4.0	0.003				.			.	.		.
1995				3	176.7	3.3	0.008				316	219.6	1.3	3.288	1.573		1.677
1996				0			0.000				40	178.4	0.9	2.121	0.403		0.549
1997				1	160.0	0.0	0.000				34	192.4	2.0	3.508	0.542		0.565
1998				1	160.0	0.0	0.001				13	206.9	7.3	3.000	0.152		0.197
1999											8	173.5	5.6	0.931	0.052		0.209

Appendix C40.-

spanish grunt
Haemulon macrostomium

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				0			0.000										
1979				2	300.0	90.0	0.000										
1980				0			0.000										
1981				4	297.5	29.5	0.001										
1982				4	292.5	24.3	0.001										
1983				1	370.0	0.0	0.001				0			0.000	0.000		0.000
1984				1	240	0	0.000				0			0.000	0.000		0.000
1985				2	320.0	50.0	0.000				0			0.000	0.000		0.000
1986				3	300.0	5.8	0.000				0			0.000	0.000		0.000
1987				2	290.0	10.0	0.000				0			0.000	0.000		0.000
1988				5	286.0	9.3	0.001				2	280.0	50.0	0.008	0.004		0.076
1989				1	270.0	0.0	0.000				19	231.6	10.2	0.113	0.017		0.023
1990				2	345.0	85.0	0.000				11	288.2	17.9	0.024	0.029		0.000
1991				1	290.0	0.0	0.000				2	230.0	0.0	0.056	0.000		0.000
1992				0			0.000				1	270.0	0.0	0.000	0.009		0.188
1993				0			0.000				.			.	.		.
1994				2	240.0	10.0	0.000				.			.	.		.
1995				2	275.0	45.0	0.000				2	235.0	15.0	0.071	0.000		1.016
1996				2	285.0	15.0	0.000				3	293.3	29.6	0.028	0.028		0.014
1997				0			0.000				7	300.7	7.9	0.006	0.108		0.000
1998				1	290.0	0.0	0.000				2	233.3	13.3	0.189	0.000		0.000
1999											0			0.013	0.000		0.022

Appendix C42.-

sailors choice
Haemulon parra

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				2	205.0	5.0	0.001										
1979				4	280.0	16.3	0.004										
1980				19	232.6	9.5	0.005										
1981				23	268.3	7.5	0.003										
1982				0			0.002										
1983				14	255.7	6.4	0.004				0			0.000	0.000		0.000
1984				1	300.0	0.0	0.002				0			0.000	0.000		0.000
1985				8	233.8	9.4	0.003				0			0.000	0.000		0.000
1986				22	236.4	5.4	0.002				2	240.0	10.0	0.000	0.429		0.286
1987				48	266.5	4.2	0.007				3	260.0	10.0	0.000	0.081		0.081
1988				89	239.0	2.7	0.025				10	255.0	10.4	0.000	0.063		0.051
1989				37	263.0	6.0	0.014				25	231.0	7.8	0.000	0.109		0.065
1990				25	238.8	4.8	0.006				64	231.7	3.3	0.008	0.332		0.255
1991				18	241.7	5.3	0.007				1	300.0	0.0	0.000	0.035		0.010
1992				23	251.3	7.2	0.005				0			0.021	0.054		0.000
1993				33	241.8	3.9	0.017				.			.	.		.
1994				33	244.5	5.6	0.007				.			.	.		.
1995				50	222.4	2.9	0.019				3	216.7	16.7	0.000	0.047		0.036
1996				55	235.6	3.7	0.018				0			0.000	0.000		0.000
1997				16	238.1	6.5	0.012				4	254.3	8.9	0.000	0.065		0.058
1998				22	237.3	7.2	0.013				1	260.0	0.0	0.000	0.132		0.008
1999											1	260.0	0.0	0.000	0.025		0.013

Appendix C43.-

white grunt
Haemulon plumieri

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				1039	205.7	0.8	0.085										
1977				154	216.1	2.5	0.008										
1978				371	223.7	1.4	0.195										
1979				168	237.9	2.8	0.327										
1980				433	228.0	1.6	0.345										
1981				664	224.8	1.2	0.375										
1982				164	221.0	2.1	0.371										
1983				694	225.3	1.3	0.189				17	217.1	4.8	0.083	0.472		0.472
1984				320	215.5	1.6	0.173				0			0.000	0.000		0.000
1985				1391	224.6	0.8	0.256				0			0.000	0.000		0.000
1986				848	235.5	1.2	0.187				1	170.0	0.0	0.857	0.000		0.143
1987				706	237.4	1.3	0.184				47	227.0	5.4	0.520	1.155		1.264
1988				730	231.5	1.1	0.240				155	198.9	2.5	3.113	0.651		0.801
1989				584	224.9	1.1	0.202				521	205.0	1.6	2.854	1.065		1.128
1990				821	226.6	1.0	0.255				370	207.5	1.8	3.513	1.032		1.279
1991				414	221.1	1.3	0.117				95	210.9	2.1	0.396	1.210		1.266
1992				703	226.1	1.1	0.178				49	201.9	5.6	2.226	0.299		0.373
1993				953	220.3	0.8	0.308				.			.	.		.
1994				968	221.1	0.8	0.277				.			.	.		.
1995				383	219.6	1.2	0.227				196	189.7	2.0	12.014	0.538		1.613
1996				659	217.9	1.0	0.315				53	199.7	3.1	3.360	0.612		0.737
1997				382	219.9	1.1	0.183				81	222.0	3.8	2.700	1.115		1.242
1998				454	216.5	1.2	0.175				40	210.1	4.6	1.532	0.432		0.462
1999											10	192.6	7.3	1.125	0.215		0.316

Appendix C44.-

bluestriped grunt
Haemulon sciurus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				394	214.7	1.3	0.050										
1977				140	209.9	1.7	0.010										
1978				122	245.3	3.4	0.043										
1979				55	252.2	3.9	0.082										
1980				168	242.5	2.1	0.067										
1981				191	235.3	1.9	0.058										
1982				112	241.4	2.5	0.131										
1983				245	222.8	1.6	0.049				2	235.0	5.0	0.000	0.056		0.056
1984				183	230.8	2.1	0.061				1	230.0	0.0	0.000	0.250		0.250
1985				237	237.2	2.2	0.053				0			0.000	0.000		0.000
1986				202	240.0	1.9	0.041				0			0.286	0.000		0.000
1987				288	235.5	1.6	0.069				17	241.2	4.1	0.081	0.459		0.459
1988				206	230.0	1.8	0.061				56	214.1	5.0	0.151	0.079		0.178
1989				167	234.1	2.0	0.042				304	224.5	1.9	0.640	0.637		0.861
1990				211	226.6	1.7	0.059				247	232.1	3.0	1.580	0.351		0.664
1991				180	228.8	2.2	0.055				146	208.2	1.6	2.628	0.715		1.998
1992				321	231.3	1.5	0.068				64	199.6	3.2	2.083	0.029		0.429
1993				189	225.3	1.6	0.066				.			.	.		.
1994				233	225.3	1.5	0.054				.			.	.		.
1995				130	226.1	1.9	0.064				23	223.0	5.1	1.208	0.135		0.188
1996				194	226.7	1.5	0.076				40	216.6	3.9	1.457	0.225		0.564
1997				156	220.6	1.6	0.073				91	265.8	4.7	2.152	1.206		1.433
1998				81	226.3	2.9	0.056				33	204.9	5.2	0.811	0.106		0.295
1999											6	190.3	8.4	0.496	0.010		0.126

Appendix C45.-

striped grunt
Haemulon striatum

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				0			0.000										
1979				0			0.001										
1980				0			0.001										
1981				3	216.7	21.9	0.001										
1982				0			0.000										
1983				0			0.000				0			0.000	0.000		0.000
1984				0			0.000				0			0.000	0.000		0.000
1985				0			0.000				0			0.000	0.000		0.000
1986				0			0.000				0			0.000	0.000		0.000
1987				0			0.000				0			0.000	0.000		0.000
1988				0			0.000				0			0.000	0.000		0.000
1989				0			0.000				0			0.000	0.000		0.000
1990				3	253.3	18.6	0.001				0			0.005	0.000		0.000
1991				1	250.0	0.0	0.000				0			0.042	0.000		0.000
1992				0			0.000				0			0.000	0.000		0.000
1993				0			0.000				.			.	.		.
1994				3	223.3	18.6	0.000				.			.	.		.
1995				0			0.000				0			0.000	0.000		0.000
1996				0			0.000				0			0.000	0.000		0.000
1997				20	221.5	6.3	0.010				0			0.000	0.000		0.000
1998				47	227.4	4.1	0.025				0			0.000	0.000		0.000
1999											0			0.000	0.000		0.000

Appendix C46.-

pigfish
Orthopristis chrysoptera

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				5	194.0	6.8	0.000										
1977				0			0.000										
1978				0			0.000										
1979				0			0.001										
1980				2	265.0	5.0	0.000										
1981				0			0.000										
1982				1	230.0	0.0	0.000										
1983				9	232.2	5.2	0.002										
1984				0			0.000										
1985				0			0.000										
1986				5	184.0	5.1	0.001										
1987				2	225.0	55.0	0.001										
1988				0			0.000										
1989				0			0.000										
1990				6	178.3	4.0	0.003										
1991				0			0.000										
1992				0			0.000										
1993				0			0.000										
1994				0			0.000										
1995				0			0.000										
1996				0			0.000										
1997				0			0.000										
1998				0			0.000										
1999																	

Appendix C47.-

great barracuda
Sphyraena barracuda

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				179	553.1	13.9	0.040										
1977				38	722.6	37.5	0.028										
1978				138	622.8	18.0	0.028										
1979				38	554.7	27.2	0.030										
1980				88	581.0	23.2	0.053										
1981				54	666.5	28.7	0.036										
1982				44	583.2	39.4	0.038										
1983				66	591.7	28.5	0.023				0			0.000	0.000		0.000
1984				15	640.0	54.6	0.020				0			0.000	0.000		0.000
1985				79	610.5	21.6	0.018				2	1300.0	15.0	0.000	0.333		0.333
1986				123	597.8	20.6	0.026				1	600.0	0.0	0.143	0.000		0.143
1987				116	534.8	13.6	0.038				1	1100.0	0.0	0.000	0.027		0.027
1988				35	636.6	37.0	0.018				22	871.8	8.0	0.027	0.030		0.057
1989				50	539.4	31.6	0.029				97	754.5	2.6	0.086	0.065		0.151
1990				69	646.1	19.1	0.024				124	857.8	2.9	0.086	0.142		0.228
1991				83	554.6	18.2	0.026				92	923.5	3.1	0.448	0.514		0.962
1992				81	638.6	24.9	0.025				6	733.3	16.5	0.000	0.000		0.000
1993				73	650.0	24.1	0.022				.			.	.		.
1994				114	576.3	20.1	0.028				.			.	.		.
1995				47	516.2	26.4	0.027				25	886.0	5.6	0.179	0.097		0.204
1996				49	640.2	32.3	0.026				17	617.7	5.8	0.321	0.042		0.237
1997				53	592.8	28.0	0.024				3	824.0	15.3	0.071	0.017		0.038
1998				26	583.5	33.5	0.038				3	770.0	29.7	0.023	0.013		0.036
1999											0			0.000	0.000		0.000

Appendix C48.-

jolthead porgy
Calamus bajonado

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.018										
1977				0			0.085										
1978				27	317.4	12.8	0.145										
1979				4	312.5	14.9	0.099										
1980				29	285.2	9.9	0.082										
1981				132	290.9	4.8	0.073										
1982				86	305.8	5.7	0.039										
1983				87	290.8	5.5	0.028				2	240.0	0.0	0.056	0.000		0.056
1984				104	286.8	6.3	0.048				0			0.000	0.000		0.000
1985				229	318.7	4.2	0.039				0			0.000	0.000		0.000
1986				43	319.1	10.8	0.009				0			0.286	0.000		0.000
1987				59	318.3	9.3	0.013				0			0.000	0.000		0.000
1988				130	292.1	4.5	0.039				0			0.020	0.000		0.000
1989				80	323.4	6.5	0.023				6	233.3	1.1	0.013	0.000		0.002
1990				137	290.2	4.7	0.026				5	250.0	1.4	0.065	0.000		0.020
1991				77	281.9	4.3	0.023				0			0.000	0.000		0.000
1992				144	304.3	4.6	0.038				0			0.000	0.000		0.000
1993				58	298.4	8.2	0.018				.			.	.		.
1994				69	297.1	5.8	0.016				.			.	.		.
1995				24	282.9	10.9	0.011				0			0.000	0.000		0.000
1996				24	291.3	12.1	0.011				0			0.000	0.000		0.000
1997				23	310.0	10.2	0.009				0			0.000	0.000		0.000
1998				43	280.9	9.0	0.022				0			0.013	0.000		0.000
1999											0			0.000	0.000		0.000

Appendix C49.-

saucereye porgy
Calamus calamus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				0			0.000										
1979				0			0.000										
1980				31	303.9	10.1	0.017										
1981				125	271.9	5.6	0.038										
1982				26	262.7	9.5	0.004										
1983				44	265.0	5.9	0.005				0			0.000	0.000		0.000
1984				3	253.3	12.0	0.002				1	280.0	0.0	0.250	0.000		0.250
1985				144	268.9	3.7	0.020				0			0.000	0.000		0.000
1986				46	283.0	6.8	0.006				2	290.0	0.0	0.286	0.000		0.286
1987				17	275.9	11.6	0.002				7	210.7	0.7	0.243	0.000		0.189
1988				6	266.7	29.9	0.002				0			0.081	0.000		0.000
1989				13	233.1	8.3	0.004				8	230.0	1.3	0.050	0.000		0.026
1990				48	254.8	6.0	0.014				9	222.2	0.7	0.138	0.000		0.033
1991				21	282.9	11.4	0.005				2	275.0	2.5	0.028	0.000		0.028
1992				33	287.9	7.7	0.008				0			0.032	0.000		0.000
1993				54	250.9	6.4	0.023				.			.	.		.
1994				41	259.3	5.8	0.010				.			.	.		.
1995				11	257.3	12.8	0.006				5	250.0	2.2	0.179	0.000		0.031
1996				13	242.3	7.7	0.005				1	260.0	0.0	0.028	0.000		0.014
1997				2	240.0	30.0	0.001				3	225.0	1.8	0.110	0.000		0.027
1998				2	270.0	10.0	0.001				0			0.076	0.000		0.000
1999											3	233.7	1.9	0.351	0.000		0.106

Appendix C50.- **yellow jack**

Caranx bartholomaei

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				0			0.000										
1979				0			0.001										
1980				6	440.0	69.3	0.002										
1981				46	435.4	18.5	0.007										
1982				13	405.4	31.6	0.002										
1983				23	452.6	34.6	0.003				65	300.7	6.2	2.056	0.000		1.806
1984				3	360.0	45.8	0.001				0			0.000	0.000		0.000
1985				19	336.3	13.2	0.002				0			0.000	0.000		0.000
1986				16	451.3	29.8	0.001				0			0.000	0.000		0.000
1987				38	391.1	13.9	0.007				29	276.6	7.3	0.838	0.027		0.784
1988				44	389.5	18.6	0.010				19	340.0	15.4	0.558	0.004		0.187
1989				16	385.0	30.8	0.004				37	418.6	19.7	0.079	0.037		0.104
1990				45	399.8	18.5	0.006				61	385.4	11.6	0.063	0.043		0.106
1991				27	388.9	17.4	0.005				3	450.0	28.9	0.010	0.021		0.031
1992				52	382.3	12.2	0.009				71	250.0	0.0	0.060	0.000		0.000
1993				60	317.0	9.7	0.010				.			.	.		.
1994				36	363.1	17.3	0.004				.			.	.		.
1995				18	371.7	21.9	0.001				7	307.1	20.4	0.119	0.000		0.067
1996				15	372.0	21.7	0.003				1	330.0	0.0	0.014	0.000		0.014
1997				10	395.0	19.0	0.006				9	338.9	10.9	0.042	0.000		0.042
1998				14	330.7	9.4	0.006				7	303.2	26.5	0.114	0.015		0.030
1999											0			0.013	0.000		0.000

Appendix C51.- **blue runner**

Caranx crysos

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				1	300.0	0.0	0.011										
1977				1	440.0	0.0	0.007										
1978				0			0.004										
1979				0			0.015										
1980				29	282.1	20.3	0.022										
1981				113	260.7	6.3	0.042										
1982				86	251.6	4.7	0.041										
1983				155	250.7	3.9	0.033				22	303.6	20.6	0.611	0.000		0.611
1984				14	279.3	18.9	0.023				0			0.000	0.000		0.000
1985				91	282.7	7.4	0.033				0			0.667	0.000		0.000
1986				237	260.1	4.5	0.047				0			0.000	0.000		0.000
1987				183	259.5	3.7	0.045				2	210.0	10.0	0.054	0.000		0.054
1988				127	250.7	3.6	0.045				10	300.0	9.1	0.058	0.000		0.058
1989				102	263.0	5.1	0.031				91	223.5	5.0	0.079	0.000		0.079
1990				72	261.1	4.5	0.037				183	302.1	6.4	0.704	0.042		0.738
1991				78	245.4	5.4	0.027				0			0.028	0.000		0.000
1992				99	250.0	3.6	0.021				2	180.0	20.0	0.000	0.000		0.000
1993				70	268.1	5.3	0.030				.			.	.		.
1994				98	245.6	3.3	0.055				.			.	.		.
1995				65	231.4	5.2	0.032				30	250.0	3.9	0.313	0.000		0.313
1996				99	241.6	3.2	0.035				23	300.0	0.0	0.319	0.000		0.319
1997				73	243.6	3.4	0.056				20	183.0	3.2	0.250	0.000		0.250
1998				136	246.1	3.2	0.098				4	257.1	11.1	0.045	0.000		0.045
1999											10	226.0	6.4	0.250	0.000		0.250

Appendix C52.-

crevalle jack
Caranx hippos

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				0			0.000										
1979				0			0.004										
1980				3	486.7	63.6	0.004										
1981				0			0.002										
1982				12	285.8	18.6	0.009										
1983				13	400.8	26.0	0.009										
1984				1	270.0	0.0	0.000										
1985				2	245.0	45.0	0.001										
1986				4	282.5	17.5	0.001										
1987				5	340.0	41.5	0.001										
1988				9	236.7	5.8	0.000										
1989				3	320.0	110.0	0.001										
1990				4	410.0	51.2	0.002										
1991				0			0.000										
1992				1	250.0	0.0	0.001										
1993				3	433.3	83.5	0.002										
1994				9	343.3	22.4	0.008										
1995				2	260.0	10.0	0.000										
1996				2	320.0	40.0	0.002										
1997				1	390.0	0.0	0.000										
1998				2	255.0	15.0	0.004										
1999																	

Appendix C53.-

horse-eye jack
Caranx latus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				0			0.000										
1979				0			0.000										
1980				1	290.0	0.0	0.001										
1981				4	430.0	63.4	0.001										
1982				1	310.0	0.0	0.000										
1983				6	296.7	16.7	0.001										
1984				0			0.000										
1985				2	630.0	30.0	0.002										
1986				2	425.0	85.0	0.001										
1987				0			0.000										
1988				0			0.000										
1989				0			0.000										
1990				0			0.000										
1991				1	240.0	0.0	0.000										
1992				0			0.000										
1993				0			0.000										
1994				0			0.000										
1995				1	690.0	0.0	0.000										
1996				0			0.000										
1997				0			0.000										
1998				0			0.000										
1999																	

Appendix C54.-

bar jack
Caranx ruber

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				1	320.0	0.0	0.000										
1979				0			0.000										
1980				2	525.0	125.0	0.000										
1981				15	326.0	23.1	0.002										
1982				1	320.0	0.0	0.001										
1983				2	330.0	40.0	0.001				45	310.0	4.1	2.639	1.250		1.250
1984				0			0.000				0			3.500	0.000		0.000
1985				7	348.6	17.9	0.002				0			0.000	0.000		0.000
1986				7	391.4	17.9	0.001				1	250.0	0.0	0.143	0.143		0.143
1987				8	350.0	21.2	0.001				1	320.0	0.0	3.568	0.027		0.027
1988				5	400.0	20.5	0.000				14	262.0	6.4	1.950	0.051		0.051
1989				1	280.0	0.0	0.000				77	255.2	2.1	1.694	0.297		0.297
1990				5	338.0	41.9	0.001				84	403.7	18.3	1.777	0.361		0.361
1991				4	270.0	0.0	0.001				8	266.3	6.0	1.901	0.092		0.092
1992				4	305.0	42.7	0.000				6	266.4	9.1	1.705	0.047		0.047
1993				9	331.1	26.1	0.006				.			.	.		.
1994				11	367.3	14.9	0.000				.			.	.		.
1995				0			0.000				20	286.9	13.2	1.226	0.190		0.190
1996				2	345.0	15.0	0.000				10	250.0	0.0	4.864	0.139		0.139
1997				5	344.0	21.6	0.001				4	295.0	19.8	0.167	0.021		0.021
1998				3	330.0	17.3	0.002				3	322.0	34.4	1.847	0.038		0.038
1999											2	312.5	108.3	0.061	0.163		0.163

Appendix C55.-

bermuda chub
Kyphosus sectatrix

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				0			0.000										
1979				0			0.004										
1980				6	340.0	49.3	0.010										
1981				30	280.3	19.5	0.005										
1982				21	264.3	11.7	0.006										
1983				17	223.5	10.4	0.002				0			0.000	0.000		0.000
1984				7	250.0	20.8	0.002				0			0.000	0.000		0.000
1985				11	252.7	16.2	0.001				0			0.000	0.000		0.000
1986				11	304.5	39.8	0.002				0			0.000	0.000		0.000
1987				16	276.3	17.9	0.003				0			0.000	0.000		0.000
1988				0			0.000				186	285.1	3.8	0.840	0.000		0.833
1989				0			0.000				323	275.0	2.3	1.059	0.000		1.049
1990				1	250.0	0.0	0.002				74	275.8	4.7	0.314	0.000		0.298
1991				14	370.0	13.1	0.002				194	249.3	4.1	2.806	0.000		2.100
1992				6	278.3	23.3	0.001				8	298.8	20.6	0.055	0.000		0.046
1993				12	261.7	13.6	0.004				.			.	.		.
1994				4	290.0	15.8	0.001				.			.	.		.
1995				0			0.000				178	239.2	2.9	2.912	0.000		2.192
1996				0			0.000				132	256.8	4.2	2.602	0.000		1.836
1997				0			0.000				47	261.7	6.0	0.850	0.000		0.694
1998				19	280.0	14.3	0.016				26	223.4	10.5	0.591	0.000		0.392
1999											2	206.7	22.3	0.300	0.000		0.225

Appendix C56.-

gray angelfish
Pomacanthus arcuatus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976																	
1977																	
1978																	
1979																	
1980																	
1981																	
1982																	
1983											2	350.0	0.0	0.306	0.056		
1984											1	380.0	0.0	0.250	0.250		
1985											0			0.000	0.000		
1986											0			0.286	0.000		
1987											5	392.0	15.0	0.162	0.135		
1988											10	370.0	5.6	0.552	0.044		
1989											18	371.8	6.9	0.358	0.028		
1990											33	367.3	4.5	0.513	0.079		
1991											0			0.334	0.000		
1992											4	397.5	18.9	0.315	0.023		
1993											.			.	.		
1994											.			.	.		
1995											0			0.390	0.000		
1996											3	360.0	10.0	0.399	0.042		
1997											2	357.5	13.0	0.600	0.017		
1998											3	365.0	12.7	0.174	0.021		
1999											0			0.163	0.000		

Appendix C59.-

blue parrotfish
Scarus coeruleus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976																	
1977																	
1978																	
1979																	
1980																	
1981																	
1982																	
1983											0			0.028	0.000		
1984											0			0.000	0.000		
1985											0			0.000	0.000		
1986											0			0.000	0.000		
1987											0			0.027	0.000		
1988											0			0.075	0.000		
1989											0			0.066	0.000		
1990											0			0.106	0.000		
1991											0			0.049	0.000		
1992											0			0.048	0.000		
1993											.			.	.		
1994											.			.	.		
1995											0			0.070	0.000		
1996											0			0.083	0.000		
1997											0			0.008	0.000		
1998											0			0.114	0.000		
1999											0			0.074	0.000		

Appendix C61.-

rainbow parrotfish
Scarus guacamaia

	CREEL Survey Data							RVC Survey Data								
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976																	
1977																	
1978																	
1979																	
1980																	
1981																	
1982																	
1983											0			0.000	0.000		
1984											0			0.000	0.000		
1985											0			0.000	0.000		
1986											0			0.000	0.000		
1987											0			0.000	0.000		
1988											0			0.039	0.000		
1989											5	650.0	0.0	0.060	0.011		
1990											0			0.032	0.000		
1991											0			0.014	0.000		
1992											0			0.028	0.000		
1993											.			.	.		
1994											.			.	.		
1995											0			0.071	0.000		
1996											0			0.083	0.000		
1997											0			0.050	0.000		
1998											0			0.087	0.000		
1999											0			0.000	0.000		

Appendix C62.-

princess parrotfish
Scarus taeniopterus

	CREEL Survey Data							RVC Survey Data								
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976																	
1977																	
1978																	
1979																	
1980																	
1981																	
1982																	
1983											0			0.278	0.000		
1984											0			0.000	0.000		
1985											0			0.000	0.000		
1986											0			0.000	0.000		
1987											18	277.9	11.0	1.662	0.473		
1988											14	277.1	13.9	0.689	0.064		
1989											19	241.1	6.2	1.264	0.095		
1990											6	280.0	15.3	5.579	0.025		
1991											6	250.0	12.9	1.868	0.076		
1992											30	259.3	5.0	3.395	0.295		
1993											.			.	.		
1994											.			.	.		
1995											1	280.0	0.0	1.224	0.005		
1996											1	240.0	0.0	2.398	0.014		
1997											1	250.0	0.0	1.506	0.015		
1998											0			1.174	0.000		
1999											2	300.8	33.3	0.218	0.058		

Appendix C63.-

queen parrotfish
Scarus vetula

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976																	
1977																	
1978																	
1979																	
1980																	
1981																	
1982																	
1983											0			0.000	0.000		
1984											0			0.000	0.000		
1985											0			0.000	0.000		
1986											0			0.000	0.000		
1987											4	405.0	21.0	0.081	0.108		
1988											10	365.0	11.6	0.111	0.050		
1989											39	383.1	7.1	0.362	0.135		
1990											20	366.5	8.9	0.115	0.083		
1991											13	377.7	10.2	0.256	0.141		
1992											1	320.0	0.0	0.078	0.011		
1993											.			.	.		
1994											.			.	.		
1995											5	350.0	13.8	0.266	0.047		
1996											8	337.5	6.2	0.264	0.111		
1997											2	353.3	48.1	0.056	0.025		
1998											9	340.0	11.7	0.341	0.129		
1999											0			0.013	0.000		

Appendix C64.-

greenblotch parrotfish
Sparisoma atomarium

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976																	
1977																	
1978																	
1979																	
1980																	
1981																	
1982																	
1983											0			0.000	0.000		
1984											0			0.000	0.000		
1985											0			0.000	0.000		
1986											0			0.000	0.000		
1987											0			0.000	0.000		
1988											0			0.000	0.000		
1989											0			0.033	0.000		
1990											0			0.090	0.000		
1991											0			0.146	0.000		
1992											0			0.222	0.000		
1993											.			.	.		
1994											.			.	.		
1995											0			0.479	0.000		
1996											0			0.139	0.000		
1997											0			0.306	0.000		
1998											0			0.273	0.000		
1999											0			0.075	0.000		

Appendix C65.-

redband parrotfish

Sparisoma aurofrenatum

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976																	
1977																	
1978																	
1979																	
1980																	
1981																	
1982																	
1983											15	186.7	4.9	1.806	0.417		
1984											14	223.6	10.8	0.000	3.500		
1985											0			0.000	0.000		
1986											5	260.6	10.7	1.500	0.643		
1987											27	216.8	9.0	1.811	0.730		
1988											150	206.9	2.5	5.050	0.722		
1989											266	208.5	1.9	4.712	1.072		
1990											134	212.1	2.4	5.054	0.541		
1991											46	198.9	3.8	3.938	0.569		
1992											43	207.8	3.5	3.577	0.403		
1993											.			.	.		
1994											.			.	.		
1995											56	208.3	4.3	4.276	0.410		
1996											64	219.1	4.1	6.514	0.885		
1997											47	208.1	4.5	4.386	0.666		
1998											27	218.2	6.7	5.706	0.409		
1999											24	201.3	6.0	3.699	0.660		

Appendix C65.-

redband parrotfish

Sparisoma aurofrenatum

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976																	
1977																	
1978																	
1979																	
1980																	
1981																	
1982																	
1983											15	186.7	4.9	1.806	0.417		
1984											14	223.6	10.8	0.000	3.500		
1985											0			0.000	0.000		
1986											5	260.6	10.7	1.500	0.643		
1987											27	216.8	9.0	1.811	0.730		
1988											150	206.9	2.5	5.050	0.722		
1989											266	208.5	1.9	4.712	1.072		
1990											134	212.1	2.4	5.054	0.541		
1991											46	198.9	3.8	3.938	0.569		
1992											43	207.8	3.5	3.577	0.403		
1993											.			.	.		
1994											.			.	.		
1995											56	208.3	4.3	4.276	0.410		
1996											64	219.1	4.1	6.514	0.885		
1997											47	208.1	4.5	4.386	0.666		
1998											27	218.2	6.7	5.706	0.409		
1999											24	201.3	6.0	3.699	0.660		

Appendix C68.-

redfin parrotfish
Sparisoma rubripinne

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976																	
1977																	
1978																	
1979																	
1980																	
1981																	
1982																	
1983											0			0.361	0.000		
1984											0			0.250	0.000		
1985											0			0.000	0.000		
1986											0			0.000	0.000		
1987											2	360.0	40.0	0.270	0.054		
1988											13	382.3	31.0	0.055	0.060		
1989											46	347.0	6.7	0.309	0.182		
1990											18	341.7	9.4	0.041	0.077		
1991											2	425.0	25.0	0.093	0.021		
1992											6	330.0	14.4	0.106	0.057		
1993											.			.	.		
1994											.			.	.		
1995											9	331.1	16.5	0.291	0.089		
1996											6	365.0	15.2	0.328	0.083		
1997											8	313.1	8.2	0.173	0.133		
1998											6	317.5	8.8	0.265	0.091		
1999											3	325.0	16.2	0.089	0.093		

Appendix C69.-

stoplight parrotfish
Sparisoma viride

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976																	
1977																	
1978																	
1979																	
1980																	
1981																	
1982																	
1983											0			0.861	0.000		
1984											0			0.250	0.000		
1985											0			0.000	0.000		
1986											0			0.000	0.000		
1987											9	405.6	1.1	0.946	0.243		
1988											43	410.2	0.4	1.776	0.167		
1989											60	406.2	0.4	1.782	0.250		
1990											57	414.9	0.4	1.980	0.240		
1991											20	407.5	0.5	1.947	0.236		
1992											5	400.0	0.0	1.644	0.037		
1993											.			.	.		
1994											.			.	.		
1995											4	395.0	0.3	1.805	0.031		
1996											2	400.0	0.0	2.987	0.028		
1997											2	410.0	1.2	2.773	0.023		
1998											2	400.0	0.0	2.314	0.030		
1999											2	477.5	15.8	1.264	0.049		

Appendix C70.-

grey triggerfish
Balistes capriscus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	**n**	**Legal**	**S.E.**	**n**	**Actual**	**S.E.**	**Actual**	**n**	**Legal**	**S.E.**	**n**	**Actual**	**S.E.**	**IM**	**Mat**	**Legal**	**Actual**
1976	0			0			0.000										
1977	0			0			0.000										
1978	0			0			0.000										
1979	0			0			0.000										
1980	1	220.0	0.0	1	220.0	0.0	0.002										
1981	3	293.3	23.3	3	293.3	23.3	0.001										
1982	15	373.3	28.6	15	373.3	28.6	0.006										
1983	14	323.6	18.0	14	323.6	18.0	0.002	0			0			0.000	0.000	0.000	0.000
1984	2	365.0	15.0	2	365.0	15.0	0.002	0			0			0.000	0.000	0.000	0.000
1985	7	344.3	22.2	7	344.3	22.2	0.000	0			0			0.000	0.000	0.000	0.000
1986	3	416.7	38.4	3	416.7	38.4	0.001	0			0			0.000	0.000	0.000	0.000
1987	15	322.7	22.9	15	322.7	22.9	0.002	0			0			0.000	0.000	0.000	0.000
1988	15	311.3	17.2	15	311.3	17.2	0.003	0			0			0.000	0.000	0.000	0.000
1989	5	298.0	13.2	5	298.0	13.2	0.002	8	247.5	8.6	8	247.5	8.6	0.058	0.000	0.036	0.036
1990	8	315.0	14.3	8	315.0	14.3	0.001	1	300.0	0.0	1	300.0	0.0	0.004	0.000	0.004	0.004
1991	27	399.3	18.3	27	399.3	18.3	0.013	0			0			0.000	0.000	0.000	0.000
1992	17	405.3	14.6	17	405.3	14.6	0.004	1	240.0	0.0	1	240.0	0.0	0.011	0.000	0.011	0.011
1993	28	352.5	11.3	28	352.5	11.3	0.013	.			.			.	.	.	.
1994	17	386.5	10.3	25	341.6	15.1	0.008	.			.			.	.	.	.
1995	3	400.0	30.6	4	367.5	39.0	0.001	0			0			0.000	0.000	0.000	0.000
1996	3	366.7	14.5	4	340.0	28.6	0.001	0			1	250.0	0.0	0.042	0.000	0.000	0.014
1997	1	430.0	0.0	7	272.9	26.7	0.002	0			0			0.000	0.000	0.000	0.000
1998	2	405.0	45.0	3	343.3	66.9	0.001	0			0			0.000	0.000	0.000	0.000
1999								0			0			0.138	0.000	0.000	0.000

Appendix C71.-

queen triggerfish
Balistes vetula

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	**n**	**Legal**	**S.E.**	**n**	**Actual**	**S.E.**	**Actual**	**n**	**Legal**	**S.E.**	**n**	**Actual**	**S.E.**	**IM**	**Mat**	**Legal**	**Actual**
1976				0			0.000										
1977				0			0.000										
1978				0			0.000										
1979				0			0.001										
1980				3	326.7	33.8	0.001										
1981				7	337.1	20.0	0.001										
1982				1	300.0	0.0	0.001										
1983				7	337.1	15.8	0.001				0			0.000	0.000		0.000
1984				0			0.000				0			0.000	0.000		0.000
1985				3	360.0	60.0	0.001				0			0.000	0.000		0.000
1986				2	285.0	45.0	0.000				0			0.000	0.000		0.000
1987				6	325.0	16.9	0.002				1	260.0	0.0	0.027	0.000		0.027
1988				1	250.0	0.0	0.000				3	293.3	6.7	0.020	0.000		0.020
1989				7	317.1	6.1	0.004				8	323.8	8.4	0.021	0.000		0.021
1990				10	323.0	10.4	0.002				3	383.3	16.7	0.012	0.000		0.012
1991				4	325.0	17.6	0.001				2	360.0	10.0	0.072	0.000		0.021
1992				1	270.0	0.0	0.000				0			0.000	0.000		0.000
1993				9	292.2	11.2	0.004				.			.	.		.
1994				6	331.7	20.6	0.002				.			.	.		.
1995				0			0.000				0			0.000	0.000		0.000
1996				1	370.0	0.0	0.000				1	250.0	0.0	0.042	0.000		0.014
1997				3	286.7	29.1	0.005				1	305.0	0.0	0.027	0.000		0.015
1998				1	260.0	0.0	0.000				0			0.000	0.000		0.000
1999											1	283.8	89.2	0.148	0.000		0.040

Appendix C72.-

ocean triggerfish
Cantherhines sufflamen

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				0			0.000										
1979				0			0.011										
1980				16	412.5	14.8	0.014										
1981				44	436.8	10.7	0.005										
1982				1	290.0	0.0	0.001										
1983				23	443.0	12.4	0.008				0			0.000	0.000		0.000
1984				1	420.0	0.0	0.001				0			0.000	0.000		0.000
1985				19	386.8	23.8	0.004				0			0.000	0.000		0.000
1986				28	439.6	9.7	0.005				0			0.000	0.000		0.000
1987				20	364.0	14.2	0.003				1	420.0	0.0	0.000	0.027		0.027
1988				34	399.4	9.8	0.010				8	348.8	24.6	0.025	0.019		0.044
1989				16	426.3	13.4	0.005				5	382.0	15.6	0.010	0.012		0.022
1990				38	408.7	10.0	0.008				2	350.0	0.0	0.008	0.000		0.008
1991				5	346.0	43.4	0.001				1	400.0	0.0	0.000	0.010		0.010
1992				28	399.6	13.4	0.003				2	300.0	0.0	0.023	0.000		0.023
1993				12	421.7	19.3	0.003				.			.	.		.
1994				4	490.0	56.1	0.001				.			.	.		.
1995				12	398.3	13.1	0.008				0			0.000	0.000		0.000
1996				6	430.0	12.4	0.001				1	300.0	0.0	0.014	0.000		0.014
1997				3	523.3	14.5	0.000				2	340.0	50.5	0.033	0.008		0.033
1998				6	428.3	36.6	0.002				0			0.000	0.000		0.000
1999											0			0.000	0.000		0.000

Appendix C74.-

doctorfish
Acanthurus chirurgus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				0			0.000										
1979				0			0.000										
1980				0			0.000										
1981				0			0.000										
1982				0			0.000										
1983				1	230.0	0.0	0.001				41	239.8	4.6	2.632	1.146		1.146
1984				0			0.003				5	278.0	17.1	3.500	1.250		1.250
1985				1	270.0	0.0	0.000				0			0.000	0.000		0.000
1986				4	220.0	10.8	0.001				0			0.000	0.000		0.000
1987				6	255.0	8.5	0.001				9	293.3	21.5	0.216	0.243		0.243
1988				1	260.0	0.0	0.000				95	264.9	3.4	0.113	0.407		0.407
1989				4	252.5	36.4	0.001				106	247.6	3.8	0.219	0.234		0.234
1990				6	280.0	9.7	0.001				74	258.5	4.4	0.449	0.092		0.092
1991				0			0.000				8	208.8	6.4	0.774	0.105		0.105
1992				0			0.000				5	264.0	35.3	0.705	0.044		0.044
1993				0			0.000				.			.	.		.
1994				0			0.000				.			.	.		.
1995				3	243.3	3.3	0.001				13	216.2	4.7	0.583	0.097		0.097
1996				1	250.0	0.0	0.003				4	205.0	5.0	2.192	0.056		0.056
1997				3	246.7	14.5	0.001				22	221.9	7.7	1.549	0.282		0.282
1998				3	260.0	11.5	0.002				15	262.4	7.0	0.621	0.200		0.200
1999											7	223.6	12.9	2.027	0.232		0.232

Appendix C75.-

spotted seatrout

Cynoscion nebulosus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				33	357.3	9.2	0.002										
1977				18	443.9	7.8	0.016										
1978				43	374.0	8.6	0.034										
1979				14	382.1	14.1	0.018										
1980				34	412.1	11.6	0.011										
1981				19	425.8	18.1	0.007										
1982				144	375.3	5.2	0.028										
1983				119	349.0	5.1	0.017										
1984				31	356.1	9.2	0.024										
1985				24	356.3	11.2	0.009										
1986				9	372.2	17.7	0.003										
1987				10	412.0	17.7	0.002										
1988				0			0.000										
1989				1	510.0	0.0	0.002										
1990				0			0.000										
1991				0			0.000										
1992				7	381.4	6.7	0.016										
1993				0			0.000										
1994				2	360.0	10.0	0.008										
1995				12	377.5	6.3	0.019										
1996				0			0.000										
1997				0			0.000										
1998				9	407.8	9.2	0.011										
1999																	

Appendix C76.-

permit

Trachinotus falcatus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	0			0			0.000										
1977	0			0			0.000										
1978	0			0			0.000										
1979	1	1010.0	0.0	1	1010.0	0.0	0.000										
1980	0			0			0.000										
1981	3	643.3	63.3	3	643.3	63.3	0.001										
1982	1	270.0	0.0	1	270.0	0.0	0.000										
1983	3	723.3	26.7	3	723.3	26.7	0.000	0			0			0.000	0.000	0.000	0.000
1984	2	585.0	85.0	2	585.0	85.0	0.001	0			0			0.000	0.000	0.000	0.000
1985	1	710.0	0.0	1	710.0	0.0	0.000	0			0			0.000	0.000	0.000	0.000
1986	1	580.0	0.0	1	580.0	0.0	0.000	0			0			0.000	0.000	0.000	0.000
1987	0			0			0.000	0			0			0.000	0.000	0.000	0.000
1988	3	476.7	27.3	3	476.7	27.3	0.000	0			0			0.000	0.000	0.000	0.000
1989	0			0			0.000	0			0			0.000	0.000	0.000	0.000
1990	6	573.3	40.1	6	573.3	40.1	0.001	2	500.0	0.0	2	500.0	0.0	0.008	0.000	0.008	0.008
1991	0			0			0.000	0			0			0.000	0.000	0.000	0.000
1992	1	700.0	0.0	1	700.0	0.0	0.000	0			0			0.000	0.000	0.000	0.000
1993	0			0			0.000	.			.			.	.	.	.
1994	0			0			0.000	.			.			.	.	.	.
1995	0			0			0.000	0			0			0.000	0.000	0.000	0.000
1996	0			0			0.000	0			0			0.000	0.000	0.000	0.000
1997	0			0			0.000	0			0			0.000	0.000	0.000	0.000
1998	1	680.0	0.0	1	680.0	0.0	0.000	0			0			0.000	0.000	0.000	0.000
1999								0			0			0.000	0.000	0.000	0.000

Appendix C77.-

african pompano
Alectis ciliaris

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	0			0			0.000										
1977	0			0			0.000										
1978	0			0			0.000										
1979	1	680.0	0.0	1	680.0	0.0	0.001										
1980	1	300.0	0.0	1	300.0	0.0	0.000										
1981	0			0			0.000										
1982	2	465.0	115.0	2	465.0	115.0	0.001										
1983	1	500.0	0.0	1	500.0	0.0	0.000										
1984	0			0			0.000										
1985	7	384.3	30.9	7	384.3	30.9	0.004										
1986	3	526.7	80.9	3	526.7	80.9	0.006										
1987	0			0			0.000										
1988	1	620.0	0.0	1	620.0	0.0	0.001										
1989	0			0			0.000										
1990	2	800.0	10.0	2	800.0	10.0	0.001										
1991	6	335.0	8.5	6	335.0	8.5	0.001										
1992	0			0			0.000										
1993	0			0			0.000										
1994	0			0			0.000										
1995	0			0			0.000										
1996	0			0			0.000										
1997	0			0			0.000										
1998	0			0			0.000										
1999																	

Appendix C78.-

dolphin
Coryphaena hippurus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				422	567.6	9.0	0.464										
1977				167	612.9	12.9	0.299										
1978				297	614.2	10.4	0.315										
1979				118	642.9	20.3	0.242										
1980				220	614.9	12.7	0.188										
1981				493	567.9	8.7	0.386										
1982				344	601.7	7.9	0.480										
1983				248	661.9	13.3	0.302										
1984				5	660.0	93.8	0.107										
1985				561	583.3	4.9	0.335										
1986				388	724.0	8.5	0.218										
1987				148	614.9	14.5	0.151										
1988				218	563.8	9.2	0.206										
1989				493	532.3	5.8	0.552										
1990				365	590.9	8.4	0.213										
1991				448	590.4	7.0	0.222										
1992				458	576.4	8.3	0.225										
1993				443	527.9	6.2	0.304										
1994				506	566.0	5.7	0.297										
1995				166	657.5	13.8	0.258										
1996				222	575.8	11.6	0.253										
1997				202	538.2	10.1	0.290										
1998				11	596.4	28.2	0.214										
1999																	

Appendix C79.-

atlantic bonito
Sarda sarda

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.023										
1977				0			0.015										
1978				0			0.010										
1979				0			0.008										
1980				7	475.7	16.6	0.012										
1981				28	542.1	28.1	0.011										
1982				4	422.5	68.0	0.005										
1983				6	478.3	101.4	0.003										
1984				0			0.000										
1985				3	636.7	55.5	0.001										
1986				28	425.4	31.8	0.010										
1987				0			0.000										
1988				0			0.000										
1989				3	316.7	16.7	0.001										
1990				0			0.000										
1991				4	715.0	55.2	0.002										
1992				1	670.0	0.0	0.000										
1993				1	620.0	0.0	0.000										
1994				0			0.001										
1995				0			0.000										
1996				0			0.000										
1997				1	450.0	0.0	0.002										
1998				0			0.000										
1999																	

Appendix C80.-

little tunny
Euthynnus alletteratus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				0			0.000										
1979				0			0.002										
1980				0			0.000										
1981				0			0.000										
1982				1	490.0	0.0	0.000										
1983				13	578.5	25.1	0.002										
1984				0			0.000										
1985				4	677.5	70.8	0.001										
1986				1	370.0	0.0	0.000										
1987				12	503.3	44.5	0.003										
1988				7	452.9	73.8	0.003										
1989				6	651.7	40.0	0.002										
1990				11	446.4	52.5	0.002										
1991				11	569.1	50.4	0.002										
1992				8	570.0	50.6	0.002										
1993				15	444.0	35.5	0.007										
1994				18	476.7	33.4	0.004										
1995				2	475.0	175.0	0.001										
1996				18	620.0	42.1	0.006										
1997				2	490.0	180.0	0.001										
1998				6	423.3	38.7	0.006										
1999																	

Appendix C81.-

sailfish

Istiophorus platypterus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				1	1750	0	0.002										
1977				0			0.001										
1978				0			0.002										
1979				1	1750.0	0.0	0.001										
1980				2	1740.0	60.0	0.002										
1981				1	1650.0	0.0	0.002										
1982				2	1870.0	140.0	0.002										
1983				4	1875.0	97.2	0.002										
1984				0			0.000										
1985				5	1708.0	75.6	0.001										
1986				1	2450.0	0.0	0.001										
1987				1	1870.0	0.0	0.001										
1988				1	1590.0	0.0	0.002										
1989				1	1670.0	0.0	0.001										
1990				1	1590.0	0.0	0.000										
1991				1	1750.0	0.0	0.001										
1992				0			0.001										
1993				1	1780.0	0.0	0.000										
1994				2	1615.0	35.0	0.001										
1995				1	1600.0	0.0	0.002										
1996				1	1700.0	0.0	0.001										
1997				0			0.000										
1998				0			0.000										
1999																	

Appendix C82.-

skipjack tuna

Katsuwonus pelamis

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				0			0.000										
1979				0			0.002										
1980				0			0.000										
1981				0			0.000										
1982				0			0.000										
1983				11	590.9	21.1	0.002										
1984				1	500.0	0.0	0.003										
1985				0			0.000										
1986				0			0.000										
1987				3	660.0	47.3	0.002										
1988				1	640.0	0.0	0.000										
1989				0			0.002										
1990				7	625.7	25.4	0.002										
1991				0			0.000										
1992				5	560.0	10.5	0.003										
1993				2	530.0	20.0	0.001										
1994				3	606.7	58.1	0.002										
1995				0			0.000										
1996				2	585.0	55.0	0.003										
1997				1	650.0	0.0	0.001										
1998				1	610.0	0.0	0.000										
1999																	

Appendix C83.-

blackfin tuna
Thunnus atlanticus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.000										
1977				0			0.000										
1978				0			0.000										
1979				0			0.000										
1980				1	580.0	0.0	0.005										
1981				0			0.001										
1982				3	520.0	65.1	0.003										
1983				2	460.0	20.0	0.001										
1984				0			0.002										
1985				1	730.0	0.0	0.001										
1986				7	588.6	71.9	0.002										
1987				0			0.000										
1988				0			0.000										
1989				0			0.000										
1990				1	800.0	0.0	0.001										
1991				0			0.000										
1992				1	780.0	0.0	0.000										
1993				5	594.0	51.0	0.004										
1994				1	320.0	0.0	0.001										
1995				0			0.000										
1996				0			0.000										
1997				2	560.0	0.0	0.002										
1998				2	365.0	15.0	0.006										
1999																	

Appendix C84.-

king mackerel
Scomberomorus cavalla

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	42	741.7	20.4	42	741.7	20.4	0.000										
1977	11	733.6	35.3	11	733.6	35.3	0.000										
1978	6	720.0	58.0	6	720.0	58.0	0.001										
1979	6	721.7	79.4	6	721.7	79.4	0.005										
1980	9	834.4	42.2	9	834.4	42.2	0.010										
1981	10	757.0	66.1	10	757.0	66.1	0.007										
1982	11	821.8	36.4	11	821.8	36.4	0.007										
1983	9	731.1	26.4	9	731.1	26.4	0.006										
1984	0			0			0.007										
1985	7	931.4	75.3	7	931.4	75.3	0.003										
1986	2	910.0	40.0	2	910.0	40.0	0.002										
1987	9	747.8	48.9	9	747.8	48.9	0.009										
1988	4	800.0	59.6	4	800.0	59.6	0.002										
1989	6	668.3	30.2	6	668.3	30.2	0.004										
1990	16	848.1	52.9	16	848.1	52.9	0.009										
1991	13	773.8	27.1	13	773.8	27.1	0.006										
1992	3	740.0	49.3	3	740.0	49.3	0.002										
1993	11	788.2	41.9	11	788.2	41.9	0.004										
1994	9	860.0	65.0	9	860.0	65.0	0.004										
1995	2	875.0	105.0	2	875.0	105.0	0.005										
1996	4	845.0	38.6	4	845.0	38.6	0.009										
1997	1	1090.0	0.0	1	1090.0	0.0	0.000										
1998	3	880.0	90.7	3	880.0	90.7	0.003										
1999																	

Appendix C85.- **spanish mackerel**
Scomberomorus maculatus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	**n**	**Legal**	**S.E.**	**n**	**Actual**	**S.E.**	**Actual**	**n**	**Legal**	**S.E.**	**n**	**Actual**	**S.E.**	**IM**	**Mat**	**Legal**	**Actual**
1976	28	571.4	14.2				0.000										
1977	11	606.4	38.5				0.000										
1978	4	575.0	32.8				0.002										
1979	3	410.0	10.0				0.002										
1980	4	505.0	42.5				0.011										
1981	13	533.8	25.1				0.005										
1982	18	567.8	21.8				0.019										
1983	2	495.0	65.0				0.003										
1984	0						0.002										
1985	3	400.0	15.3				0.001										
1986	2	660.0	160.0				0.012										
1987	8	463.8	30.2				0.007										
1988	1	460.0	0.0				0.002										
1989	0						0.000										
1990	1	450.0	0.0				0.001										
1991	11	550.0	38.7				0.006										
1992	9	533.3	21.8				0.003										
1993	3	606.7	58.1				0.002										
1994	2	415.0	25.0				0.001										
1995	3	516.7	18.6				0.002										
1996	0						0.000										
1997	1	470.0	0.0				0.001										
1998	1	510.0	0.0				0.000										
1999																	

Appendix C86.- **cero**
Scomberomorus regalis

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	**n**	**Legal**	**S.E.**	**n**	**Actual**	**S.E.**	**Actual**	**n**	**Legal**	**S.E.**	**n**	**Actual**	**S.E.**	**IM**	**Mat**	**Legal**	**Actual**
1976				0			0.000										
1977				0			0.000										
1978				3	783.3	53.6	0.000										
1979				22	495.0	18.9	0.007										
1980				72	512.2	13.5	0.008										
1981				59	508.8	12.2	0.009										
1982				21	546.7	24.2	0.006										
1983				31	521.3	19.4	0.004				3	566.7	6.0	0.111	0.000		
1984				4	487.5	76.0	0.003				0			0.000	0.000		
1985				29	491.0	19.7	0.002				0			0.000	0.000		
1986				45	612.7	18.5	0.005				0			0.000	0.000		
1987				61	482.0	10.6	0.010				1	500.0	0.0	0.027	0.000		
1988				27	505.2	17.1	0.004				9	514.4	3.3	0.054	0.000		
1989				8	558.8	35.8	0.002				3	463.3	1.3	0.009	0.000		
1990				24	521.7	24.9	0.004				16	513.8	3.7	0.068	0.004		
1991				12	480.8	33.8	0.002				7	562.9	9.3	0.108	0.000		
1992				29	478.6	17.4	0.005				0			0.000	0.000		
1993				57	498.1	10.4	0.013				.			.	.		
1994				22	484.1	18.6	0.003				.			.	.		
1995				17	511.2	20.8	0.005				4	525.0	9.7	0.036	0.000		
1996				6	476.7	18.2	0.001				6	488.3	5.0	0.097	0.000		
1997				11	495.5	34.1	0.002				0			0.006	0.000		
1998				9	592.2	31.5	0.003				3	436.7	2.1	0.041	0.000		
1999											0			0.000	0.000		

Appendix C87.-

greater amberjack
Seriola dumerili

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	0			0			0.000										
1977	0			0			0.000										
1978	1	1060.0	0.0	1	1060.0	0.0	0.000										
1979	4	845.0	119.1	4	845.0	119.1	0.002										
1980	4	877.5	76.6	4	877.5	76.6	0.003										
1981	25	970.8	62.3	25	970.8	62.3	0.005										
1982	11	1106.4	22.5	11	1106.4	22.5	0.002										
1983	7	835.7	139.9	7	835.7	139.9	0.001	0			0			0.000	0.000	0.000	0.000
1984	0			0			0.000	0			0			0.000	0.000	0.000	0.000
1985	4	467.5	90.6	4	467.5	90.6	0.000	0			0			0.000	0.000	0.000	0.000
1986	7	702.9	65.1	7	702.9	65.1	0.001	0			0			0.000	0.000	0.000	0.000
1987	15	1058.7	50.9	15	1058.7	50.9	0.003	0			0			0.000	0.000	0.000	0.000
1988	1	1020.0	0.0	1	1020.0	0.0	0.000	0			0			0.000	0.000	0.000	0.000
1989	6	596.7	164.7	6	596.7	164.7	0.002	0			0			0.000	0.000	0.000	0.000
1990	0			1	400.0	0.0	0.000	2	1675.0	155.0	2	1675.0	155.0	0.000	0.008	0.008	0.008
1991	8	1017.5	24.5	9	953.3	67.7	0.001	0			0			0.000	0.000	0.000	0.000
1992	0			0			0.000	0			0			0.000	0.000	0.000	0.000
1993	1	1000.0	0.0	1	1000.0	0.0	0.000	.			.			.	.	.	.
1994	2	945.0	75.0	2	945.0	75.0	0.000	.			.			.	.	.	.
1995	2	1110.0	110.0	2	1110.0	110.0	0.001	0			0			0.000	0.000	0.000	0.000
1996	2	1050.0	20.0	3	900.0	150.4	0.002	0			0			0.000	0.000	0.000	0.000
1997	0			1	670.0	0.0	0.000	0			0			0.000	0.000	0.000	0.000
1998	1	1010.0	0.0	1	1010.0	0.0	0.000	0			0			0.000	0.000	0.000	0.000
1999								0			0			0.000	0.000	0.000	0.000

Appendix C88.-

tripletail
Lobotes surinamensis

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	0			0			0.000										
1977	0			0			0.000										
1978	0			0			0.000										
1979	0			0			0.000										
1980	0			0			0.000										
1981	4	380.0	44.2	4	380.0	44.2	0.004										
1982	5	372.0	32.0	5	372.0	32.0	0.006										
1983	0			0			0.000										
1984	0			0			0.000										
1985	1	370.0	0.0	1	370.0	0.0	0.000										
1986	4	402.5	8.5	4	402.5	8.5	0.001										
1987	0			0			0.001										
1988	0			0			0.000										
1989	3	366.7	47.0	3	366.7	47.0	0.001										
1990	2	430.0	80.0	2	430.0	80.0	0.002										
1991	7	434.3	26.4	7	434.3	26.4	0.002										
1992	3	480.0	45.8	3	480.0	45.8	0.001										
1993	2	350.0	50.0	2	350.0	50.0	0.002										
1994	9	430.0	11.9	9	430.0	11.9	0.003										
1995	1	480.0	0.0	1	480.0	0.0	0.003										
1996	1	400.0	0.0	2	385.0	15.0	0.005										
1997	0			1	340.0	0.0	0.001										
1998	1	480.0	0.0	1	480.0	0.0	0.001										
1999																	

Appendix C89.-

wahoo
Acanthocybium solandri

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976				0			0.001										
1977				3	940.0	181.5	0.001										
1978				3	860.0	113.6	0.002										
1979				3	1066.7	23.3	0.006										
1980				10	1056.0	67.0	0.004										
1981				6	931.7	106.4	0.003										
1982				8	1015.0	69.9	0.003										
1983				4	1150.0	143.6	0.003										
1984				2	1130.0	90.0	0.021										
1985				4	1127.5	57.9	0.001										
1986				8	1003.8	45.8	0.003										
1987				5	1162.0	74.8	0.004										
1988				7	985.7	63.8	0.008										
1989				3	1150.0	75.1	0.001										
1990				2	1015.0	5.0	0.003										
1991				9	1134.4	43.5	0.005										
1992				4	1055.0	26.3	0.002										
1993				8	1183.8	91.3	0.006										
1994				7	1002.9	79.8	0.004										
1995				2	1095.0	25.0	0.003										
1996				6	1045.0	86.1	0.005										
1997				1	1200.0	0.0	0.002										
1998				2	890.0	210.0	0.003										
1999																	

Appendix C90.-

spiny lobster
Panulirus Argus

	CREEL Survey Data							RVC Survey Data									
	Lbar						CPUE	Lbar						CPUE			
Year	n	Legal	S.E.	n	Actual	S.E.	Actual	n	Legal	S.E.	n	Actual	S.E.	IM	Mat	Legal	Actual
1976	313	838.9	3.5	313	838.9	3.5	1.067										
1977	674	855.2	3.0	674	855.2	3.0	0.814										
1978	1175	846.4	2.2	1175	846.4	2.2	0.880										
1979	658	842.9	2.8	658	842.9	2.8	1.059										
1980	1350	844.9	2.0	1350	844.9	2.0	0.944										
1981	771	859.4	3.0	771	859.4	3.0	0.672										
1982	1695	829.5	1.6	1695	829.5	1.6	0.926										
1983	700	829.8	2.5	700	829.8	2.5	0.759										
1984	624	836.3	2.5	624	836.3	2.5	0.603										
1985	373	845.9	3.4	373	845.9	3.4	0.796										
1986	1190	852.2	2.0	1190	852.2	2.0	0.813										
1987	879	843.0	2.4	879	843.0	2.4	0.822										
1988	732	835.7	2.3	732	835.7	2.3	0.761										
1989	873	848.0	2.3	873	848.0	2.3	0.863										
1990	1653	857.2	1.8	1653	857.2	1.8	0.780										
1991	278	869.7	4.8	278	869.7	4.8	1.359										
1992	107	854.4	7.2	107	854.4	7.2	1.523										
1993	231	857.9	4.6	231	857.9	4.6	1.079										
1994	295	861.6	4.8	295	861.6	4.8	1.443										
1995	429	863.2	3.1	429	863.2	3.1	2.184										
1996	329	859.4	4.3	329	859.4	4.3	1.416										
1997	168	844.9	5.2	168	844.9	5.2	1.222										
1998	130	869.5	8.1	130	869.5	8.1	1.375										
1999																	

Appendix D1: SAS programs for processing reef fish visual census data and estimating average length in the exploited phase and catch per unit effort (see **Figure 21**).

```
/*program fkdat3.sas*/
/*processes FK reef fish 99 bio data*/
/*applies 2-stage numbers-at-length algorithm*/
/*bnp region, all species*/
options nodate nonumber;
data r1;
  infile '/us4/sgsmith/reefsamp/rf99/under5.txt';
  input smpcode$ 1-14 species$ 17-24 @33 catch
    @40 meansize @48 minsize @56 maxsize;
run;
proc sort;
  by species;
quit;
data s1;
  infile '/us4/sgsmith/reefsamp/species.prn';
  input species$ 1-8 latin$ 16-47 common2$ 49-77 family$ 79-99
    specnum 101-104 famnum 111-113 bbtrawl 121 creel 129 rvc 137;
  if rvc=1;
  keep species specnum;
run;
proc sort;
  by species;
quit;
/*proc print;
quit;*/
data s2;
  merge r1 s1;
  by species;
  if catch=. then delete;
run;
/*proc print;
quit;*/
/*proc freq;
  tables species;
quit;*/
proc sort;
  by smpcode;
quit;
/*proc print;
quit;*/
data p1;
  infile '/us4/sgsmith/reefsamp/rf99/rf99_fkphys.txt';
  input month 1-2 day 4-5 yr 7-8 rfblk$ 10-16 stn 18 div$ 20
    smpcode$ 22-35 observ 37-38 @40 ddlat @50 ddlong @60 depth
    regkey 67 subreg 69 spa 71-72 reeftype 74;
  if yr=99 then yr=1999;
  else yr=yr;
run;
proc sort;
  by smpcode;
quit;
/*proc print;
quit;*/
data m1;
  merge p1 s2;
  by smpcode;
run;
data m2;
  set m1;
  if stn=. then delete;
  if regkey=1;
  drop smpcode observ subreg spa species;
run;
/*proc print;
quit;*/
proc sort;
  by yr month day rfblk stn div specnum;
quit;
proc transpose out=m3;
  by yr month day rfblk stn div ddlat ddlong depth regkey reeftype;
  var catch;
  id specnum;
quit;
proc transpose out=m4;
  by yr month day rfblk stn div ddlat ddlong depth regkey reeftype;
quit;
data m5;
  set m4;
  specode=_name_;
  if catch=. then catch=0;
  drop _name_;
run;
/*proc print;
quit;*/
data m6;
  set m5;
  format ddlat ddlong 9.5;
  format depth 6.3;
  file '/us4/sgsmith/reefsamp/tmp1.txt';
  put yr 1-4 month 6-7 day 9-10 rfblk$ 12-18 stn 20-21 div$ 23
    @25 ddlat @35 ddlong @45 depth regkey 52 reeftype 54
    specode$ 56-59 @61 catch;
run;
data m7;
  infile '/us4/sgsmith/reefsamp/tmp1.txt';
  input yr 1-4 month 6-7 day 9-10 rfblk$ 12-18 stn 20-21 div$ 23
    @25 ddlat @35 ddlong @45 depth regkey 52 reeftype 54
    specnum 57-59 @61 catch;
run;
proc sort;
  by yr month day rfblk stn div specnum;
quit;
/*proc print;
quit;*/
data m8;
  merge m2 m7;
  by yr month day rfblk stn div specnum catch;
run;
proc sort;
  by specnum;
quit;
/*proc print;
```

```
quit;*/
data s3;
  set s1;
run;
proc sort;
  by specnum;
quit;
/*proc print;
quit;*/
data m9;
  merge m8 s3;
  by specnum;
  if catch=. then delete;
run;
/*proc print;
quit;*/
data r2;
  set m9;
  if meansize=. then meansize=0;
  else meansize=meansize;
  if minsize=0 then minsize=.;
  else minsize=minsize;
  if maxsize=0 then maxsize=.;
  else maxsize=maxsize;
run;
/*proc print;
quit;*/
/*proc univariate;
  var minsize maxsize;
quit;*/
data r3a;
  set r2;
  if minsize=.;
  L3=meansize;
  A3=catch;
  L1=.;
  A1=.;
  L2=.;
  A2=.;
  L4=.;
  A4=.;
  L5=.;
  A5=.;
  drop catch minsize meansize maxsize;
run;
data r3b;
  set r2;
  if minsize ne .;
  if catch=1;
  L3=meansize;
  A3=catch;
  L1=.;
  A1=.;
  L2=.;
  A2=.;
  L4=.;
  A4=.;
  L5=.;
  A5=.;
  drop catch minsize meansize maxsize;
run;
data r3c;
  set r2;
  if minsize ne .;
  if catch=2;
  L1=minsize;
  A1=1;
  L5=maxsize;
  A5=1;
  L2=.;
  A2=.;
  L4=.;
  A4=.;
  L3=.;
  A3=.;
  drop catch minsize meansize maxsize;
run;
data r3d;
  set r2;
  if minsize ne .;
  if catch=3;
  L1=minsize;
  A1=1;
  L3=meansize;
  A3=1;
  L5=maxsize;
  A5=1;
  L2=.;
  A2=.;
  L4=.;
  A4=.;
  drop catch minsize meansize maxsize;
run;
data r3e;
  set r2;
  if minsize ne .;
  if catch=4;
  L1=minsize;
  A1=1;
  L3=meansize;
  A3=2;
  L5=maxsize;
  A5=1;
  L2=.;
  A2=.;
  L4=.;
  A4=.;
  drop catch minsize meansize maxsize;
run;
data r3f;
  set r2;
  if minsize ne .;
  if 5<=catch<=99;
  L1=minsize;
  A1=1;
  L3=meansize;
  A3=0.5*catch;
  L5=maxsize;
  A5=1;
  L2=(L3+L1)/2;
  A2=(catch-(A1+A3+A5))/2;
  L4=(L3+L5)/2;
  A4=A2;
  drop catch minsize meansize maxsize;
```

```
run;
data r3g;
  set r2;
  if minsize ne .;
  if catch>99;
  L1=minsize;
  A1=0.01*catch;
  L3=meansize;
  A3=0.5*catch;
  L5=maxsize;
  A5=0.01*catch;
  L2=(L3+L1)/2;
  A2=(catch-(A1+A3+A5))/2;
  L4=(L3+L5)/2;
  A4=A2;
  drop catch minsize meansize maxsize;
run;
/*proc print;
quit;*/
data r4;
  set r3a r3b r3c r3d r3e r3f r3g;
run;
/*proc print;
quit;*/
data r5a;
  set r4;
  if L1=. then delete;
  len=L1;
  abund=A1;
  keep yr month day regkey depth reeftype rfblk stn div
    ddlat ddlong specnum species len abund;
run;
data r5b;
  set r4;
  if L2=. then delete;
  len=L2;
  abund=A2;
  keep yr month day regkey depth reeftype rfblk stn div
    ddlat ddlong specnum species len abund;
run;
data r5c;
  set r4;
  if L3=. then delete;
  len=L3;
  abund=A3;
  keep yr month day regkey depth reeftype rfblk stn div
    ddlat ddlong specnum species len abund;
run;
data r5d;
  set r4;
  if L4=. then delete;
  len=L4;
  abund=A4;
  keep yr month day regkey depth reeftype rfblk stn div
    ddlat ddlong specnum species len abund;
run;
data r5e;
  set r4;
  if L5=. then delete;
  len=L5;
  abund=A5;
  keep yr month day regkey depth reeftype rfblk stn div
    ddlat ddlong specnum species len abund;
run;
/*proc print;
quit;*/
data r6;
  set r5a r5b r5c r5d r5e;
run;
proc sort;
  by specnum yr rfblk stn div len;
quit;
/*proc print;
quit;*/
proc means noprint data=r2;
  class specnum yr rfblk stn;
  var catch;
  output out=a1 mean=avnum sum=sumnum;
quit;
data a2;
  set a1;
  if _type_=15;
  drop _type_ _freq_;
run;
/*proc print;
quit;*/
data r7;
  merge r6 a2;
  by specnum yr rfblk stn;
run;
/*proc print;
quit;*/
data r8;
  set r7;
  if abund=0 then num=0;
  else num=(abund/sumnum)*avnum;
run;
/*proc univariate;
  var len num;
quit;
proc print;
quit;*/
data r9;
  set r8;
  format ddlat ddlong 9.5;
  format depth 6.3 len 6.1 num 10.3;
  file '/us4/sgsmith/reefsamp/rf99/fk99/fkdat3_99.txt';
  put yr 1-4 month 6-7 day 9-10 rfblk$ 12-18 stn 20-28
    @30 ddlat @40 ddlong @50 depth regkey 57 reeftype 59
    species$ 61-68 specnum 70-72 @74 len @81 num;
run;


/*program fkdat3a_bnp.sas*/
/*processes BNP region reef fish data*/
/*creates lbar analysis dataset*/
/*all species*/
options nodate nonumber;
data b1;
  infile '/us4/sgsmith/reefsamp/fkdat3_7996.txt';
  input yr 1-4 month 6-7 day 9-10 rfblk$ 12-18 specnum 20-22
    @24 ddlat @34 ddlong @44 depth regkey 51 reeftype 53
    species$ 55-62 stn$ 64-72 @74 len @81 num;
```

```
  if len>0;
  keep yr specnum species len num;
run;
data b2;
  infile '/us4/sgsmith/reefsamp/rf9798/fkdat3_9798.txt';
  input yr 1-4 month 6-7 day 9-10 rfblk$ 12-18 stn$ 20-28
    @30 ddlat @40 ddlong @50 depth regkey 57 reeftype 59
    species$ 61-68 specnum 70-72 @74 len @81 num;
  if len>0;
  keep yr specnum species len num;
run;
data b3;
  infile '/us4/sgsmith/reefsamp/rf99/fk99/fkdat3_99.txt';
  input yr 1-4 month 6-7 day 9-10 rfblk$ 12-18 stn$ 20-28
    @30 ddlat @40 ddlong @50 depth regkey 57 reeftype 59
    species$ 61-68 specnum 70-72 @74 len @81 num;
  if len>0;
  keep yr specnum species len num;
run;
data b4;
  set b1 b2 b3;
run;
proc sort;
  by specnum yr;
quit;
/*proc print;
quit;*/
data b5;
  set b4;
  format len 6.1 num 10.3;
  file '/us4/sgsmith/bnp/rvc_lbardat.txt';
  put yr 1-4 species$ 6-13 specnum 15-17 @19 len @26 num;
run;

/*program rvc_lbar.sas*/
/*processes BNP region reef fish data*/
/*computes lbar*/
/*by species and year*/
options nodate nonumber;
data b1;
  infile '/us4/sgsmith/bnp/rvc_lbardat.txt';
  input yr 1-4 species$ 6-13 specnum 15-17 @19 len @26 num;
  if specnum=133;
run;
data r1;
  set b1;
  if yr<1985 and len<19 then delete;
  if yr>=1985 and len<30 then delete;
  /*if yr>=1990 and len<51 then delete;*/
  /*if len>100 then delete;*/
run;
/*proc print;
quit;*/
/*proc univariate plot;
  var len;
quit;*/
proc means noprint vardef=wdf;
  class species yr;
  var len;
  weight num;
  id specnum;
  output out=r2 mean=lbar var=s2 sumwgt=n;
quit;
data r3;
  set r2;
  if _type_=3;
  se_lbar=sqrt(s2/n);
  format lbar 7.2 se_lbar 6.2;
  drop _type_ _freq_;
run;
/*proc print;
quit;*/
data y1;
  infile '/us4/sgsmith/bnp/rvc_yrts.txt';
  input yr id;
run;
data r4;
  merge r3 y1;
  by yr;
  if (yr<1993 or yr>1994) and (n=.) then n=0;
  else n=n;
  if specnum=. then specnum=133;
  else specnum=specnum;
  if species='        ' then species='OCY CHRY';
  else species=species;
  drop id;
run;
proc print noobs;
  var specnum species yr n lbar se_lbar;
  title ' ';
quit;


/*program fkdat3b_bnp.sas*/
/*processes BNP region reef fish data*/
/*creates cpue analysis dataset*/
/*all species, reeftypes 4-6*/
options nodate nonumber;
data b1;
  infile '/us4/sgsmith/reefsamp/fkdat3_7996.txt';
  input yr 1-4 month 6-7 day 9-10 rfblk$ 12-18 specnum 20-22
    @24 ddlat @34 ddlong @44 depth regkey 51 reeftype 53
    species$ 55-62 stn$ 64-72 @74 len @81 num;
  if reeftype>=4;
  keep yr specnum species len num rfblk stn;
run;
data b2;
  infile '/us4/sgsmith/reefsamp/rf9798/fkdat3_9798.txt';
  input yr 1-4 month 6-7 day 9-10 rfblk$ 12-18 stn$ 20-28
    @30 ddlat @40 ddlong @50 depth regkey 57 reeftype 59
    species$ 61-68 specnum 70-72 @74 len @81 num;
  if reeftype>=4;
  keep yr specnum species len num rfblk stn;
run;
data b3;
  infile '/us4/sgsmith/reefsamp/rf99/fk99/fkdat3_99.txt';
  input yr 1-4 month 6-7 day 9-10 rfblk$ 12-18 stn$ 20-28
    @30 ddlat @40 ddlong @50 depth regkey 57 reeftype 59
    species$ 61-68 specnum 70-72 @74 len @81 num;
  if reeftype>=4;
  keep yr specnum species len num rfblk stn;
run;
data b4;
  set b1 b2 b3;
```

```
run;
proc sort;
  by specnum yr;
quit;
/*proc print;
quit;*/
data b5;
  set b4;
  format len 6.1 num 10.3;
  file '/us4/sgsmith/bnp/rvc_cpuedat.txt';
  put yr 1-4 species$ 6-13 specnum 15-17 rfblk$ 19-25 stn$ 27-35
    @37 len @44 num;
run;

/*program rfds1.sas*/
/*2-stage SRS design, FK reef fish data*/
/*species-lifestage*/
options nodate nonumber;
data rd1;
  infile '/us4/sgsmith/bnp/rvc_cpuedat.txt';
  input yr 1-4 species$ 6-13 specnum 15-17 rfblk$ 19-25 stn$ 27-35
    @37 len @44 num;
  if specnum=232;
run;
/*proc print;
quit;*/
data rd2;
  set rd1;
  if len<87.7 then jnum=num;
  else jnum=0;
  if len=0 or len>=87.7 then anum=num;
  else anum=0;
  if len=0 or len>=35.0 then enum=num;
  else enum=0;
  /*if len=0 or (yr<1990 and len>=30) or
     (yr>=1990 and len>=51) then enum=num;
  else enum=0;*/
run;
/*proc print;
quit;*/
proc means noprint;
  class yr rfblk stn;
  var jnum anum enum;
  id species specnum;
  output out=r1 sum=j_abund a_abund e_abund;
quit;
data r2;
  set r1;
  if _type_=7;
  drop _type_ _freq_ ;
run;
/*proc print;
quit;*/
proc means noprint;
  class yr rfblk;
  var e_abund;
  id species specnum;
  output out=r3 mean=cpi var=vari;
quit;
data r4;
  set r3;
  if _type_=3;
  m=_freq_;
  if vari=. then vari=0;
  drop _type_ _freq_;
run;
/*proc print;
quit;*/
/*          */
/*SRS scheme*/
/*          */
proc means data=r4 noprint;
  class yr;
  var cpi vari m;
  id species specnum;
  output out=r5 mean=avcp mean1 m
     sum=sum1 varm nm var=s1 var1 var2;
quit;
data r6;
  set r5;
  if _type_=1;
  n=_freq_;
  s2=varm/n;
  keep yr species specnum avcp m n nm s1 s2;
run;
/*proc print;
quit;*/
data r7;
  set r6;
  mtot=226;
  ntot=978;
  fn=n/ntot;
  fm=m/mtot;
  vbar_cp=((1-fn)*s1/n)+((fn*(1-fm)*s2)/nm);
  se_cp=sqrt(vbar_cp);
  cv_cp=(se_cp/avcp)*100;
  std2=sqrt(s2);
  su=s1-(s2/Mtot);
  stdu=sqrt(su);
  if stdu ne 0 then mopt=std2/stdu;
  else mopt=0;
  format avcp se_cp 9.5;
  format m mopt 5.2;
  format cv_cp 6.2;
run;
data y1;
  infile '/us4/sgsmith/bnp/rvc_yrts.txt';
  input yr id;
run;
data r8;
  merge r7 y1;
  by yr;
  if (yr<1993 or yr>1994) and n=. then avcp=0;
  else avcp=avcp;
  if specnum=. then specnum=232;
  else specnum=specnum;
  if species='        ' then species='SPH BARR';
  else species=species;
  drop id;
run;
proc print noobs;
  var specnum species yr n m mopt nm avcp se_cp cv_cp;
  title 'SRS 2-stage';
quit;
```

Appendix D2: SAS programs for processing BNP recreational creel survey data and estimating average length in the exploited phase and catch per unit effort (see **Figure 21**).

```
/*program creellbar.sas*/
/*processes creel fish length data, 1976-1998*/
/*computes lbar by species and year*/
options nonumber nodate;
data f1a;
  infile '/us4/sgsmith/bnp/creel/creel_len_7687.prn';
  input month 7-8 day 14-15 yr 22-23 intnum 26-30 specode 33-36
    len 40-43 common$ 51-72 area 75;
  if area=0 then delete;
  drop common intnum;
run;
data f1b;
  infile '/us4/sgsmith/bnp/creel/creel_len_8891.prn';
  input month 6-7 day 13-14 yr 21-22 intnum 25-29 specode 32-35
    len 40-43 common$ 52-71 area 74;
  if area=0 then delete;
  drop common intnum;
run;
/*proc print;
quit;*/
data f1c;
  infile '/us4/sgsmith/bnp/creel/CreelLen.txt';
  input obs 1-6 month 12-13 day 19-20 yr 24-27 area 32-33
    specode 40-43 common$ 49-69 len 72-74;
  if specode=9999 then delete;
  if area=. then area=37;
  else area=area;
  if area=17 or area=36 or area=37 then delete;
  if yr<1999;
  drop obs common;
run;
data f2;
  set f1a f1b f1c;
  if len=0 then delete;
run;
/*proc print;
quit;*/
proc sort;
  by specode;
quit;
data s1;
  infile '/us4/sgsmith/bnp/creel/creelspecies.prn';
  input specode specnum;
run;
proc sort;
  by specode;
quit;
/*proc print;
quit;*/
data f3;
  merge s1 f2;
  by specode;
  if len=. then delete;
run;
proc sort;
  by specnum;
quit;
/*proc print;
quit;*/
/*proc freq;
  tables specode;
quit;*/
data r1;
  infile '/us4/sgsmith/reefsamp/species.prn';
  input species$ 1-8 latin$ 16-47 common2$ 49-77 family$ 79-99
    specnum 101-104 famnum 111-113 bbtrawl 121 creel 129 rvc 137;
  if creel=1;
  keep species specnum;
run;
proc sort;
  by specnum;
quit;
/*proc print;
quit;*/
data r2;
  merge r1 f3;
  by specnum;
  if len=. then delete;
run;
proc sort;
  by species;
quit;
/*proc print;
quit;*/
data r3;
  set r2;
  if yr=76 then yr=1976;
  else if yr=77 then yr=1977;
  else if yr=78 then yr=1978;
  else if yr=79 then yr=1979;
  else if yr=80 then yr=1980;
  else if yr=81 then yr=1981;
  else if yr=82 then yr=1982;
  else if yr=83 then yr=1983;
  else if yr=84 then yr=1984;
  else if yr=85 then yr=1985;
  else if yr=86 then yr=1986;
  else if yr=87 then yr=1987;
  else if yr=88 then yr=1988;
  else if yr=89 then yr=1989;
  else if yr=90 then yr=1990;
  else if yr=91 then yr=1991;
  else yr=yr;
  if specnum=16;
  if yr<1994 and len<22 then delete;
  if yr>=1994 and len<30 then delete;
  /*if yr>=1990 and len<51 then delete;*/
  /*if len>100 then delete;*/
run;
/*proc univariate plot;
  var len;
quit;*/
proc means noprint;
  class species yr;
```

```
  var len;
  id specnum;
  output out=r4 n=n mean=lbar stderr=se_lbar;
quit;
data r5;
  set r4;
  if _type_=3;
  if se_lbar=. then se_lbar=0;
  format lbar 7.2 se_lbar 6.2;
  drop _type_ _freq_;
run;
data y1;
  infile '/us4/sgsmith/bnp/creel/yr_ts.txt';
  input yr id;
run;
data r6;
  merge r5 y1;
  by yr;
  if n=. then n=0;
  else n=n;
  if specnum=. then specnum=16;
  else specnum=specnum;
  if species='        ' then species='BAL CAPR';
  else species=species;
  drop id;
run;
proc print noobs;
  title ' ';
quit;


/*program creelcpdat.sas*/
/*processes creel cpue data, 1976-1998*/
/*creates analysis dataset, all species*/
options nonumber nodate;
data c1;
  infile '/us4/sgsmith/bnp/creel/creelint_7687.prn';
  input @1 intid persons 17-18 eff_hrs 25-26 trgspec 31-36
    area 41-42 party 51-52 month 58-59 day 65-66 yr 73-74
    specode 76-80 catch 81-85;
  if eff_hrs=0 then delete;
  if area=17 or area>30 then delete;
  trip=intid*10;
  yr=yr+1900;
  type=0;
  drop intid;
run;
data c2;
  infile '/us4/sgsmith/bnp/creel/creelint_8891.prn';
  input @1 intid persons 18-19 eff_hrs 26-27 trgspec 32-37
    area 42-43 party 53-54 month 60-61 day 66-67 yr 74-75
    specode 76-80 catch 81-85;
  if area=17 then delete;
  trip=intid*10;
  yr=yr+1900;
  type=0;
  drop intid;
run;
data c3a;
  infile '/us4/sgsmith/bnp/creel/Census_91-93.prn';
  input trip 3-8 specode 14-18 catch 26-30;
  if specode=. then specode=0;
  else specode=specode;
run;
proc sort;
  by trip;
quit;
data c3b;
  infile '/us4/sgsmith/bnp/creel/Trip_91-93.prn';
  input trip 2-7 month 9-10 day 12-13 yr 15-18 party 32-33
    persons 45-46 eff_hrs 56-57 trgspec 64-69 area 79-80;
run;
proc sort;
  by trip;
quit;
data c3;
  merge c3a c3b;
  by trip;
  if specode=. then specode=0;
  else specode=specode;
  if catch=. then catch=0;
  else catch=catch;
  if yr=. or yr>1993 then delete;
  if eff_hrs=. then delete;
  if area=17 then delete;
  if party=. then party=0;
  else party=party;
  type=0;
run;
data c4a;
  infile '/us4/sgsmith/bnp/creel/Census.prn';
  input trip 2-7 month 13-14 day 16-17 yr 19-22
    specode 28-32 catch 41-45;
  if specode=. then specode=0;
  else specode=specode;
run;
proc sort;
  by trip yr month day;
quit;
data c4b;
  infile '/us4/sgsmith/bnp/creel/Trip.prn';
  input trip 3-8 month 13-14 day 16-17 yr 19-22 party 37-38
    type 48-49 persons 61-62 eff_hrs 73-74 trgspec 81-86 area 95-96;
run;
proc sort;
  by trip yr month day;
quit;
data c4;
  merge c4a c4b;
  by trip yr month day;
  if specode=. then specode=0;
  else specode=specode;
  if catch=. then catch=0;
  else catch=catch;
  if eff_hrs=. then delete;
  if yr<1993 or yr>1998 then delete;
  if party>7 or party=. then party=0;
  else party=party;
  if type=. then type=0;
  else type=type;
  if area=17 or area=36 or area=37 then delete;
run;
data c5;
  set c1 c2 c3 c4;
```

```
run;
proc sort;
  by yr month day trip;
quit;
/*proc print;
quit;*/
/*proc freq;
  tables yr party type area;
quit;*/
/*proc univariate plot;
  var trip catch;
quit;*/
proc sort;
  by specode;
quit;
data s1;
  infile '/us4/sgsmith/bnp/creel/creelspecies.prn';
  input specode specnum;
run;
proc sort;
  by specode;
quit;
/*proc print;
quit;*/
data c6;
  merge s1 c5;
  by specode;
  if specnum=. then delete;
run;
proc sort;
  by specnum;
quit;
/*proc print;
quit;*/
/*proc freq;
  tables specode;
quit;*/
data r1;
  infile '/us4/sgsmith/reefsamp/species.prn';
  input species$ 1-8 latin$ 16-47 common$ 49-77 family$ 79-99
    specnum 101-104 famnum 111-113 bbtrawl 121 creel 129 rvc 137;
  if creel=1;
  keep species specnum family;
run;
proc sort;
  by specnum;
quit;
/*proc print;
quit;*/
data r2;
  merge r1 c6;
  by specnum;
run;
proc sort;
  by species;
quit;
/*proc print;
quit;*/
data r3;
  set r2;
  if party=0 then delete;
run;
```

```
proc sort;
  by yr trip;
quit;
data f1;
  set r3;
  if specnum=269 and party<6;
  if trgspec=1211 then lob=0;
  else lob=1;
  keep specnum yr trip lob;
run;
proc sort;
  by yr trip;
quit;
data f2;
  merge f1 r3;
  by yr trip;
  if lob=1 then delete;
  if lob=0 then party=7;
  else party=party;
  drop lob;
run;
data f3;
  set f2;
  if (specnum=266 or specnum=270 or specnum=271) and party<6;
  if trgspec=1211 then lob=0;
  else lob=1;
  keep specnum yr trip lob;
run;
proc sort;
  by yr trip;
quit;
data f4;
  merge f3 f2;
  by yr trip;
  if lob=1 then delete;
  if lob=0 then party=7;
  else party=party;
  drop lob;
run;
/*proc print;
quit;*/
/*proc freq;
  tables species*party;
quit;*/
data f5;
  set f4;
  if party>5;
  if specnum=700 then unk=1;
  else unk=0;
  if specnum=266 then con=1;
  else con=0;
  if 269<=specnum<=271 then lob=1;
  else lob=0;
  if unk=0 and con=0 and lob=0 then fsh=1;
  else fsh=0;
run;
proc means noprint;
  class yr trip;
  var lob fsh con unk;
  id party;
  output out=f6 sum=lob fsh con unk;
quit;
```

```
data f7;
  set f6;
  if _type_=3;
  if lob>0 and fsh=0 then gear='DL';
  else if lob=0 and fsh>0 then gear='DF';
  else if lob>0 and fsh>0 then gear='DM';
  else if lob=0 and fsh=0 and con>0 then gear='DC';
  else gear='DU';
  keep yr trip gear;
run;
data f8;
  merge f5 f7;
  by yr trip;
  if gear='DU' and trgspec=1211 then gear='DL';
  else if gear='DU' and (trgspec=0 or trgspec=9999) then gear='DM';
  else if gear='DU' and 5300<=trgspec<=8800 then gear='DF';
  else if gear='DU' and trgspec=20 then gear='DC';
  else gear=gear;
  if gear='DU' or gear='DC' then delete;
  drop lob fsh unk con;
run;
data f9;
  set f4;
  if party<=5;
  if trip=. then delete;
  gear='HK';
run;
data f10;
  set f8 f9;
  if specnum=700 then species='UNK SPE.';
run;
proc sort;
  by yr trip;
quit;
data u1;
  set f10;
  if specnum=700 then unk=1;
  else unk=0;
  if specnum ne 700 then oth=1;
  else oth=0;
run;
proc means noprint;
  class yr trip;
  var unk oth;
  output out=u2 sum=unk oth;
quit;
data u3;
  set u2;
  if _type_=3;
  if unk>0 and oth=0 then crct=1;
  else crct=0;
  keep yr trip crct;
run;
data u4;
  merge f10 u3;
  by yr trip;
  if crct=1 and catch>0 then delete;
  drop crct;
run;
data a1;
  set u4;
  if area=16 or 24<=area<=25 or 34<=area<=35 then delete;
```

```
  if 1<=area<=4 or 7<=area<=11 or area=18 or 20<=area<=22
    or area=27 or area=31 or area=38 then reg='BAY';
  else if area=5 or area=19 or area=23 then reg='REF';
  else if area=6 or area=26 then reg='PEL';
  else if 12<=area<=14 or area=28 or area=32 then reg='BRF';
  else if area=15 then reg='PRF';
  else if 29<=area<=30 or area=33 then reg='BPL';
  else reg='UNK';
  if reg='BPL' then delete;
run;
proc sort;
  by yr trip;
quit;
data a2;
  set a1;
  if 87<=specnum<=98 or specnum=100 or specnum=123
    or 125<=specnum<=126 or 129<=specnum<=133 or specnum=269
    or 198<=specnum<=203 or 214<=specnum<=218 or specnum=227
    or specnum=706 or specnum=724 or specnum=731 then reef=1;
  else reef=0;
  if specnum=34 or 37<=specnum<=38 or specnum=286
    or specnum=290 or specnum=303 or 306<=specnum<=307
    or 193<=specnum<=194 or specnum=309 then pela=1;
  else pela=0;
  if reef=0 and pela=0 then mixd=1;
  else mixd=0;
run;
proc means noprint;
  class yr trip;
  var reef pela mixd;
  output out=a3 sum=reef pela mixd;
quit;
data a4;
  set a3;
  if _type_=3;
  if reef>0 and pela=0 then spc='R';
  else if pela>0 and reef=0 then spc='P';
  else if reef>0 and pela>0 then spc='B';
  else spc='U';
  keep yr trip spc;
run;
data a5;
  merge a1 a4;
  by yr trip;
  if spc='B' and (reg='BAY' or reg='BRF') then delete;
  if spc='B' and (reg='PEL' or reg='REF') then reg='PRF';
  else reg=reg;
  if spc='P' then reg='PEL';
  else reg=reg;
  if spc='R' and (reg='PEL' or reg='PRF') then reg='REF';
  else reg=reg;
run;
proc sort;
  by gear species reg;
quit;
/*proc print;
quit;*/
/*proc freq;
  by gear;
  tables species*reg;
quit;*/
data a6;
```

```
  set a5;
  file '/us4/sgsmith/bnp/creel/creel_catch.txt';
  put yr 1-4 trip 6-11 specnum 13-15 species$ 17-24 catch 26-30;
run;
data z1;
  set a5;
  if specnum=713 and catch>0 then trig=1;
  else trig=0;
  if specnum=702 and catch>0 then jack=1;
  else jack=0;
  if specnum=706 and catch>0 then grunt=1;
  else grunt=0;
  if specnum=722 and catch>0 then chub=1;
  else chub=0;
  if specnum=724 and catch>0 then snap=1;
  else snap=0;
  if specnum=729 and catch>0 then tuna=1;
  else tuna=0;
  if specnum=731 and catch>0 then group=1;
  else group=0;
  if specnum=711 and catch>0 then porgy=1;
  else porgy=0;
run;
/*proc print;
quit;*/
/*proc freq;
  tables specnum*pres;
quit;*/
proc means noprint;
  class yr trip;
  var trig jack grunt chub snap tuna group porgy;
  id persons eff_hrs gear reg;
  output out=z2 sum=trig jack grunt chub snap tuna
    group porgy;
quit;
data z3;
  set z2;
  if _type_=3;
  drop _type_ _freq_;
run;
/*proc print;
quit;*/
/*proc freq;
  tables gear*reg;
quit;*/
data z4;
  set z3;
  file '/us4/sgsmith/bnp/creel/creel_effort.txt';
  put yr 1-4 trip 6-11 gear$ 13-14 reg$ 16-18 persons 20-21
    eff_hrs 23-24 trig 26 jack 28 grunt 30 chub 32 snap 34
    tuna 36 group 38 porgy 40;
run;
```

```
/*program creelcpue.sas*/
/*processes creel cpue data, 1976-1998*/
/*computes CPUE by year*/
/*single species and gear*/
options nonumber nodate;
data c1;
  infile '/us4/sgsmith/bnp/creel/creel_catch.txt';
  input yr 1-4 trip 6-11 specnum 13-15 species$ 17-24 catch 26-30;
  format species $char8.;
run;
data c2;
  set c1;
  if specnum=232;
run;
proc sort;
  by yr trip;
quit;
data e1;
  infile '/us4/sgsmith/bnp/creel/creel_effort.txt';
  input yr 1-4 trip 6-11 gear$ 13-14 reg$ 16-18 persons 20-21
    eff_hrs 23-24 trig 26 jack 28 grunt 30 chub 32 snap 34
    tuna 36 group 38 porgy 40;
  effort=persons*eff_hrs;
  drop persons eff_hrs;
run;
proc sort;
  by yr trip;
quit;
data e2;
  merge c2 e1;
  by yr trip;
run;
/*proc print;
quit;*/
/*             */
/*hook and line*/
/*             */
data r1h;
  set e2;
  /*if porgy=1 then delete;*/
  if gear='HK';
  if specnum=. and (reg='BRF' or reg='PRF') then delete;
  if reg='REF' or reg='BRF' or reg='PRF' or reg='BAY' or reg='PEL';
  if specnum=. then specnum=232;
  else specnum=specnum;
  if species='        ' then species='SPH BARR';
  else species=species;
  if catch=. then catch=0;
  else catch=catch;
  cpue=catch/effort;
  /*if cpue>3 then delete;*/
  keep yr trip specnum species gear cpue;
run;
/*            */
/*diving gears*/
/*            */
/*data r1d;
  set e2;
  if group=1 then delete;
  if gear='DF' or gear='DM';
  if specnum=. and gear='DM' then delete;
  gear='DV';
  if specnum=. and (reg='BRF' or reg='PRF') then delete;
  if reg='REF';
  if specnum=. then specnum=218;
  else specnum=specnum;
  if species='        ' then species='MYC VENE';
  else species=species;
  if catch=. then catch=0;
  else catch=catch;
```

```
  cpue=catch/effort;
  if cpue>20 then delete;
  keep yr trip specnum species gear cpue;
run;*/
/*proc print;
quit;*/
/*proc univariate plot;
  var cpue;
quit;*/
proc means noprint;
  class specnum yr;
  var cpue;
  id species gear;
  output out=r2 n=n mean=avcp var=varcp;
quit;
data r3;
  set r2;
  if _type_=3;
  vbar_cp=varcp/n;
  se_cp=sqrt(vbar_cp);
  if avcp>0 then cv_cp=(se_cp/avcp)*100;
  else cv_cp=0;
run;
proc print noobs;
  var specnum species gear yr n avcp se_cp cv_cp;
quit;
```

Appendix E. - PROGRAM LBAR

```
C*******************************************************************
C     COMPUTES Z FROM THE LENTH-BASED FORMULA OF                   *
C     EHRHARDT, N.M. and J.S. AULT. 1992.                          *
C     Transactions of the American Fisheries Society 121:115-122. *
C      ~/mab/lbar/lbar.f                                           *
C                                                                  *
C*******************************************************************
      open(unit=4,file='lbar_gr_black.dat',status='old')
      READ(4,*)XLINF,XLL,XK,XM,ITS,XF
      READ(4,*)TL,TC,T0
      READ(4,*)XLC,XLBAR
      XZ=XM+XF
      WRITE(6,*)'CALCULATING MORTALITY ESTIMATE'
C*****EHRHARDT & AULT
      DO 1000 I=1,ITS
      Z=I*.0001
      X1=((XLINF-XLL)/(XLINF-XLC))**(Z/XK)
      X2=((Z*(XLC-XLBAR))+(XK*(XLINF-XLBAR)))/
     $    ((Z*(XLL-XLBAR))+(XK*(XLINF-XLBAR)))
      XX=X2-X1
      IF(XX.LE.0) GOTO 1010
 1000 CONTINUE
 1010 WRITE(6,*)'COMPLETED MORTALITY ITERATIONS'
      ZERR=((Z-XZ)/XZ)*100.
C*****BEVERTON & HOLT
      ZBH=(XK*(XLINF-XLBAR))/(XLBAR-XLC)
      ZERBH=((ZBH-XZ)/XZ)*100.
C*****SSENTONGO & LARKIN
      Y=-ALOG(1.-XLBAR/XLINF)
      YC=-ALOG(1.-XLC/XLINF)
      ZSL=XK*(1./(Y-YC))
      ZSLERR=((ZSL-XZ)/XZ)*100.
      XLLO=XLINF*(1.-EXP(-XK*((TC)-T0)))
      XLHI=XLINF*(1.-EXP(-XK*((TL)-T0)))
      XF2EA=Z-XM
      WRITE(6,*)'XLLO = ',XLLO,'XLHI = ',XLHI
      WRITE(6,*)
      WRITE(6,*)'INPUT PARAMETERS:'
      WRITE(6,*)'LINF = ',XLINF,'  L-LAMBDA = ',XLL
      WRITE(6,*)'LC = ',XLC,'  K = ',XK
      WRITE(6,*)'LBAR = ',XLBAR,'   Z = ',XZ
      WRITE(6,*)
      WRITE(6,*)'E&A Z EST = ',Z
      WRITE(6,*)'ESTIMATED ERROR E&A = ',ZERR
      WRITE(6,*)'ESTIMATED F = ',XF2EA
      WRITE(6,*)
c      WRITE(6,*)'B&H Z EST = ',ZBH
c      WRITE(6,*)'ESTIMATED ERROR B&H = ',ZERBH
c      WRITE(6,*)
c      WRITE(6,*)'S&L Z EST = ',ZSL
c      WRITE(6,*)'ESTIMATED ERROR S&L = ',ZSLERR
 9999 STOP
      END
```

Appendix F. - PROGRAM REEFS

```
C***********************************************************************
C
C     MAIN PROGRAM MODULE OF REEFS.
C     Reef fish Equilibrium Exploitation Fishery Simulator
C     SIMULATES STOCHASTIC CONTINUOUS RECRUITMENT, GROWTH AND
C     MORTALITY LIFE HISTORIES FOR EXPLOITED MARINE FISH STOCKS.
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C
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C***********************************************************************
      INTEGER ZZ,X,SMOS
      COMMON P(492,492),Z(492,492),A(492,492),XM(492,492),F(492,492),
     $       R(492),RN(492,492),YN(492,492),YW(492,492),MFR
      COMMON/A/XAKV,T0,ULINF,WINF,MRM,TR,MFC
      COMMON/B/FRQ(40),SE(492),SLT(492)
      COMMON/C/POPLEN(1000),SYLND(1000),XLENPT(1000),TSL(1000),
     $         TSY,TSLC,SALC,NTOTLI
      COMMON/D/XDLENPT(1000),DPOP(1000),DYPD(1000),TDL(1000),
     $         TYD,TPD,TDLC,DALC
      COMMON/E/PD(492,35),PDY(492,35),XLD(492,35)
      COMMON/S/XE(492),WT(492),BIOM(492),POPP(492),TLC(492),
     $TL(492),TWC(492),AL,PBIRTH(492),ALC,AVWT,AFBM,AFPN,FPJ,
     $CX(492),ACBIR(492),RPJ,YWJ,PPA,BMJ,PJ,SSB,
     $YNJ,TOTLC,TOTLP,TOTWC,PJCX,CXT,ACBT,FEC(492),FBMJ,
     $FRPJ,LL,S(492,12),TAC(492),AAC,ALPGTC
      DIMENSION FM(492),F1MF(492),SXR(492),RA(492),RC(492),
     *SLT1(492),BIT(492),BIRTHS(492),
     *RBIOM(492),AP(492),AYW(492),AYN(492),FP(12),AM(12),XMU(5),
     *ST(492,4)
      OPEN(UNIT=16,FILE='vb.dat',STATUS='OLD')
      OPEN(UNIT=15,FILE='fpr.dat',STATUS='OLD')
      OPEN(UNIT=14,FILE='ypr.dat',STATUS='OLD')
      OPEN(UNIT=13,FILE='select.dat',STATUS='OLD')
      OPEN(UNIT=12,FILE='styldn.dat',STATUS='OLD')
      OPEN(UNIT=11,FILE='lenfreq.dat',STATUS='OLD')
      OPEN(UNIT=10,FILE='yldpr.dat',STATUS='OLD')
      OPEN(UNIT=9,FILE='avlength.dat',STATUS='OLD')
      OPEN(UNIT=8,FILE='probden.dat',STATUS='OLD')
      OPEN(UNIT=7,FILE='length.dat',STATUS='OLD')
      OPEN(UNIT=5,FILE='repro.dat',STATUS='OLD')
      OPEN(UNIT=4,FILE='lendist.dat',STATUS='OLD')
      OPEN(UNIT=3,FILE='frac.dat',STATUS='OLD')
C      OPEN(UNIT=2,FILE='fec.dat',STATUS='OLD')
      OPEN(UNIT=1,FILE='snapper_gray.dat',STATUS='old')
      WRITE(*,*)'Initializing continuous-time data arrays***'
      read (1,*) NDT,MOS,NTL,MFR,MFC,MRM,NFOT,NROT
      read (1,*) NOUT,NAVA,NLL,NOPT,NDIST,NAMP,NPLOT,NSRCH
      read (1,*) ULINF,WINF,XAKV,T0,XNM,FMORT,ALPHA,BETA
      read (1,*) EQUIL,TR,PER,PARM1,PARM2,XNMF,DTL
      read (1,*) ALSLB,BLSB,A4,B4,NYPR,PPAMAX
      read (1,*) XNTS,NFRANGE,fstep,LLS,LOL,LUP
      data (fp(i),i=1,12)/1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1./
      data (am(i),i=1,12)/1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1./
      data (FRQ(I),I=1,7)/.0009,.0016,.0027,.0045,.0072,.0108,.0159/
      data (FRQ(I),I=8,14)/.0222,.03,.0389,.0484,.0579,.0665,.0736/
      data (FRQ(I),I=15,19)/.0781,.0796,.0781,.0736,.0665/
      data (FRQ(I),I=20,24)/.0579,.0484,.0389,.03,.0222/
      data (FRQ(I),I=25,31)/.0159,.0108,.0072,.0045,.0027,.0016,.0009/
cc   31 FORMAT(8I10)
cc   33 FORMAT(3F15.0)
cc   29 FORMAT(8F10.0)
C***********************************************************************
C     INITIALIZE CONTINUOUS SIMULATION ARRAYS
C***********************************************************************
      NS=0
      LL=0
      Y=0.
      AYNJ=0.
      XDT=float(NDT)
      DT=1/XDT
      NM=NTL*NDT
      NMC=NM+1
      IF(EQUIL.EQ.0) GOTO 444
      NMT=NM+MOS
      GOTO 445
  444 NMT=NM
  445 XMU(1)=0.0
      XAKV=XAKV/XDT
      NTS=INT(XNTS)
      XXNTS=XNTS/12.
      XXXNTS=1.0/XXNTS
      NTSS=INT(XXXNTS)
      T0=T0*XDT
      J=1
      DO 199 I=1,NM
      XJ=FLOAT(I)
      XE(J)=1.-EXP(-XAKV*((XJ-0.5)-T0))
c      XE(J)=1.-EXP(-XAKV*((XJ)-T0))
      IF(XE(J))191,191,192
  192 SLT(J)=ULINF*XE(J)
      WT(J)=WINF*(XE(J)**B4)
C     WRITE(16,*)J,SLT(J),st(j,1)
c      WT(J)=A4*(SLT(J)**B4)
      IF(J.LT.MRM) GOTO 193
      LL=1
      IF(LL.EQ.1) GOTO 11000
      IF(LL.EQ.0) GOTO 11001
11001 FEC(J)=ALPHA+(BETA*WT(J))
11000 FEC(J)=ALPHA*(SLT(J)**BETA)
      GOTO 198
  191 SLT(J)=0.0
      WT(J)=0.0
  193 FEC(J)=0.0
  198 J=J+1
  199 CONTINUE
      DO 55 I=1,NM
      XI=FLOAT(I)
      SE(I)=ALSLB*(1.-EXP(-BLSB*(XI-0.5)))
ccc      SE(I)=ALSLB*((I)**BSLB)
   55 CONTINUE
C***********************************************************************
C     NATURAL MORTALITY ARRAY                                          *
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C*********************************************************************
      DO 13 I=1,NMT
      DO 12 J=1,(MFR-1)
      XM(I,J)=0.0
   12 CONTINUE
   13 CONTINUE
C      DO 34 I=1,NMT
C      XM(I,45)=(XNM/XDT)*0.36
C   34 CONTINUE
      DO 40 I=1,NMT
      DO 35 J=MFR,NMT
      XM(I,J)=XNM/XDT
   35 CONTINUE
   40 CONTINUE
      GOTO 92
C*********************************************************************
C     AVAILABILITY ARRAY                                              *
C*********************************************************************
C     SELECTIVITY PATTERNS                                            *
C     VARIABLE NAME = NAVA                                            *
C
C     CONSTANT FOR ALL INTERVALS = 1                                  *
C     SEASONALLY AVAILABLE = 2                                        *
C*********************************************************************
   92 IF(NAVA.EQ.1) GOTO 41
      IF(NAVA.EQ.2) GOTO 91
   41 DO 43 I=1,NMT
      DO 42 J=1,(MFC-1)
      A(I,J)=0.0
   42 CONTINUE
   43 CONTINUE
      DO 50 I=1,NMT
      DO 45 J=MFC,NM
      A(I,J)=1.0
   45 CONTINUE
   50 CONTINUE
      IF(LLS.EQ.0) GOTO 1566
      IF(LLS.EQ.1) GOTO 1560
 1560 DO 1564 I=1,NMT
      DO 1562 J=LOL,LUP
      A(I,J)=0.
 1562 CONTINUE
 1564 CONTINUE
C*****************************************************
C     SELECTION ARRAYS                               *
C*****************************************************
 1566 READ(13,*)(ST(J,1),ST(J,2),ST(J,3),ST(J,4),J=1,NM)
cc 1500 FORMAT(4F10.0)
      K=0
      LL=1
      DO 1505 I=1,NDT
      K=K+1
      DO 1504 J=1,NM
      s(J,I)=ST(J,LL)
 1504 CONTINUE
      IF(K.LT.3) GOTO 1505
      K=0
      LL=LL+1
 1505 CONTINUE
      GOTO 200
C*********************************************************************
C     SEASONAL AVAILABILITY                                           *
C*********************************************************************
   91 DO 107 I=1,NLL
      DO 106 M=1,12
      K=(I-1)*12+M
      IF(AM(M).EQ.0) GOTO 95
      IF(AM(M).EQ.1) GOTO 97
   95 X=K
      J=1
      DO 96 JJ=X,1,-1
      IF(J.GT.NMT) GOTO 96
      A(JJ,J)=0.0
      J=J+1
   96 CONTINUE
      GOTO 106
   97 X=K
      J=1
      DO 98 JJ=X,1,-1
      IF(J.GT.NMT) GOTO 98
      A(JJ,J)=1.0
      J=J+1
   98 CONTINUE
  106 CONTINUE
  107 CONTINUE
      GOTO 200
C*********************************************************************
C     BIRTH RATE FUNCTION ARRAYS                                      *
C*********************************************************************
C     CALCULATION OF AGE(SIZE) SPECIFIC BIRTH RATES                   *
C     (NET MATERNITY LxMx) BY MANIPULATION OF THE                     *
C     FECUNDITY ON WEIGHT RELATIONSHIP                                *
C*********************************************************************
  200 RHO=0.8
      XLAMBDA=0.8
      FECUN=0.0
      SMPFEC=0.0
      DO 201 JJ=1,MRM
      FEC(JJ)=0.0
  201 CONTINUE
      DO 206 JJ=MRM,NM
      FEC(JJ)=ALPHA*(WT(JJ)**BETA)
      IF(RHO.NE.XLAMBDA) GOTO 202
      IF(RHO.EQ.XLAMBDA) GOTO 203
  202 BIT(JJ)=FEC(JJ)*(((XLAMBDA**(JJ+1-MRM))-(RHO**
     *         (JJ+1-MRM)))/(RHO-XLAMBDA))
      GOTO 205
  203 BIT(JJ)=FEC(JJ)*(JJ+1-MRM)*(RHO**(JJ-MRM))
      GOTO 205
  205 BIRTHS(JJ)=BIT(JJ)*((EXP(-XM(1,JJ)))**(JJ-1))
      FECUN=FECUN+FEC(JJ)
  206 CONTINUE
      DO 207 JJ=1,NM
      PBIRTH(JJ)=FEC(JJ)/FECUN
      PBIRTH(JJ)=PBIRTH(JJ)*100.
      SMPFEC=SMPFEC+PBIRTH(JJ)
  207 CONTINUE
C*********************************************************************
C     FISHING MORTALITY ARRAY                                         *
C*********************************************************************
C     FISHING MORTALITY PATTERNS                                      *
C     VARIABLE NAME = NFOT                                            *
C     POPE'S (1971) METHOD = 1                                        *
C     CONSTANT FOR ALL INTERVALS = 2                                  *
C     SEASONAL FISHING STRATEGY = 3                                   *
C*********************************************************************
      IF(NFOT.EQ.1) GOTO 21
      IF(NFOT.EQ.2) GOTO 60
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      IF(NFOT.EQ.3) GOTO 130
C*****POPE'S MID-YEAR APPROXIMATION
   21 DO 20 I=1,NMT
      DO 19 L=1,14
      L1=0
      L1=(L-1)*12
      IF(I.EQ.L1) GOTO 18
      IF(I.NE.L1) GOTO 19
   18 DO 17 J=1,NMT
      F(I,J)=FMORT/XDT
   17 CONTINUE
      GOTO 20
   19 CONTINUE
      DO 15 J=1,NMT
      F(I,J)=0.
   15 CONTINUE
   20 CONTINUE
      GOTO 84
C*****F CONSTANT EVERY INTERVAL
   60 DO 62 I=1,NMT
      DO 61 J=1,(MFC-1)
      F(I,J)=0.
   61 CONTINUE
   62 CONTINUE
C       DO 63 I=1,NMT
C       F(I,45)=(FMORT/XDT)*0.36
C   63 CONTINUE
      DO 67 I=1,NMT
      DO 64 J=MFC,NMT
      F(I,J)=FMORT/XDT
   64 CONTINUE
   67 CONTINUE
      GOTO 84
C*****SEASONAL FISHING MORTALITY STRATEGY
  130 DO 149 I=1,NLL
      DO 148 M=1,12
      K=(I-1)*12+M
      IF(FP(M).EQ.0) GOTO 131
      IF(FP(M).EQ.1) GOTO 135
  131 X=K
      J=1
      DO 141 JJ=X,1,-1
      IF(J.GT.NMT) GOTO 141
      F(JJ,J)=0.
      J=J+1
  141 CONTINUE
      GOTO 148
  135 X=K
      J=1
      DO 142 JJ=X,1,-1
      IF(J.GT.NMT) GOTO 142
      F(JJ,J)=FMORT/XNMF
      J=J+1
  142 CONTINUE
  148 CONTINUE
  149 CONTINUE
      GOTO 84
C*********************************************************************
C     RECRUITMENT ARRAYS                                             *
C*********************************************************************
C     RECRUITMENT DISTRIBUTION FUNCTIONS                             *
C     VARIABLE NAME = NROT                                           *
C                                                                    *
C     DISCRETE = 1                                                   *
C     CONTINUOUS UNIFORM = 2                                         *
C     TRIGONOMETRIC DISTRIBUTION = 3                                 *
C     BETA DISTRIBUTION = 4                                          *
C                                                                    *
C     TR = TOTAL ANNUAL MAGNITUDE OF RECRUITMENT                     *
C*********************************************************************
   84 IF(NROT.EQ.1) GOTO 86
      IF(NROT.EQ.2) GOTO 87
      IF(NROT.EQ.3) GOTO 88
      IF(NROT.EQ.4) GOTO 90
C*****DISCRETE ANNUAL RECRUITMENT
   86 NNTL=NTL+1
      DO 71 I=1,NNTL
      DO 70 J=1,NDT
      IF(J.NE.1) GOTO 68
      IF(J.EQ.1) GOTO 69
   69 L=(I-1)*12+J
      R(L)=TR
      GOTO 70
   68 L=(I-1)*12+J
      R(L)=0.0
   70 CONTINUE
   71 CONTINUE
      GOTO 79
C*****CONTINUOUS UNIFORM RECRUITMENT
   87 DO 85 I=1,NMT
      R(I)=TR/XDT
   85 CONTINUE
      GOTO 79
C*****TRIGONOMETRIC RECRUITMENT *************************************
C     VARIABLE NAME = PER                                            *
C     PER = 12 (BIMODAL ANNUALLY)                                    *
C     PER = 24 (UNIMODAL ANNUALLY)                                   *
C*******************************************************************
   88 PI=3.1415927
      AMPL=(2*PI)/PER
      SUM=0.
      S2=0.
      S3=0.
      DO 188 J=1,12
      RA(J)=SIN(AMPL*J)
      RA(J)=ABS(RA(J))
      SUM=SUM+RA(J)
  188 CONTINUE
      DO 187 J=1,12
      RC(J)=RA(J)/SUM
      S2=S2+RC(J)
  187 CONTINUE
      LCOUNT=0
      DO 189 I=1,NTL
      S3=0.
      K=0.
      DO 186 J=1,12
      K=LCOUNT+J
      R(K)=RC(J)*TR
      S3=S3+R(K)
  186 CONTINUE
      LCOUNT=LCOUNT+12
  189 CONTINUE
      IF(MOS.EQ.0) GOTO 79
      DO 184 J=NMC,NMT
      KK=J-NM
      R(J)=RC(KK)*TR
  184 CONTINUE
```

```
      K=0.
      GOTO 79
C***********************************************************************
C     BETA DISTRIBUTION                                                *
C                                                                      *
C     PARAMETERS OF THE BETA DISTRIBUTION                              *
C     PARM1 = ALPHA 1                                                  *
C     PARM2 = ALPHA 2                                                  *
C***********************************************************************
   90 PI=3.1415927
      A1P=PARM1-1.
      A2P=PARM2-1.
      A3P=(PARM1+PARM2)-1.
      XN1F=EXP(-A1P)*(A1P**A1P)*(SQRT(2*PI*A1P))
      XN2F=EXP(-A2P)*(A2P**A2P)*(SQRT(2*PI*A2P))
      XN3F=EXP(-A3P)*(A3P**A3P)*(SQRT(2*PI*A3P))
      BETADS=(XN1F*XN2F)/XN3F
      GOTO 221
c      SUM=0.
c      S2=0.
c      DO 220 J=1,12
c      TIME=J/12.
c      RA(J)=((TIME**A1P)*((1-TIME)**A2P))/BETADS
c      SUM=SUM+RA(J)
c  220 CONTINUE
c      DO 219 J=1,NDT
c      RC(J)=RA(J)/SUM
c      S2=S2+RC(J)
c  219 CONTINUE
c      LCOUNT=0.
c      NNTL=NTL+1
c      DO 218 I=1,NNTL
c      S3=0.
c      K=0.
c      DO 217 J=1,12
c      K=LCOUNT+J
c      R(K)=RC(J)*TR
c      S3=S3+R(K)
c  217 CONTINUE
c      LCOUNT=LCOUNT+12
c      K=0.
c  218 CONTINUE
c      IF(MOS.EQ.0) GOTO 79
c      DO 216 J=NMC,NMT
c      KK=J-NM
c      R(J)=RC(KK)*TR
c  216 CONTINUE
c      GOTO 79
C*****************************************************
C     CONSTRAINED BETA WRT TIME                       *
C*****************************************************
  221 XCON=6.
      SUM=0.
      S2=0.
      DO 222 J=1,NDT
      TIME=J/XCON
      IF(J.GT.XCON) GOTO 226
      RA(J)=((TIME**A1P)*((1-TIME)**A2P))/BETADS
      WRITE(*,*)TIME,RA(J)
      SUM=SUM+RA(J)
      GOTO 222
  226 RA(J)=0.
  222 CONTINUE
      DO 223 J=1,NDT
      RC(J)=RA(J)/SUM
      WRITE(*,*)J,RC(J)
      S2=S2+RC(J)
  223 CONTINUE
      LCOUNT=0.
      NNTL=NTL+1
      DO 225 I=1,NNTL
      S3=0.
      K=0.
      DO 224 J=1,NDT
      K=LCOUNT+J
      IF(J.GT.XCON) GOTO 227
      R(K)=RC(J)*TR
      WRITE(*,*)I,J,R(K)
      GOTO 224
  227 R(K)=0.
      GOTO 224
c      S3=S3+R(K)
  224 CONTINUE
      LCOUNT=LCOUNT+12
      K=0.
  225 CONTINUE
      IF(MOS.EQ.0) GOTO 79
      DO 236 J=NMC,NMT
      KK=J-NM
      R(J)=RC(KK)*TR
  236 CONTINUE
C*****************************************************
C     STATIONARY CONDITIONS                           *
C*****************************************************
   79 WRITE(*,*)'CALCULATING STATIONARY VECTORS'
      IF(NYPR.EQ.0) GOTO 80
      WRITE(*,*)'YPR SIMULATION'
      write(*,*)NTL,NTSS
      XFM=0.
      MTL=NTL*NTSS+1
      DO 490 NF=1,NFRANGE
      IF(NF.GT.1) GOTO 491
      FMX=0.
      GOTO 492
  491 XFM=XFM+1.
      FMX=XFM*fstep
  492 NTC=0
      DO 480 KK=1,MTL
      YPR=0.
      FPR=0.
      IF(KK.GT.1) GOTO 493
      MFC=0
      XMFC=0.
      GOTO 494
  493 MFC=MFC+NTS
      XMFC=XMFC+XXNTS
  494 WRITE(*,*)'YPR AT',FMX,XMFC,'(',MFC,')'
      DO 479 I=1,NMT
      DO 475 J=1,(MFC-1)
      F(I,J)=0.
      A(I,J)=0.
  475 CONTINUE
  479 CONTINUE
      DO 470 I=1,NMT
      DO 465 J=MFC,NMT
      F(I,J)=FMX/XDT
      A(I,J)=1.0
  465 CONTINUE
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  470 CONTINUE
      IF(MFC.LT.MFR) GOTO 463
      DO 1010 K=1,NMT
      SMOS=1
      CALL DYNSIM(K,SMOS)
 1010 CONTINUE
      GOTO 462
  463 YPR=0.
      FPR=0.
      GOTO 464
  462 YPR=YWJ/R(NM)
      FPR=SSB/PPAMAX
c  464 WRITE(*,*)FMX,SLT(MFC),XMFC,YPR,FPR
  464 XKK=0.1358
      T00=-0.863
      UUL=722.32
      SLL=UUL*(1.-EXP(-XKK*(XMFC-T00)))
      WRITE(14,*)FMX,XMFC,SLL,YPR
      WRITE(15,*)FMX,XMFC,SLL,FPR
  480 CONTINUE
  490 CONTINUE
      GOTO 4001
   80 WRITE(*,*)'NORMAL SIMULATION'
      DO 1000 K=1,NM
      SMOS=1
      CALL DYNSIM(K,SMOS)
 1000 CONTINUE
      K=NM
      if(NMT.GT.K) GOTO 230
      SMOS=1
      CALL LAPD(K,SMOS,NAMP,NDIST)
      CALL SCANDET(K,NM,DTL)
C*****Non-equilibrium switch
      NEQ=1
      IF(NSRCH)230,230,229
  229 CALL SCANPB(K,NM,NDIST,DTL)
      WRITE(6,*)'RETURNED SCANPB'
  230 GOTO 3000
C*******************************************************
C     DYNAMIC CONDITIONS                                *
C*******************************************************
 3799 WRITE(6,3800)
 3800 FORMAT(7X,'CALCULATING TRANSITIONAL VECTORS'//)
      DO 4000 K=NMC,NMT
      SMOS=SMOS+1
      CALL DYNSIM(K,SMOS)
      if(K.LT.NMT) GOTO 250
      CALL LAPD(K,SMOS,NAMP,NDIST)
      CALL SCANDET(K,NM,DTL)
      WRITE(*,*)'RETURNED FROM SCANDET',NSRCH,K
      NEQ=1
      IF(NSRCH)250,250,249
  249 CALL SCANPB(K,NM,NDIST,DTL)
      WRITE(*,*)'RETURNED FROM SCANPB'
  250 GOTO 3000

C**********************************************************************
C     WRITING TO DATA FILES                                           *
C**********************************************************************

c*****No Path to Statements
c      X=K
c      J=1
c      DO 820 I=X,1,-1
c      XXXX=J
c      IF(J.LT.MFR) GOTO 819
c  815 xj=j/12.
c      WRITE(4,811)xj,BIOM(J)
c  811 FORMAT(f7.2,3x,f7.2)
C      WRITE(2,813)SLT(J),PD(J,K),NPLOT
c  813 FORMAT(F15.4,F15.5,I5)
c  819 J=J+1
c  820 CONTINUE
c      DO 830 J=1,NTOTLI
C      WRITE(4,828)XLENPT(J),POPLEN(J),K
C      WRITE(11,828)XDLENPT(J),DPOP(J),K
c  830 CONTINUE
c  828 FORMAT(F15.5,F15.5,I5)
c      KKK=NM+100
c      DO 899 J=1,NTOTLI
C      WRITE(11,828)XDLENPT(J),DYPD(J),KKK
c  899 CONTINUE
C      WRITE(11,848)TDLC,TYD,DALC
c  848 FORMAT(7X,'TDLC = ',E12.6,5X,'TYD = ',E12.6,/,
c     $7X,'DETERMINISTICALLY AGGREGATED
c     $AVG LENGTH IN CATCH = ',F15.5)
c      KKKK=NM+200
c      DO 901 J=1,NTOTLI
C      WRITE(12,828)XLENPT(J),SYLND(J),KKKK
c  901 CONTINUE
C      WRITE(12,849)TSLC,TSY,SALC
c  849 FORMAT(7X,'TSLC = 'E12.6,5X,'TSY = ',E12.6,/,
c     $7X,'STOCHASTICALLY AGGREGATED
c     $ AVG LENGTH IN CATCH = ',F15.5)
c       WRITE(11,836)TPD,TYD,TSY
  836 FORMAT(5X,'TOTAL POPN NUMBERS = ',E18.7,/5X,
     $      'TOTAL YIELD IN NUMBERS = ',E18.7,/5X,
     $      'TOTAL STOCHASTIC YIELD IN NUMBERS = ',E18.7)

C**********************************************************************
C     TRANSITIONAL OUTPUT MODULE                                       *
C**********************************************************************
 3000 IF(NEQ)3002,3002,3001
 3001 MR=K
      IF(R(MR).EQ.0) GOTO 3902
      YPR=YWJ/R(MR)
      YNPR=YNJ/R(MR)
      GOTO 3903
 3002 MR=NM
      IF(R(MR).EQ.0) GOTO 3902
      YPR=YWJ/R(MR)
      YNPR=YNJ/R(MR)
      GOTO 3903
 3902 YPR=0.
      YNPR=0.
 3903 WRITE(5,1590)K
 1590 FORMAT(7X,'MONTH = ',I5)
      IF(NOUT.EQ.0) GOTO 3008
      IF(NOUT.EQ.1) GOTO 1591
 1591 WRITE(5,1592)
 1592 FORMAT('AGE',5X,'LENGTH',6X,'WEIGHT',6X,'POPN NO.',
     $9X,'AVG NO.',6X,'BIOMASS')
      X=K
      J=1
      DO 1700 I=X,SMOS,-1
      WRITE(5,1640)J,SLT(J),WT(J),P(I,J),RN(I,J),BIOM(J)
      WRITE(16,1640)j,slt(j),wt(j),rn(i,j),yn(i,j),yw(i,j)
 1640 FORMAT(I3,3X,F8.3,2X,F8.3,2X,E13.7,2X,E13.7,2X,E13.7)
```

```
      J=J+1
 1700 CONTINUE
      WRITE(5,1701)PJ,RPJ,BMJ
 1701 FORMAT('TOTAL',21X,E13.7,2X,E13.7,2X,E13.7//)
 1491 WRITE(5,1492)
 1492 FORMAT('AGE',8X,'YIELD NO.',5X,'YIELD WT.',7X,'FMORT',7X,'SELECT')
      X=K
      J=1
      DO 1400 I=X,SMOS,-1
      WRITE(5,1350)J,YN(I,J),YW(I,J),F(I,J)*A(I,J),S(J,1)
 1350 FORMAT(I3,3X,E13.7,2X,E13.7,4X,F6.4,4X,F6.4)
      J=J+1
 1400 CONTINUE
      WRITE(5,1401)YNJ,YWJ
 1401 FORMAT('TOTAL',1X,E13.7,2X,E13.7//)
      WRITE(5,1710)FMORT,XNM,MFC,AL,ALPGTC,ALC,AVWT,AAC,
     $SLT(MFC),SLT(NM)
 1710 FORMAT('ANNUAL F = ',F12.6,5X,'ANNUAL M = ',F12.6/,
     $'AGE OF FIRST CAPTURE = ',I3/,
     $'AVG LENGTH IN THE POPN = ',F13.6/,
     $'AVG LENGTH IN THE POPN >TC = ',F13.6/,
     $'AVG. LENGTH IN THE CATCH = ',F13.6/,
     $'AVG. WEIGHT IN THE CATCH = ',F13.6/,
     $'AVG. AGE IN THE CATCH = ',F13.6/,
     $'Length at first capture = ',f13.6/
     $'Maximum Length class in the catch = ',f13.6/)
      WRITE(5,1712)YPR,YNPR
 1712 FORMAT('YIELD IN WEIGHT PER RECRUIT = ',F15.8/,
     $'YIELD IN NUMBER PER RECRUIT = ',F15.8//)
      WRITE(5,3021)FPJ,FRPJ,FBMJ
 3021 FORMAT('FISHABLE TOTAL POPN SIZE = ',E13.7/,
     $'FISHABLE AVG. POPN SIZE = ',E13.7/,
     $'FISHABLE AVG. POPN BIOMASS = ',E13.7)
      WRITE(5,3022)AFPN,AFBM,TR,SSB,PPA
 3022 FORMAT('AVG. FISHABLE POPN NUMBERS PER RECRUIT = ',F13.7/,
     $'AVG. FISHABLE POPN BIOMASS PER RECRUIT = ',F13.7/,
     $'ANNUAL RECRUITMENT = 'F12.0/,'SPAWNING STOCK BIOMASS =',F12.0/
     $'STOCK FECUNDITY = ',E15.8)
      X=K
      J=1
      DO 3090 I=X,1,-1
      IF(J.LT.MFR) GOTO 3089
      xj=j/12.
      WRITE(4,3087)xj,SLT(J),BIOM(J)
 3087 FORMAT(2(f7.2,3x),f10.2)
 3089 J=J+1
 3090 CONTINUE
      GOTO 3999
 3008 WRITE(5,3010)
 3010 FORMAT(7X,'CONDENSED TRANSITIONAL OUTPUT:',//)
      WRITE(5,3020)PJ,BMJ,SSB
 3020 FORMAT(7X,'POPULATION ABUNDANCE = ',F12.3,/,7X,
     $'POPULATION BIOMASS = ',E14.7,/,7X,'SPAWNING STOCK BIOMASS = ',
     $E14.7)
      WRITE(5,3030)YWJ,YNJ
 3030 FORMAT(7X,'YIELD IN WEIGHT = ',
     $E14.7,/,7X,'YIELD IN NUMBERS = ',E14.7)
      WRITE(5,3040)AL,ALC
 3040 FORMAT('AVG LENGTH IN TOTAL POPN = ',F8.4,/,7X,
     $'AVG. LENGTH IN CATCH = ',F8.4)
      WRITE(5,3050)AVWT
 3050 FORMAT(7X,'AVG. WT. IN CATCH = ',F8.4,/)
      WRITE(5,3055)R(K),YPR
 3055 FORMAT(7X,'RECRUITMENT = ',F10.5,/,
     $7X,'YIELD PER RECRUIT = ',F9.4,//)
 3060 IF(JTRANS.NE.12) GOTO 4000
      IF(JTRANS.EQ.12) GOTO 3101
 3101 WRITE(5,3100)
 3100 FORMAT(7X,'AGE',8X,'POPN. NO.',3X,'Yweight',5X,'Ynumber')
      X=K
      J=1
      DO 3005 I=X,SMOS,-1
      WRITE(5,3004)J,AP(J),AYW(J),AYN(J),SLT(J)
 3004 FORMAT(7X,I3,2X,F10.2,5X,F12.3,5X,F12.3,5X,F12.3)
      J=J+1
 3005 CONTINUE
      WRITE(5,3110)ABMJ,ASSB,APJ
 3110 FORMAT(//,7X,'BIOMASS = ',E14.7,/,7X,'SPAWNING BIOMASS = ',
     $E14.7,/,7X,'POPULATION SIZE = ',E14.7)
      WRITE(5,3120)ATOTWC,AYNJ
 3120 FORMAT(7X,'YIELD IN WEIGHT = ',E14.7,//,7X,'YIELD IN NO. = ',
     $E14.7)
      IF(AYNJ.LE.0) GOTO 3128
c      AALC=ATOTLC/AYNJ
c      AAVWT=ATOTWC/AYNJ
      GOTO 3129
 3128 AALC=0.
      AAVWT=0.
 3129 WRITE(5,3130)AALC,AAVWT
 3130 FORMAT(7X,'AVG. LENGTH IN CATCH = ',F8.4,5X,'AVG. WEIGHT IN
     $CATCH = ',F8.4)
      WRITE(5,3140)YPR
 3140 FORMAT(7X,'ANNUAL YIELD PER RECRUIT = ',F9.6,//)
      JTRANS=0.
 3999 NS=NS+1
      IF(MOS.EQ.0) GOTO 4001
      IF(NS.GT.MOS) GOTO 4001
      IF(NS.EQ.1) GOTO 3799
      IF(MOS.GE.1) GOTO 4000
 4000 CONTINUE
 4001 STOP
      END
```

```
      SUBROUTINE DYNSIM(K,SMOS)
C**********************************************************************
C     CENTERED DYNAMIC SIMULATIONS                                     *
C**********************************************************************
C                                                                      *
C     CALCULATION OF CONTINUOUS RECRUITMENT LOOPS                      *
C                                                                      *
C**********************************************************************
      DIMENSION XOMEG(4),RM(300)
      INTEGER K,X,SMOS
      COMMON P(492,492),Z(492,492),A(492,492),XM(492,492),
     $       F(492,492),
     $        R(492),RN(492,492),YN(492,492),YW(492,492),MFR
      COMMON/A/XAKV,T0,ULINF,WINF,MRM,TR,MFC
      COMMON/B/FRQ(40),SE(492),SLT(492)
      COMMON/S/XE(492),WT(492),BIOM(492),POPP(492),TLC(492),
     $TL(492),TWC(492),AL,PBIRTH(492),ALC,AVWT,AFBM,AFPN,FPJ,
     $CX(492),ACBIR(492),RPJ,YWJ,PPA,BMJ,PJ,SSB,
     $YNJ,TOTLC,TOTLP,TOTWC,PJCX,CXT,ACBT,FEC(492),FBMJ,
     $FRPJ,LL,S(492,12),TAC(492),AAC,ALPGTC
      data RM1,RM2/-5.5,.171/
      XOMEG(1)=1.0
```

```
      XOMEG(2)=-3.0
      XOMEG(3)=3.0
      XOMEG(4)=-1.0
      TOTLP=0.
      TOTLC=0.
      TOTAC=0.
      TOTWC=0.
      YWJ=0.
      YNJ=0.
      BMJ=0.
      RPJ=0.
      FBMJ=0.
      FRPJ=0.
      FPJ=0.
      PJ=0.
      AVGL=0.
      EYPR=0.
      SSB=0.
      PPA=0.
      AL=0.
      ALC=0.
      AVWT=0.
      AVWT2=0.
      AFBM=0.
      AFPN=0.
      AAC=0.
      TLPGTC=0.
      ALPGTC=0.
      X=K
      J=1
c      write(*,*)'in dynsim',' k = ',K,R(K)
      IF(LL.GT.1) GOTO 99
      LL=1
   99 DO 500 I=X,SMOS,-1
      BIOM(J)=0.
      POPP(J)=0.
      TL(J)=0.
      TLC(J)=0.
      TWC(J)=0.
      IF(I-X)110,120,110
  120 P(I,J)=R(K)
      Z(I,J)=XM(I,J)+(A(I,J)*F(I,J)*S(J,LL))
      P(I,J+1)=P(I,J)*(EXP(-Z(I,J)))
      IF(Z(I,J))83,83,83
c      RN(I,J)=(P(I,J)/Z(I,J))*(1.0-EXP(-Z(I,J)))
      GOTO 83
  110 Z(I,J)=0.
      Z(I,J)=XM(I,J)+(A(I,J)*F(I,J)*S(J,LL))
      P(I,J)=P(I,J-1)*EXP(-Z(I,J-1))
      IF(Z(I,J).EQ.0.) GOTO 111
      RN(I,J)=0.
      RN(I,J)=(P(I,J)/Z(I,J))*(1.0-EXP(-Z(I,J)))
      RPJ=RPJ+RN(I,J)
      GOTO 83
  111 YN(I,J)=0.
      RN(I,J)=0.
   83 IF(J.LT.MFR) GOTO 150
      RM(J)=1./(1.+EXP(-(RM1+RM2*SLT(J))))
      RM(J)=1.
      BIOM(J)=WT(J)*RN(I,J)*RM(J)
      IF(J.LT.MRM) GOTO 112
      SSB=SSB+BIOM(J)
      POPP(J)=RN(I,J)*FEC(J)
      PPA=PPA+POPP(J)
  112 BMJ=BMJ+BIOM(J)
      PJ=PJ+P(I,J)
      TL(J)=RN(I,J)*SLT(J)
      TOTLP=TOTLP+TL(J)
      IF(J.LT.MFC) GOTO 150
      FPJ=FPJ+P(I,J)
      FBMJ=FBMJ+BIOM(J)
      FRPJ=FRPJ+RN(I,J)
c      VSUM=0.
c      DO 109 IV=1,4
c      VN=IV-1
c      IF(Z(I,J).EQ.0) GOTO 109
c      VSUM=VSUM+XOMEG(IV)*EXP(-VN*XAKV*((J-1)-T0))/
c     $(Z(I,J)+VN*XAKV)*(1-EXP(-(Z(I,J)+VN*XAKV)))
c  109 CONTINUE
      YW(I,J)=0.
      YN(I,J)=0.
      YW(I,J)=A(I,J)*F(I,J)*S(J,LL)*RN(I,J)*WT(J)
c      YW(I,J)=A(I,J)*F(I,J)*S(J,LL)*P(I,J)*WINF*VSUM
      YWJ=YWJ+YW(I,J)
      YN(I,J)=A(I,J)*F(I,J)*S(J,LL)*RN(I,J)
      YNJ=YNJ+YN(I,J)
      TLC(J)=YN(I,J)*SLT(J)
      TLPGTC=TLPGTC+RN(I,J)*SLT(J)
      XX=FLOAT(J)
      TAC(J)=YN(I,J)*(XX-0.5)
c      TAC(J)=0.
      TOTAC=TOTAC+TAC(J)
      TOTLC=TOTLC+TLC(J)
      TWC(J)=YN(I,J)*WT(J)
      TOTWC=TOTWC+TWC(J)
  150 J=J+1
  500 CONTINUE
      IF(RPJ) 430,1000,430
  430 AL=TOTLP/RPJ
      IF(YNJ)431,1000,431
  431 ALC=TOTLC/YNJ
      AAC=TOTAC/YNJ
      AVWT=TOTWC/YNJ
      AFBM=FBMJ/TR
      AFPN=FRPJ/TR
      ALPGTC=TLPGTC/FRPJ
      LL=LL+1
      IF(LL.LT.13) GOTO 1000
      LL=0
 1000 RETURN
      END


      SUBROUTINE LAPD(K,SMOS,NAMP,NDIST)
C***********************************************************************
C     LENGTH @ AGE PROBABILITY DISTRIBUTIONS                           *
C***********************************************************************
      DIMENSION PDM(492),PDYLD(492)
      COMMON P(492,492),Z(492,492),A(492,492),XM(492,492),F(492,492),
     $       R(492),RN(492,492),YN(492,492),YW(492,492),MFR
      COMMON/B/FRQ(40),SE(492),SLT(492)
      COMMON/E/PD(492,35),PDY(492,35),XLD(492,35)
      INTEGER SMOS
      X=K
      J=1
      DO 1 I=1,31
    1 CONTINUE
c      GOTO 991
```

```
      DO 990 I=K,SMOS,-1
      PDM(J)=P(I,J)
      PDYLD(J)=YN(I,J)
      DO 970 KK=1,NDIST
      IF(KK.LE.15) GOTO 968
      IF(KK.EQ.16) GOTO 967
      IF(KK.GT.16) GOTO 966
  968 XTEMP=FLOAT(16-KK)*0.2
      XLD(J,KK)=SLT(J)-XTEMP*SE(J)*NAMP
      PD(J,KK)=PDM(J)*FRQ(KK)
      PDY(J,KK)=YN(I,J)*FRQ(KK)
      IF(XLD(J,KK).LE.0.) GOTO 970
      IF(PD(J,KK).LE.0.) GOTO 970
      XX=FLOAT(J/12)
      WRITE(7,*)XLD(J,KK),PD(J,KK),XX
      GOTO 970
  967 XLD(J,KK)=SLT(J)
      PD(J,KK)=PDM(J)*FRQ(KK)
      PDY(J,KK)=PDYLD(J)*FRQ(KK)
      IF(XLD(J,KK).LE.0.) GOTO 970
      IF(PD(J,KK).LE.0.) GOTO 970
      XX=FLOAT(J/12)
      WRITE(7,*)XLD(J,KK),PD(J,KK),XX
      GOTO 970
  966 XTEMP=FLOAT(16-KK)*0.2
      XLD(J,KK)=SLT(J)+XTEMP*SE(J)*NAMP
      PD(J,KK)=PDM(J)*FRQ(KK)
      PDY(J,KK)=PDYLD(J)*FRQ(KK)
      IF(XLD(J,KK).LE.0.) GOTO 970
      IF(PD(J,KK).LE.0.) GOTO 970
      XX=FLOAT(J/12)
      WRITE(7,*)XLD(J,KK),PD(J,KK),XX
  970 CONTINUE
  980 CONTINUE
      J=J+1
  990 CONTINUE
  991 X=FLOAT(K)
      J=1
      RETURN
      END


      SUBROUTINE SCANDET(K,NM,DTL)
C**********************************************************************
C     SEARCHING ROUTINE FOR SCANNING DETERMINISTIC                    *
C     POPULATION LENGTH DISTRIBUTION                                  *
C**********************************************************************
      COMMON P(492,492),Z(492,492),A(492,492),XM(492,492),F(492,492),
     $       R(492),RN(492,492),YN(492,492),YW(492,492),MFR
      COMMON/B/FRQ(40),SE(492),SLT(492)
      COMMON/D/XDLENPT(1000),DPOP(1000),DYPD(1000),TDL(1000),TYD,
     $         TPD,TDLC,DALC
      WRITE(*,*)'ENTERED SCANDET'
      XLMAX=0.
      XLMIN=0.
      NTOTLI=0.
      RANGEL=0.
      XMINLEN=0.
      XMAXLEN=0.
      TYP=0.
      TPD=0.
      TDLC=0.
      DALC=0.
      TYD=0.
      XLMAX=SLT(NM)+50.0*SE(NM)
      XLMIN=SLT(MFR)-12.0*SE(MFR)
      XLMIN=INT(XLMIN)
      XLMAX=INT(XLMAX)
      IF(XLMIN.GE.0) GOTO 1958
      XLMIN=0.
 1958 NTOTLI=INT((XLMAX-XLMIN)/DTL)
      WRITE(*,*) 'CALCULATED # OF LENGTH INCREMENTS'
      RANGEL=XLMAX-XLMIN
      DO 1955 ZZ=1,NTOTLI
      DPOP(ZZ)=0.
      DYPD(ZZ)=0.
      TDL(ZZ)=0.
      IF(ZZ.NE.1) GOTO 1940
      XMINLEN=XLMIN
      XMAXLEN=XLMIN+DTL
      GOTO 1942
 1940 XMINLEN=XMAXLEN
      XMAXLEN=XMINLEN+DTL
 1942 XDLENPT(ZZ)=(XMAXLEN+XMINLEN)/2.
      X=K
      J=1
      DO 1950 I=X,1,-1
      IF(J.LT.MFR) GOTO 1949
      IF(SLT(J).LE.XMAXLEN) GOTO 1947
      GOTO 1949
 1947 IF(SLT(J).GE.XMINLEN) GOTO 1945
      GOTO 1949
 1945 DPOP(ZZ)=DPOP(ZZ)+P(I,J)
      DYPD(ZZ)=DYPD(ZZ)+YN(I,J)
      TDL(ZZ)=TDL(ZZ)+(YN(I,J)*XDLENPT(ZZ))
 1949 J=J+1
 1950 CONTINUE
      TYD=TYD+DYPD(ZZ)
      TPD=TPD+DPOP(ZZ)
      TDLC=TDLC+TDL(ZZ)
      IF(DPOP(ZZ).LE.0) GOTO 1955
      WRITE(12,*)XDLENPT(ZZ),DYPD(ZZ)
 1955 CONTINUE
      WRITE(*,*)'COMPLETED SEARCH LOOP'
      if(TYD.LE.0.) goto 2000
      DALC=TDLC/TYD
 2000 WRITE(6,*)TDLC,TYD,DALC
      RETURN
      END


      SUBROUTINE SCANPB(K,NM,NDIST,DTL)
C**********************************************************************
C     SEARCHING ROUTINE FOR SCANNING                                  *
C     PROBABILISTIC LENGTH DISTRIBUTIONS                              *
C**********************************************************************
      COMMON P(492,492),Z(492,492),A(492,492),XM(492,492),F(492,492),
     $       R(492),RN(492,492),YN(492,492),YW(492,492),MFR
      COMMON/B/FRQ(40),SE(492),SLT(492)
      COMMON/C/POPLEN(1000),SYLND(1000),XLENPT(1000),TSL(1000),
     $         TSY,TSLC,SALC,NTOTLI
      COMMON/E/PD(492,35),PDY(492,35),XLD(492,35)
      write(*,*)'Entered SCANPB'
      TSY=0.
      TSLC=0.
      SALC=0.
      XLMAX=0.
      XLMIN=0.
      NTOTLI=0.
      RANGEL=0.
      XMINLEN=0.
      XMAXLEN=0.
```

```
      XLMAX=SLT(NM)+50.0*SE(NM)
      XLMIN=SLT(MFR)-12.0*SE(MFR)
      XLMIN=INT(XLMIN)
      XLMAX=INT(XLMAX)
      IF(XLMIN.GE.0) GOTO 958
      XLMIN=0.0
  958 NTOTLI=INT((XLMAX-XLMIN)/DTL)
      WRITE(*,*)XLMAX,XLMIN,NTOTLI,DTL
      RANGEL=XLMAX-XLMIN
      DO 955 ZZ=1,NTOTLI
      POPLEN(ZZ)=0.
      SYLND(ZZ)=0.
      TSL(ZZ)=0.
      IF(ZZ.NE.1) GOTO 940
      XMINLEN=XLMIN
      XMAXLEN=XLMIN+DTL
      GOTO 942
  940 XMINLEN=XMAXLEN
      XMAXLEN=XMINLEN+DTL
  942 XLENPT(ZZ)=(XMAXLEN+XMINLEN)/2.
      X=K
      J=1
      DO 950 I=X,1,-1
      DO 949 KK=1,NDIST
      IF(J.LT.MFR) GOTO 949
      IF(XLD(J,KK).LE.XMAXLEN) GOTO 947
      GOTO 949
  947 IF(XLD(J,KK).GE.XMINLEN) GOTO 945
      GOTO 949
  945 SYLND(ZZ)=SYLND(ZZ)+PDY(J,KK)
      POPLEN(ZZ)=POPLEN(ZZ)+PD(J,KK)
      TSL(ZZ)=TSL(ZZ)+(PDY(J,KK)*XLENPT(ZZ))
  949 CONTINUE
      J=J+1
  950 CONTINUE
      TSY=TSY+SYLND(ZZ)
      TSLC=TSLC+TSL(ZZ)
      IF(POPLEN(ZZ).LE.0.) GOTO 955
      WRITE(11,*)XLENPT(ZZ),SYLND(ZZ)
cc      WRITE(11,*)XLENPT(ZZ),POPLEN(ZZ)
  955 CONTINUE
      IF(TSY.LE.0.) GOTO 1000
      SALC=TSLC/TSY
 1000 RETURN
      END
```