Fisheries Databases for Assessing Habitat Functions of Cape Romain NWR

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in cooperation with

Cape Romain National Wildlife Refuge
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Ecological Characterization

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Executive Summary. The US Fish and Wildlife Service Cape Romain National Wildlife Refuge (CRNWR) and the Center for Coastal Environmental Health and Biomolecular Research (CCEHBR) at Charleston are interested in assessing the status of our coastal resources in light of increased coastal development and recreational use. Through an Interagency Agreement, an ecological characterization was undertaken to describe the status of and potential impacts to resources at CRNWR. This report describes historic fisheries data relevant to CRNWR that can be used to evaluate the role of the Refuge as habitat for nearshore and offshore fish species. The purpose of this document is two-fold, first to give resource managers an understanding of what data are available and, second, to illustrate how these data can be applied to address specific management issues. This report provides an overview of historic fisheries data collected along the southeast coast, as well as basic summaries of that data relevant to CRNWR, indicating how these data can be used to address specific questions of interest to Refuge managers and biologists.

Fisheries Databases for Assessing Habitat Functions of Cape Romain NWR

Overview

Long-term nearshore fisheries surveys have been conducted by South Carolina Department of Natural Resources (SCDNR) through both the Southeast Area Monitoring and Assessment Program (SEAMAP) and Inshore Fisheries programs. Additionally, the Marine Resources Monitoring, Assessment and Prediction (MARMAP) program through SCDNR has been performing surveys of offshore fish communities since 1973. These efforts provide valuable long-term seasonal information on fish community structure, abundance, and biomass in the South Atlantic Bight. The Inshore Fisheries program sampled 165 inshore sites within Cape Romain NWR from 1989-2000. The SEAMAP program focused primarily on nearshore areas, in depths ranging from 4 to 19 meters, along the southeast coast from North Carolina to Florida between 1986 and 2000. MARMAP surveys also extended from North Carolina to Florida using a variety of gear types. Figure 1 summarizes the sampling of all three programs relative to Cape Romain NWR.

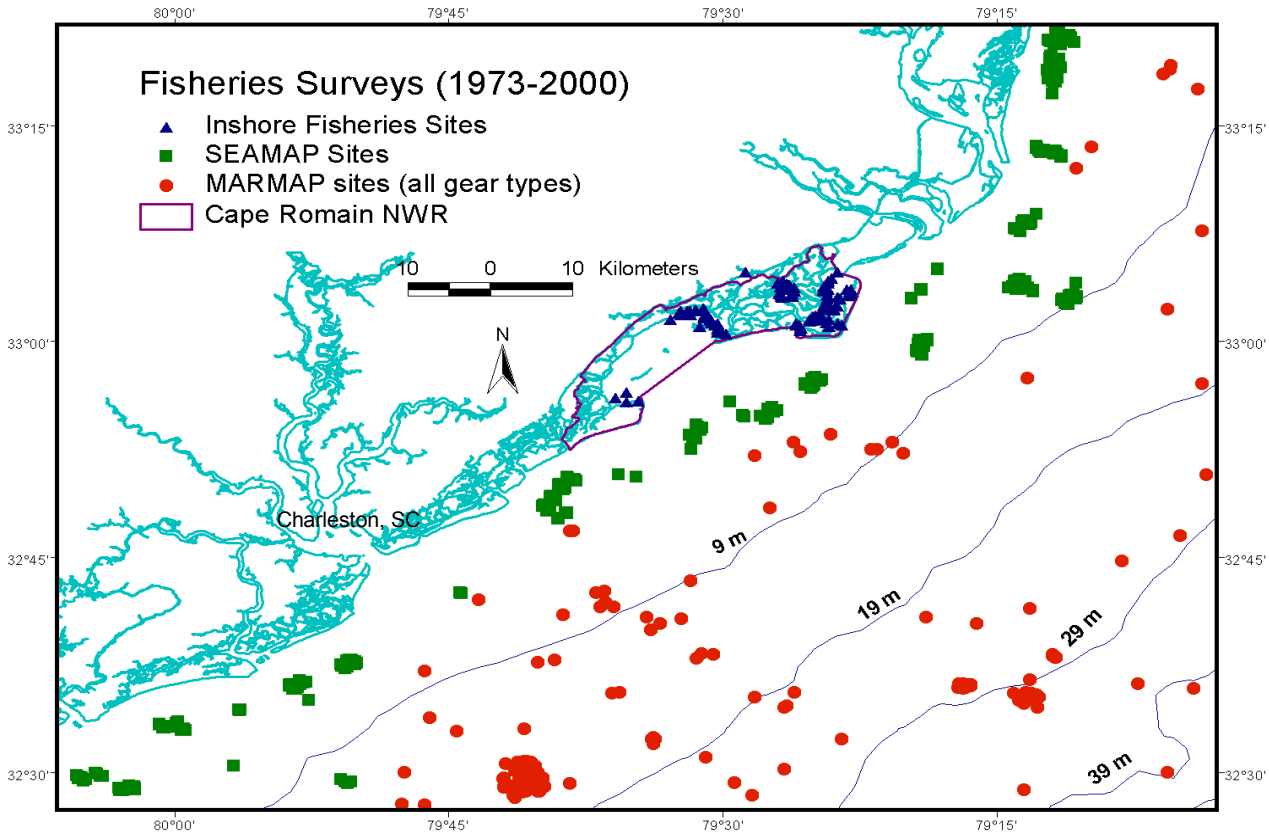


Figure 1. Inshore, nearshore, and offshore fisheries surveys (1973-2000)

Statistical and spatial analyses of these fisheries-independent data can be used to address a variety of management questions, such as: 1) Which finfish species are most abundant within the Refuge? 2) Which areas of the Refuge have the highest fish abundance and diversity? 3) How has use of the Refuge by specific species changed seasonally and historically? 4) Do certain fish species migrate between offshore spawning sites and nursery areas of the Refuge? This report will describe the synthesis of historical fisheries surveys specific to CRNWR that can be used to address these and similar questions. The purpose here is two-fold: first, to give resource managers an understanding of what data are available and, second, to illustrate how these data can be applied to address specific management issues. An overview of three relevant databases is given, while data analyses focus on SCDNR Inshore Fisheries surveys conducted within the Refuge.

B. Available Data

CCEHBR has compiled a relational database of SCDNR fisheries surveys conducted under the Inshore Fisheries, SEAMAP, and MARMAP programs. Data from each of the three long-term databases is available to CRNWR managers for analysis of the fisheries resources of the Refuge. Table 1 describes the fisheries and ancillary data contained in each of these databases. Analyses of data from Inshore Fisheries surveys at 165 sites within the Refuge are presented in the next section.

Table 1. Databases developed by NOS/CCEHBR from Inshore Fisheries, SEAMAP, and MARMAP surveys useful in assessing the function of Cape Romain NWR as fish habitat.

Survey	Inshore Fisheries	SEAMAP	MARMAP
Time frame	1989-2000	1986-2000	1973-2000
Database	Romain.mdb	seamap.mdb	MARMAP3.mdb
Spatial extent	Entire South Carolina coast (165 sites occur within CRNWR)	All nearshore trawl surveys from North Carolina to Florida	All offshore trawl and trap surveys from North Carolina to Florida
Gear used	2 types of Trammel nets and a Stop net See appendix I for gear designs	22.9m mongoose-type Falcon trawl net See appendix I for gear design	3/4 Yankee trawl (1973-80) 40/54 Fly Net (1978-87) Florida Antillean trap (1978-90) Blackfish trap (1978-90) Chevron trap (1988-00) See Appendix I for gear designs*
Abundance data	Total number and weight of fishes caught per trawl (or collection) separated by species	Total number and weight of fishes caught per trawl (or collection) separated by species	Total number and weight of fishes caught per collection separated by species
Collection data	Date, location, time of day, sampling duration	Date, latitude, longitude, vessel speed, sample duration	Date, latitude, longitude, vessel speed, sample duration

Survey	Inshore Fisheries	SEAMAP	MARMAP
Specimen data	3 lengths, weight, gonad weight, sex, maturity, age of each fish caught per trawl	Length of each fish, defined by species, caught per collection	Length of each specimen caught per collection
Bio-diversity estimates	Margalef's Species Richness (D), Shannon-Wiener Index (H') and Species Evenness (J') for each collection and each sampling location		Collections pooled into 10 min grids to estimate: Margalef's Species Richness (D), Shannon Wiener Index (H') and Species Evenness (J') for each grid
Hydro-graphic / vessel data	Depth, air temperature, water temperature, DO, salinity	Atmospheric pressure, barometric pressure, water temperature, depth, salinity	Wind direction, wind velocity, cloud cover, precipitation, air temperature, barometric pressure, sea state, bottom type, water temperature, salinity, depth for each trawl or trap collection**
Invertebrate data		Total number and weight of invertebrates caught by trawl and length of each specimen	
Notes / restrictions			*Yankee trawls used on both hard and soft bottom areas. Fly nets and traps primarily used on hard bottom. Trap random sampling design could introduce bias.
			* *From 1973-1986, hydro data was collected via bottle casts in standard hydrographic depths; starting in 1987 a CTD was used
		Bottom type data, originally developed by the SAB SEAMAP Hardbottom Mapping project using underwater video, scuba, and the occurrence of indicator reef species within MARMAP trawls and traps, have been converted into 10 min. grids.	
	Bathymetry data layers have been developed from over 33,000 bottom depth measurements from NGDC sounding and seismic data. Contour shapefiles have been created.		

C. Data summaries.

The following section provides information on abundance, seasonal distribution, and diversity of fish species from inshore fisheries surveys conducted within the Refuge.

Abundance

A summary of the twelve most abundant species caught by inshore fisheries surveys in CRNWR is given in Figure 2. The total catch per year of the twelve most abundant species, along with the number of trawls, is given in Figure 3. The same summaries are also given for economically important species. Economic value is based on annual landings and market sales data compiled for South Carolina from 1989 to 1999[1]. Figure 4 shows the most abundant, economically important species. The number of trawls and the total catch of economically important fish per year is summarized in Figure 5. Overall, while the number of inshore fisheries collections per year have increased from 1989 to 1999, there has been relatively little change in overall catch per year.

Figure 2. Twelve most abundant species caught in Inshore Fisheries surveys in CRNWR 1989-1999

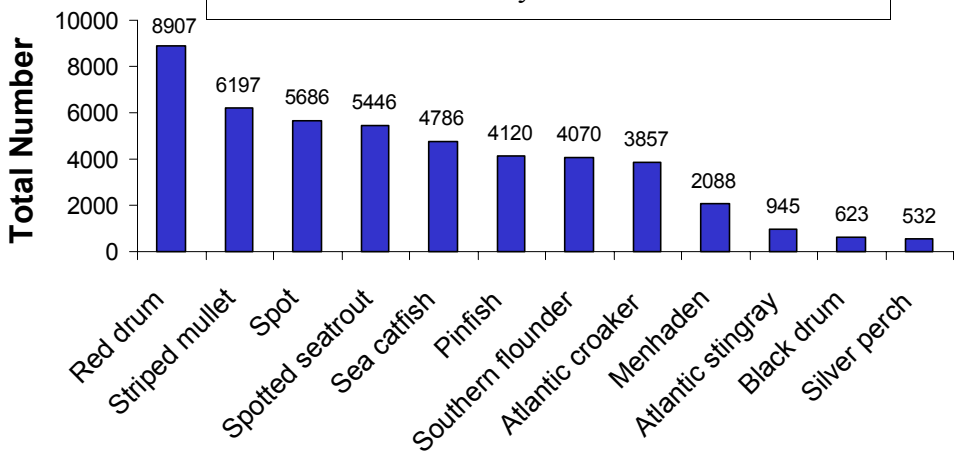
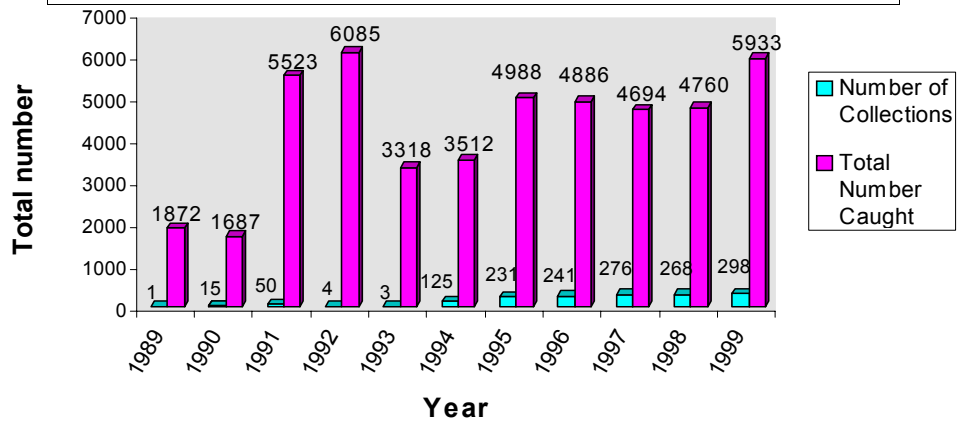


Figure 3. Annual catch of the twelve most abundant species caught in Inshore Fisheries surveys in CRNWR 1989-1999



[1] Personal communication National Marine Fisheries Service, Fisheries Statistics and Economics Div.

Figure 4. Top eleven economically valuable species caught in Inshore Fisheries surveys in CRNWR 1989-1999

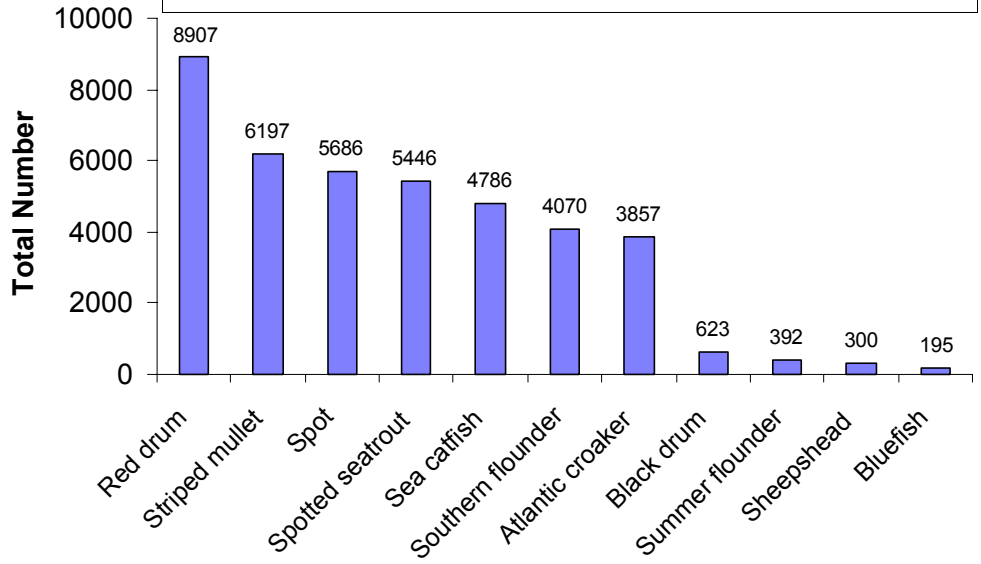
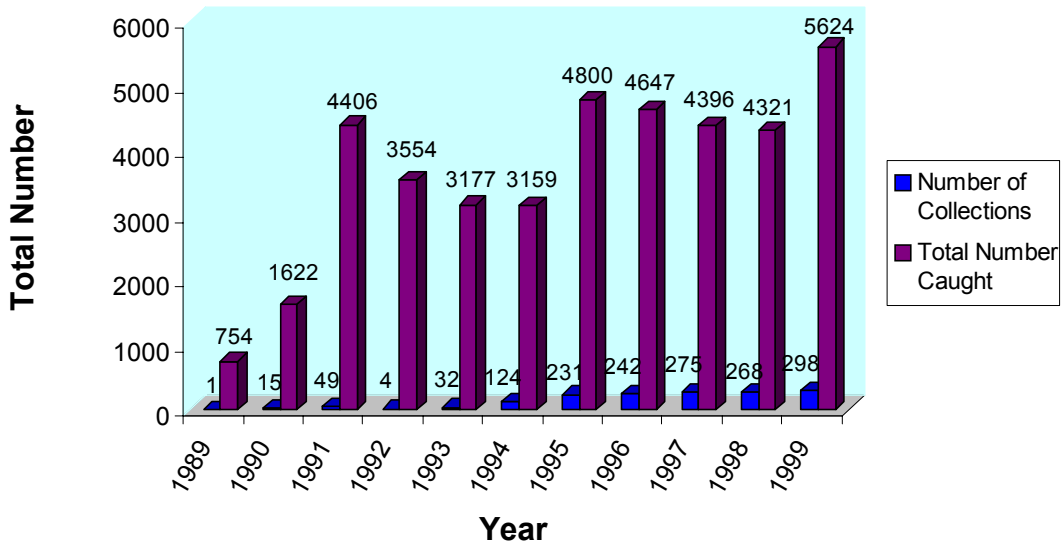


Figure 5. Annual catch of top economically valuable species caught in Inshore Fisheries surveys in CRNWR 1989-1999



The configuration of saltmarsh, tidal creeks, and open water varies from the northeast to the southwest areas of the Refuge. In Figure 6, the annual catch per collection from SCDNR Inshore Fisheries surveys are summarized for the Bulls Bay area, which is largely open water bordered by salt marsh, and the Cape Romain Harbor/Muddy Bay area, which is a mix of salt marsh and tidal creeks. The more protected areas of Romain Harbor and Muddy Bay appear to be more heavily utilized than Bulls Bay by all species within the Refuge.

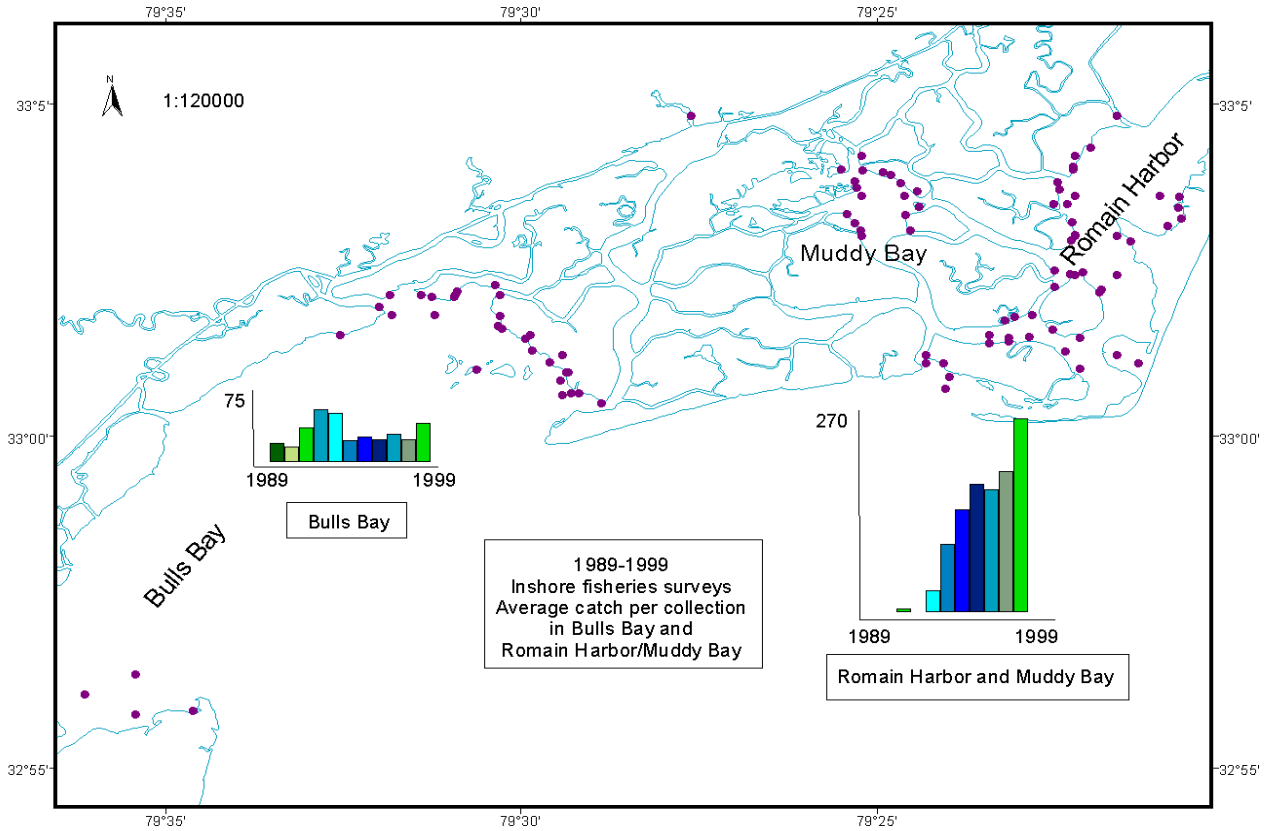


Figure 6. Inshore Fisheries annual catch per collection for Bulls Bay and Cape Romain Harbor/Muddy Bay (1989-1999)

Seasonal use of the Refuge

One of the most economically valuable species inhabiting Cape Romain NWR is spot, (*Leiostomus xanthurus*). With the use of the inshore fisheries database and GIS, it is possible to map the seasonal abundance of this species throughout the Refuge. For instance, Figure 7 illustrates which regions and in which seasons spot are most abundant based on the survey data, indicating that the area around Bull Island may be important for this species in the spring and summer.

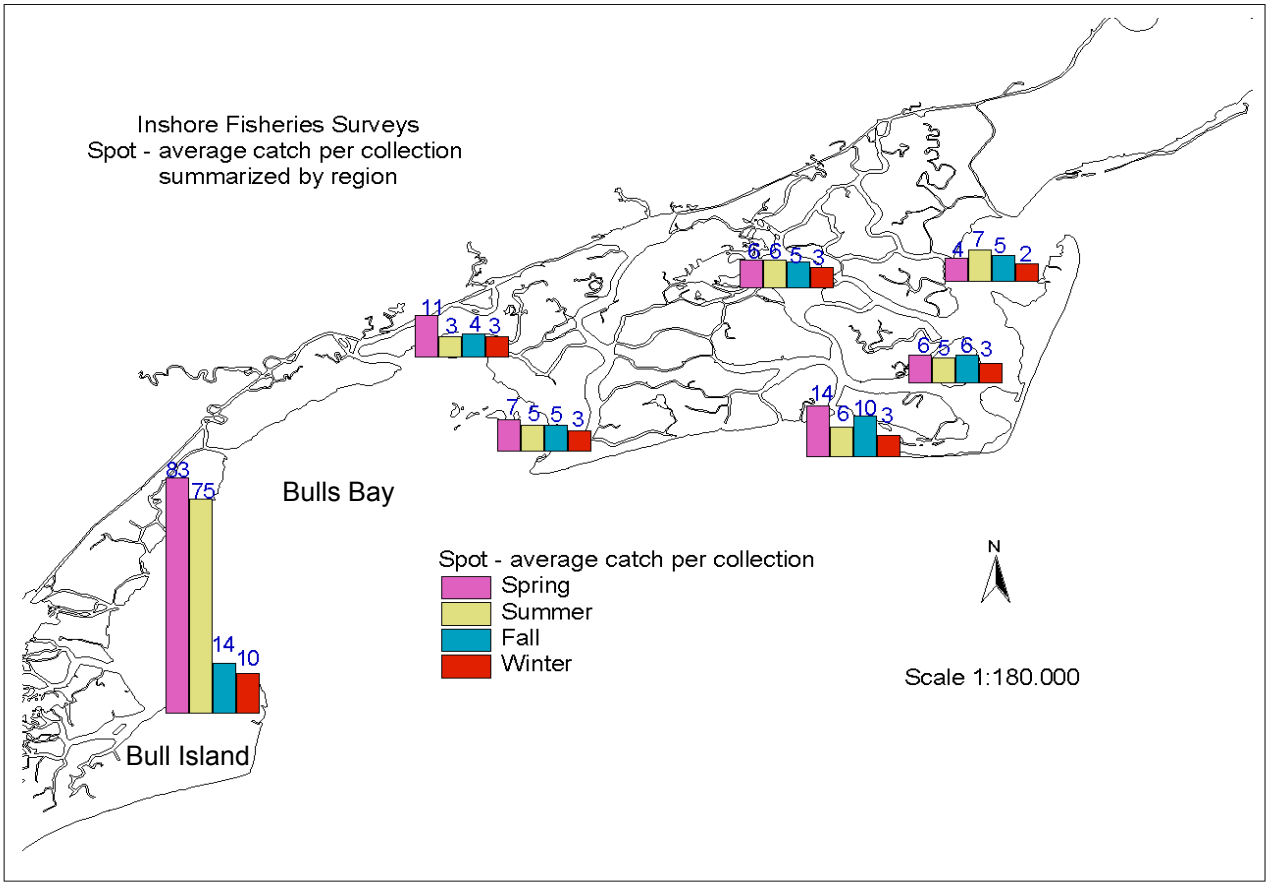


Figure 7. Seasonal distribution of spot in Cape Romain NWR (1989-2000).

Likewise, a similar analysis is performed by mapping the combined seasonal abundance of the top 12 economically important species within Cape Romain Harbor/Muddy Bay (Figure 8) and the north end of Bulls Bay (Figure 9). A detailed examination of the inshore fisheries surveys can target specific areas of the Refuge to understand how and when important species utilize this habitat.

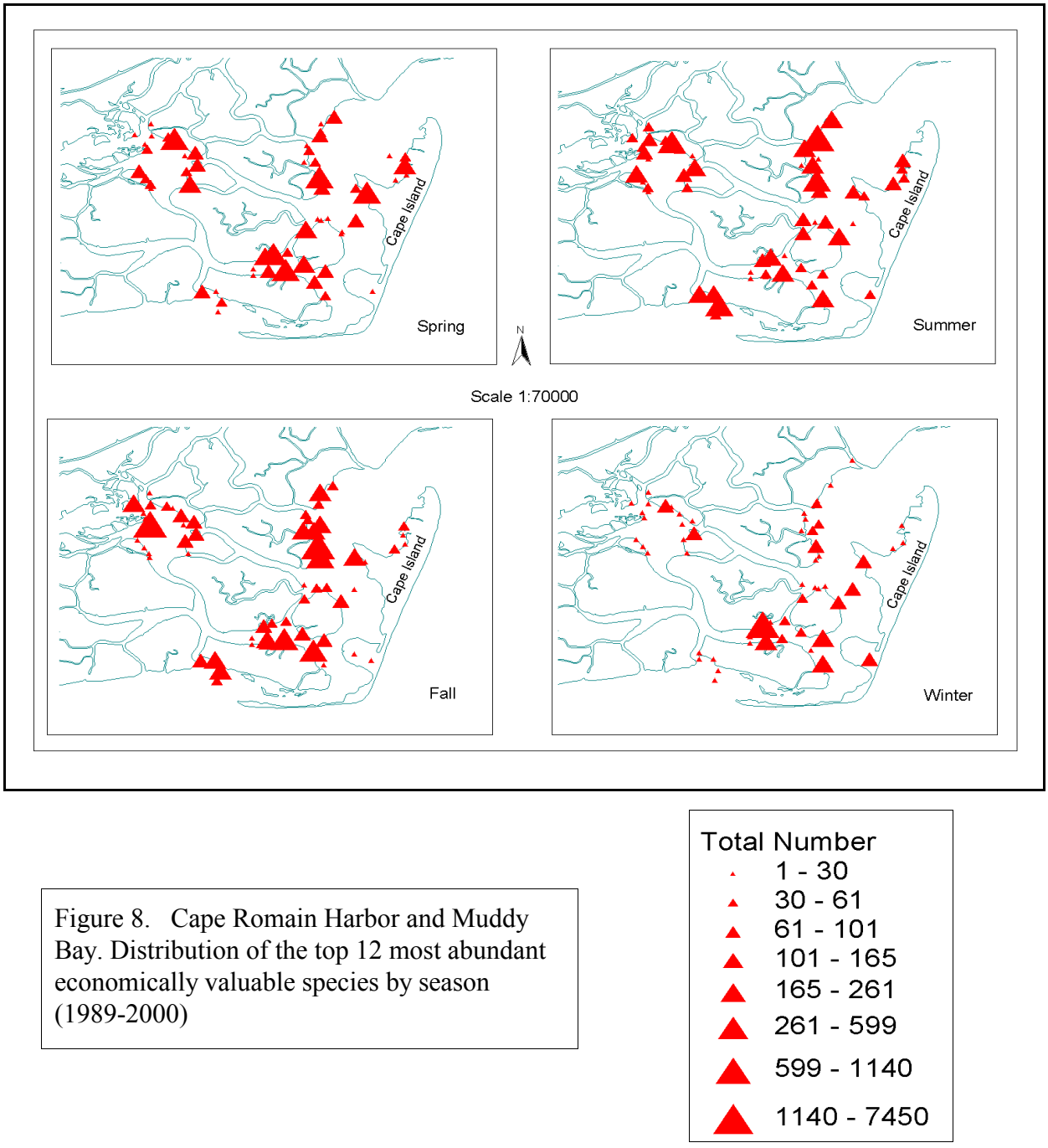
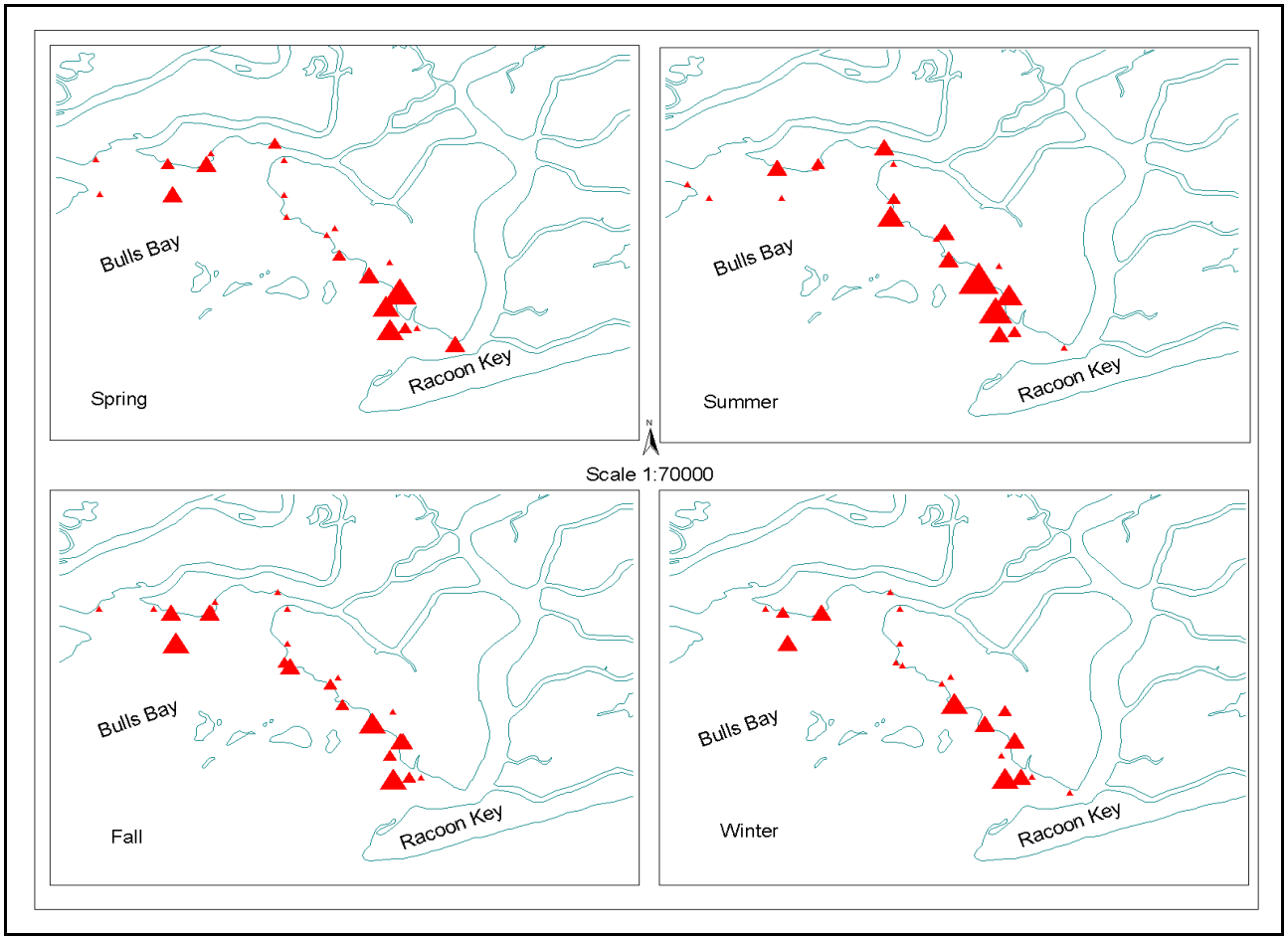


Figure 8. Cape Romain Harbor and Muddy Bay. Distribution of the top 12 most abundant economically valuable species by season (1989-2000)



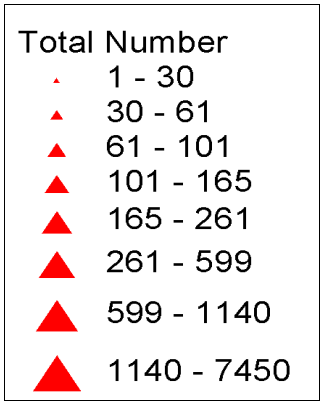


Figure 9. North end of Bulls Bay. Distribution of the top 12 most abundant economically valuable species by season (1989-2000)

Total catch of economically important species

The total number of the most abundant economically important species caught throughout the Refuge is shown graphically in Figures 10-13. The spring and summer seasons appear to have the highest species diversity, with relatively few species dominating in the fall and winter.

Species	Total Number
red drum	2300
spotted seatrout	1466
striped mullet	617
spot	264
southern flounder	102
black drum	60
atlantic croaker	7
summer flounder	7
sheepshead	2
sea catfish	1

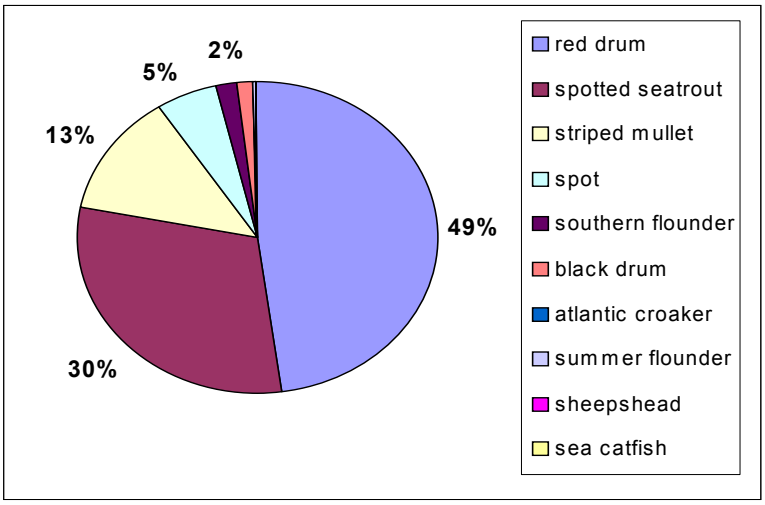


Figure 10. Total winter catch of economically valuable species from Inshore Fisheries surveys (1989-1999)

Species	Total Number
sea catfish	2641
spot	2472
red drum	1997
southern flounder	1698
atlantic croaker	1214
striped mullet	1193
spotted seatrout	804
summer flounder	144
sheepshead	99
black drum	98
bluefish	84

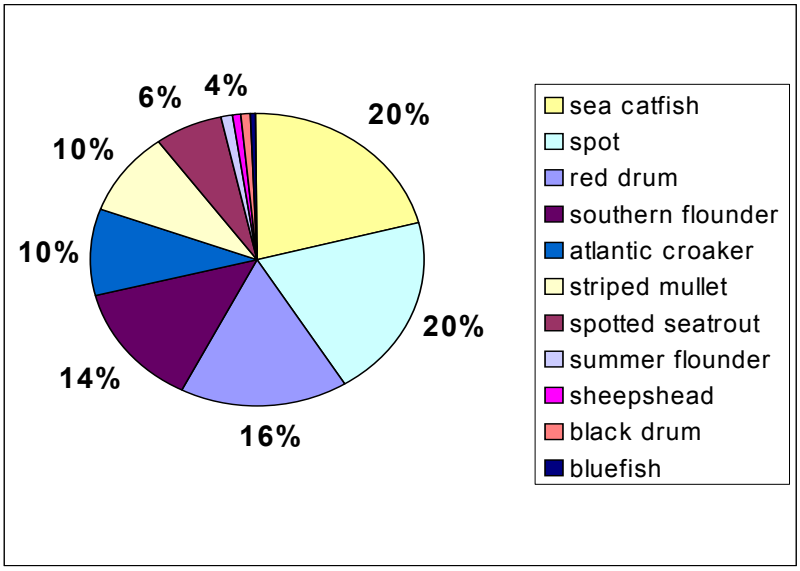


Figure 11. Total spring catch of economically valuable species from Inshore Fisheries surveys (1989-1999)

Species	Total Number
atlantic croaker	2624
red drum	2566
sea catfish	2097
southern flounder	2094
spot	1763
striped mullet	1539
spotted seatrout	1156
summer flounder	227
sheepshead	124
black drum	112
bluefish	94

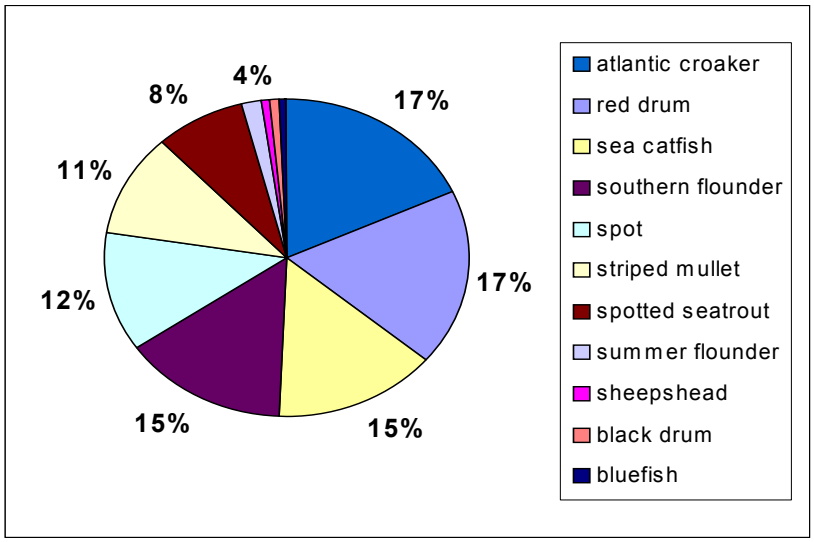


Figure 12. Total summer catch of economically valuable species from Inshore Fisheries surveys (1989-1999)

Species	Total Number
striped mullet	2848
red drum	2044
spotted seatrout	2020
spot	1187
black drum	353
southern flounder	176
sheepshead	75
sea catfish	47
bluefish	17
summer flounder	14
atlantic croaker	12

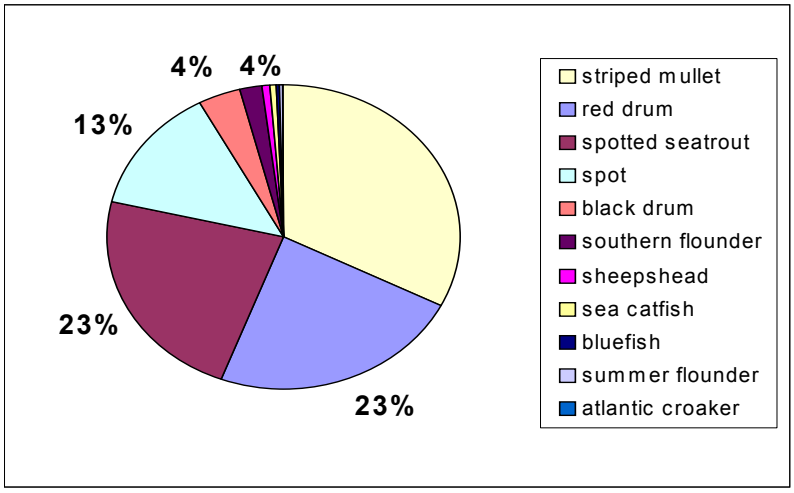


Figure 13. Total fall catch of economically valuable species from Inshore Fisheries surveys (1989-1999)

Diversity of fishes within the Cape Romain Refuge

Species diversity is probably the most commonly measured variable in community ecology. It is a dual concept that includes the number of species in the community, or species richness, and the evenness with which the individuals are divided among the species (species evenness). For the inshore fisheries data, three diversity indices have been calculated for all species in all trawls. The three estimates derived using a SAS program are Shannon-Wiener Index [H'] (Shannon and Weaver, 1949; Margalef, 1958), Pielou's (1975) Evenness Measure [J'], and Margalef's species richness [D] (1958). Species richness [D] is simply the number of species present. Species evenness, or heterogeneity [J'], is a measure of how evenly the numbers of individuals in each species are distributed. The most commonly used measure of evenness is the ratio of the observed diversity index [H'] to the maximum value the diversity index could have in a community with the same number of species [H'max]. The Shannon-Wiener Index [H'] measures the degree of uncertainty in sampling from an "indefinitely large" community. High diversity means high uncertainty. H' increases with both the number of species present and the evenness of the distribution of individuals among species. The value of H' varies from 0 for communities with only a single species to high values for communities having many species, with the number of individuals evenly distributed among species.

The following formulas were used to estimate biodiversity:

Shannon-Wiener Index:

$$H' = \frac{(N\log_2 N) - \sum(n_i \log_2 n_i)}{N}$$

where N = abundance of all species, n_i = abundance of ith species, log 2 = base 2 log

Pielou's Evenness Measure:

$$J' = \frac{H'}{H'_{max}}$$

$H'_{max} = \log S$; where S = number of species present

Margalef's species richness:

$$D \text{ (Margalef's)} = \frac{(S-1)}{\ln N}$$

where N = abundance of all species, S = number of species

Species richness (D) is calculated for each sampling location and plotted for three areas of the Refuge (Figure 14). Figure 15 shows the distribution of diversity measures throughout the Refuge. Taken together, richness (D) and H', which takes evenness into account, capture all three aspects of these diversity measures. Both species richness and Shannon-Wiener Index appear to be highest around Muddy Bay and the North end. It has been argued that the Shannon-Wiener Index (H') is independent of sample size (Sanders, 1968). However, the best way to verify this trend would be to calculate and plot information theory curves comparing the cumulative diversity parameter (H') with an increasing number of samples (Bloom, 1994).

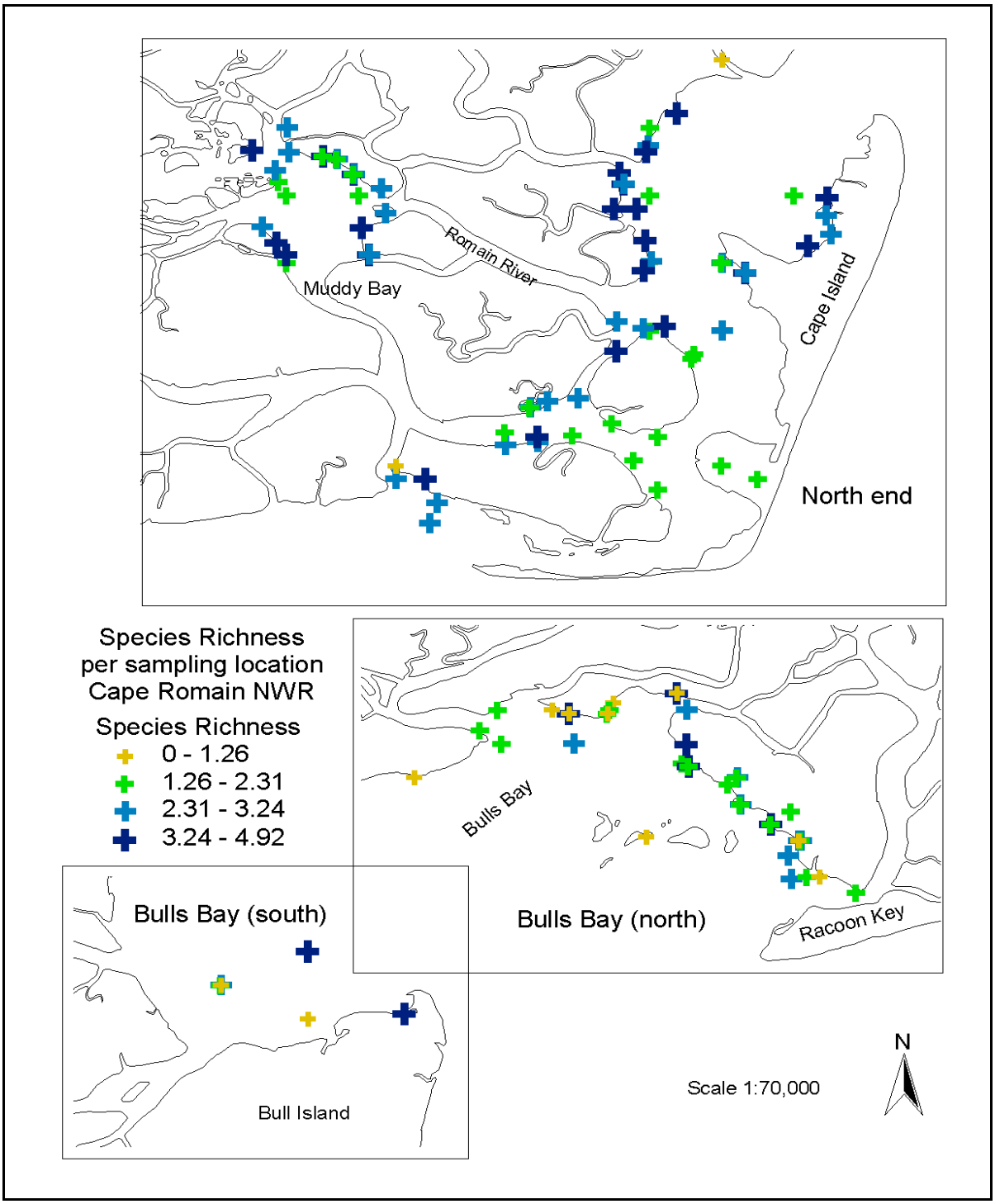


Figure 14. Species richness (D) per sampling location within Cape Romain NWR (1989-1999)

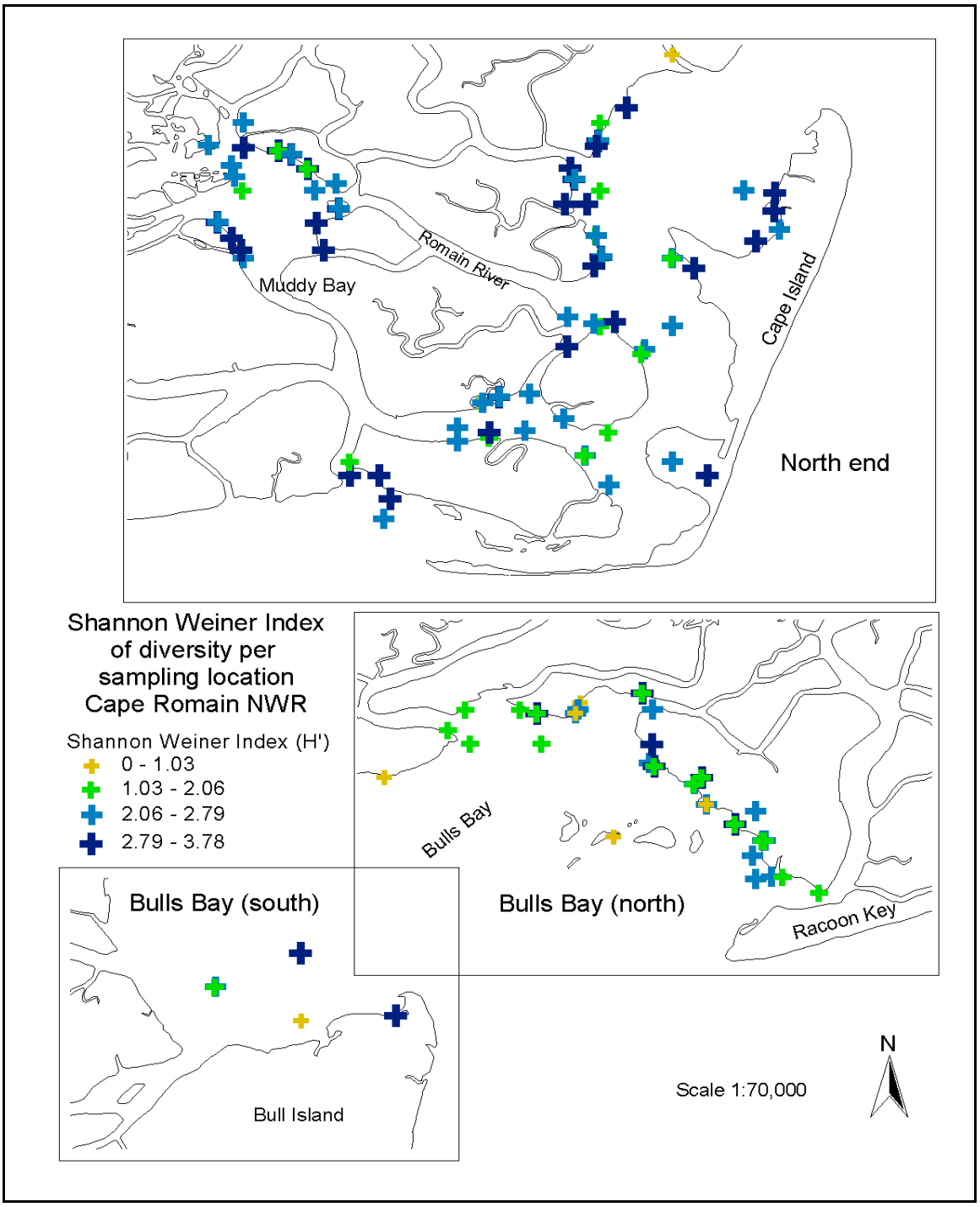


Figure 15. Species diversity (H') per sampling location within Cape Romain NWR (1989-1999)

E. Conclusions

This report gives an overview of the types of databases that are available for the quantification and spatial analysis of fisheries data pertinent to CRNWR. The Refuge likely plays an important function as habitat for fish species at various life stages. While the focus here has been on inshore fisheries data that can be applied to answer specific questions about finfish within the Refuge, future analyses, using the SEAMAP and MARMAP data can address the movement of fish from the inshore to nearshore and offshore waters. The role of the Refuge in supporting offshore fish populations can be further examined by quantifying the seasonal distribution of migratory species. Larvae and juveniles of some species, such as spot and croaker, use inshore areas as nursery grounds during the spring and summer, while adults travel to the shelf edge, about 40 miles offshore, during the fall and winter to spawn (Cain and Dean, 1976; Miglarese et al., 1982; Sedberry and Beatty, 1989; Allan and Barker, 1990; McGovern and Wenner, 1990; Able, 1999). Survey data from all three databases (Inshore Fisheries, SEAMAP and MARMAP) can be combined and mapped seasonally and the spatial aspects of fish distribution can be quantified for specific fish species or communities at various life stages. Given the significant amount of spatial and temporal data available here, further analyses should prove useful in the management of this area as fish habitat.

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Appendix I

GEAR TYPES AND DESIGNS

Inshore Fisheries:

1. Trammel net (code 098): 200 yards x 8 ft. x 14 in. stretch mesh monofilament webbing (outer walls) and 2 ½ in. stretch (inner mesh)
2. Trammel net (code 150): 150 yards x 8 ft. x 14 in. monofilament webbing (outer walls) and 3 in. stretch (inner mesh)
3. Stop net (code 128): 300 yds. x 8 ft. x 2 in. nylon mesh

SEAMAP:

1. 22.9 m. mongoose-type Falcon trawl nets without TED's:
   - body: #15 twine with 1.875 in. stretch mesh
   - cod end: #30 twine with 1.625 in. stretch mesh; protected by chafing gear of #84 twine with 4 in. stretch "scallop" mesh
   - 300 ft. three-lead bridle attached to each of a pair of wooden chain doors (10 ft. x 40 in.) and to a tongue centered on the head-rope
   - 86 ft. head-rope, excluding the tongue, with one large (60 cm) Norwegian float attached top center of net between the end of the tongue bridle cable and two 9 in. PVC foam floats located 1/4 of the distance from each end of net webbing
   - 1 ft. chain drop-back used to attach the 89 ft. footrope to the trawl door
   - 0.25 in. tickler chain connected to the door alongside the footrope

MARMAP:

1. ¾ scale version of a No. 36 Yankee trawl**:**
   - 16.5 m footrope, a 11.9 m headrope with stretched mesh dimensions of 11.4 cm in the wings, 10.2 cm to 8.9 cm in the body, 5.1 cm in the cod end, and 1.3 cm in the cod end liner
2. 40/54 High Rise Net **:**
   - 16.5 m footrope, a 12.2 m headrope and 4.1 cm stretch mesh in the cod end
3. Blackfish Traps (BFT)
4. Florida Antillean Traps (FLT)
5. Chevron Traps

Appendix II

Available Shapefiles

A. Sampling sites

1. Inshore Fisheries sites within Cape Romain NWR
2. SEAMAP sites from NC to FL
    a. Port side sampling
    b. Starboard side sampling
3. MARMAP trawl and trap sites from NC to FL

B. Seasonal use of the refuge

1. The cumulative total number of spot caught per Inshore Fisheries sampling location (similar data for both menhaden and croaker are also available).
2. Top 12 economically valuable species with cumulative total number/Inshore Fisheries sampling location
3. General species information- all species regardless of economic value caught by Inshore Fisheries

C. Annual catch for three regions of Cape Romain NWR

D. Biodiversity of fishes within Cape Romain NWR

1. Three derived indices (Species Richness, Species Evenness, and Shannon-Wiener diversity index) from Inshore Fisheries by collection
2. All three derived indices from Inshore Fisheries by sampling location

E. Basic shapefiles

1. Medium resolution coastline from NC to FL
2. 10 m bathymetric contour