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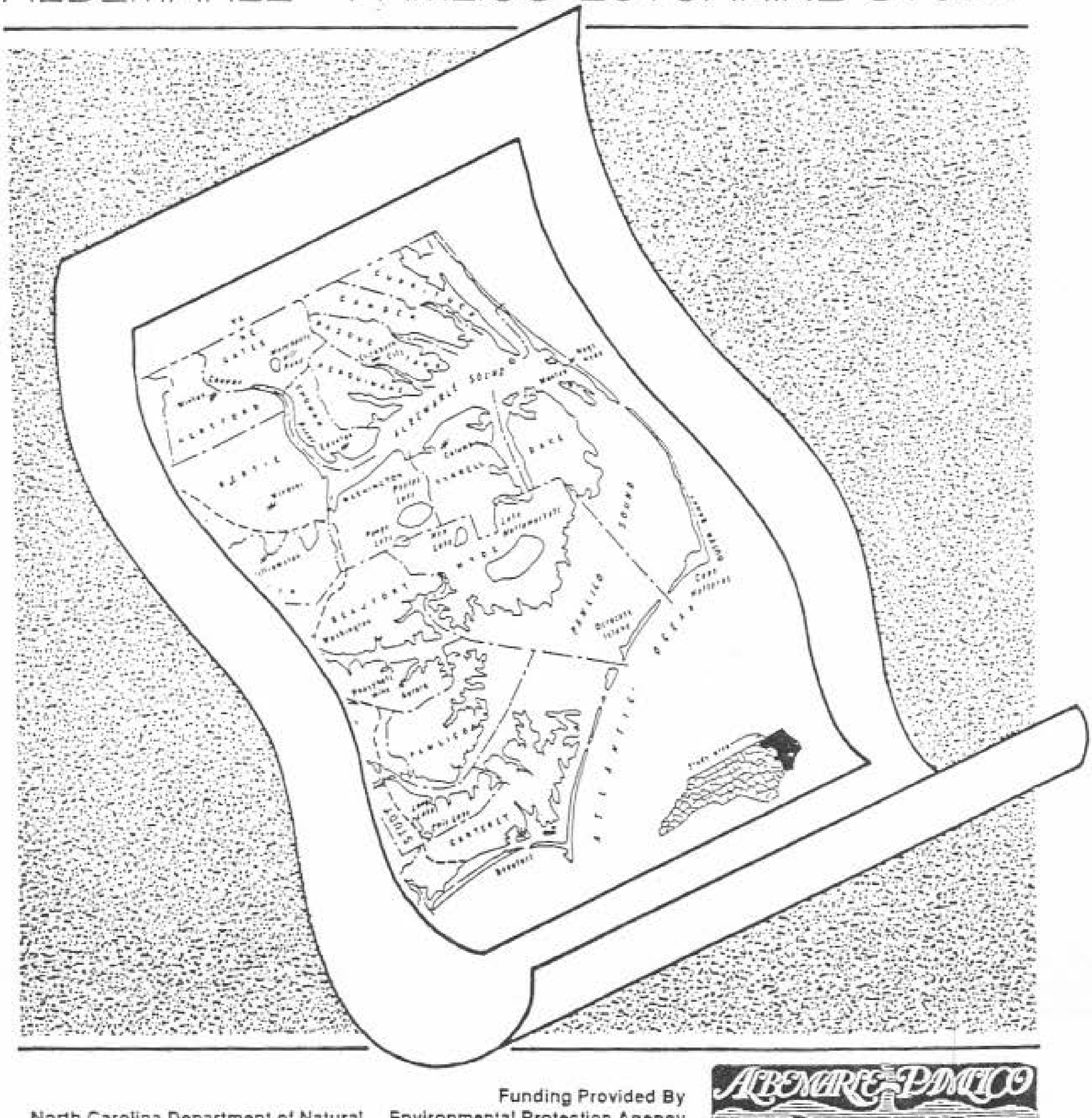
SUBMERGED AQUATIC VEGETATION IN THE ALBEMARLE-PAMLICO ESTUARINE SYSTEM

ALBEMARLE - PAMLICO ESTUARINE STUDY



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SUBMERGED AQUATIC VEGETATION IN THE ALBEMARLE-PAMLICO ESTUARINE SYSTEM

By

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SEAGRASSES IN THE ALBEMARLE PAMLICO ESTUARINE SYSTEM

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ABSTRACT

Seagrasses, marine species of submerged aquatic vegetation (SAV), form underwater nurseries, seagrass meadows, for estuarine-dependent commercially and recreationally harvestable fish and shellfish. In North Carolina about 90% of commercial landings are composed of estuarine-dependent species. Overall, the most productive SAV habitats for marine fish and shellfish in the Albemarle/Pamlico estuarine system are in the shallow < 6 ft saline waters on the eastern periphery of Pamlico Sound and throughout the sounds to the south and west including Core, Back and Bogue Sounds. These productive shallow bottoms are inhabited by seagrasses: the temperate species, eelgrass (Zostera marina), the tropical species, shoalgrass (Halodule wrightii), and the panlatitudinal widgeon grass (Ruppia maritima) which also occurs in fresh and brackish waters. The co-occurrence of these three species is unique to North Carolina and provides critical fishery habitat, food and protective cover, throughout most of the year. We estimate from previous reports, aerial overflights and preliminary analysis of our photography from 1985 and 1988, an area of marine SAV of approximately 200,000 acres from Bogue Inlet to Oregon Inlet

including Bogue, Back, Core and southern and eastern Pamlico Sounds. This area of SAV approximates that for salt marshes in North Carolina. Of this total habitat, we have carefully mapped about 5%, that in southern Core Sound. Eighty percent of this total is along the southern and eastern periphery of Pamlico Sound and our photography remains to be interpreted and mapped. Lesser areas of seagrass do occur west of Bogue Inlet, in western Pamlico Sound, and in Croatan and Roanoke Sound but these areas and brackish/freshwater areas (e.g., rivers) and Albemarle and Currituck Sounds have not been suitably photographed.

Under funding from APES we conducted a visual aerial survey (Dec. 1987) of Core Sound and eastern Albemarle and Pamlico Sounds and photographed (April 1988) Core Sound and eastern Pamlico Sound (both color and infrared at scales of 1:24,000 and 1:50,000). We collected seagrass samples in Core, eastern Pamlico, Croatan, Roanoke and eastern Albemarle Sounds (March 1988) and in Currituck Sound (Oct. 1987) to provide ground level verification for interpretation for SAV of both current and anticipated photography and to provide regional data on species composition of SAV. As a demonstration chart product, we delineated SAV from 1985 photography of southern Core Sound and produced charts of seagrass habitat in Core sound from Cape Lookout to Drum Inlet. These charts were based on USGS quadrangles and included navigation aids from NOAA nautical charts. Future funding will be required to complete interpretation and charting of SAV from 1988 photography, Cape Lookout to Oregon Inlet, analysis of SAV samples collected in Pamlico, Croatan and Roanoke Sounds, and acquisition of aerial photography for Currituck, Roanoke, Croatan, and western Pamlico Sounds.

The charts and photographs we are generating form a baseline of location and abundance of this critical fishery habitat for temporal and spatial trend analysis, environmental planning and impact evaluation, and research on functional studies of the relationship between habitat and fisheries productivity. They already have provided valuable information to habitat managers in their review of dredge and fill related permit applications and helped achieve the nomination of Core Sound, Back Sound and western Bogue Sound for designation as outstanding resource waters.

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SUMMARY AND CONCLUSIONS

Beds of seagrasses marine submerged aquatic vegetation (SAV) constitute one of the most common wetland habitats in North Carolina. Our best estimate of area of marine SAV in North Carolina from Bogue Inlet to Oregon Inlet at this time is 200,000 acres or about equal to that area for salt marshes in North Carolina. In the contiguous 48 states, North Carolina is second only to Florida in acreage of marine SAV with about five times the SAV acreage, for example, in Chesapeake Bay.

State and Federal coastal habitat managers recognize the critical role of seagrasses but are in a position of relative weakness to conserve and protect them. Needs are high for dredge and fill projects related to maintenance of the Atlantic Intracoastal Waterway and maintenance and extension of other waterways and access channels throughout eastern North Carolina. Many of these needs potentially conflict with preservation of SAV. Unfortunately, none of the federal agencies responsible for mapping wetlands (EPA, FWS, NOAA/OAD) presently include seagrasses in their maps and inventories. This is due to past difficulty of acquiring and interpreting remotely sensed data for delineating the location and areal extent of this relatively inconspicuous, submergent type of wetland habitat.

Man's use of coastal resources in the sounds of eastern North Carolina can be incompatible with long-term maintenance of those resources. Preservation of SAV as a living coastal resource requires careful documentation of the location, species composition and extent of SAV, the goal of this research. With this information, managers can make informed decisions concerning development and use of coastal lands and waterways.

The March, 1985 photography and that acquired under funding from this contract April, 1988 is the best currently available for the study area and suitable for the stated purpose of mapping SAV. Our completed charts of SAV based on 1985 photography delineate over 11,000 acres of SAV in southern Core Sound. This is about 5% of the total SAV visible in the photography that we presently have in hand. The approximate area and location of SAV habitat visible in the 1985 and 1988 photography is 200,000 acres of which about 20% is in Bogue, Back and Core Sounds, and 80% is in southern and eastern Pamlico Sounds (Fig. 1).

Unfortunately, the situation for mapping of fresh and brackish water species of SAV is another matter. Such waters in eastern North Carolina are rich in dissolved organic and particulate organic and inorganic matter. This material attenuates light rapidly and greatly restricts visualization of subsurface features including SAV habitat. The best opportunity for accurate recording of SAV under such conditions is in August or early September when many of these species have leaves or reproductive structures on or near the surface of the water. At this time of the year, however, atmospheric haze is a frequent impedement to aerial photography. The problem of haze, the relatively small sizes of individual fresh and brackish water SAV habitats, and high light attenuation of the water in fresh and brackish areas precludes the utility of larger scale photography, e.g. 1:24,000 and requires smaller scale photography, e.g. 1:12,000. This greatly increases costs,

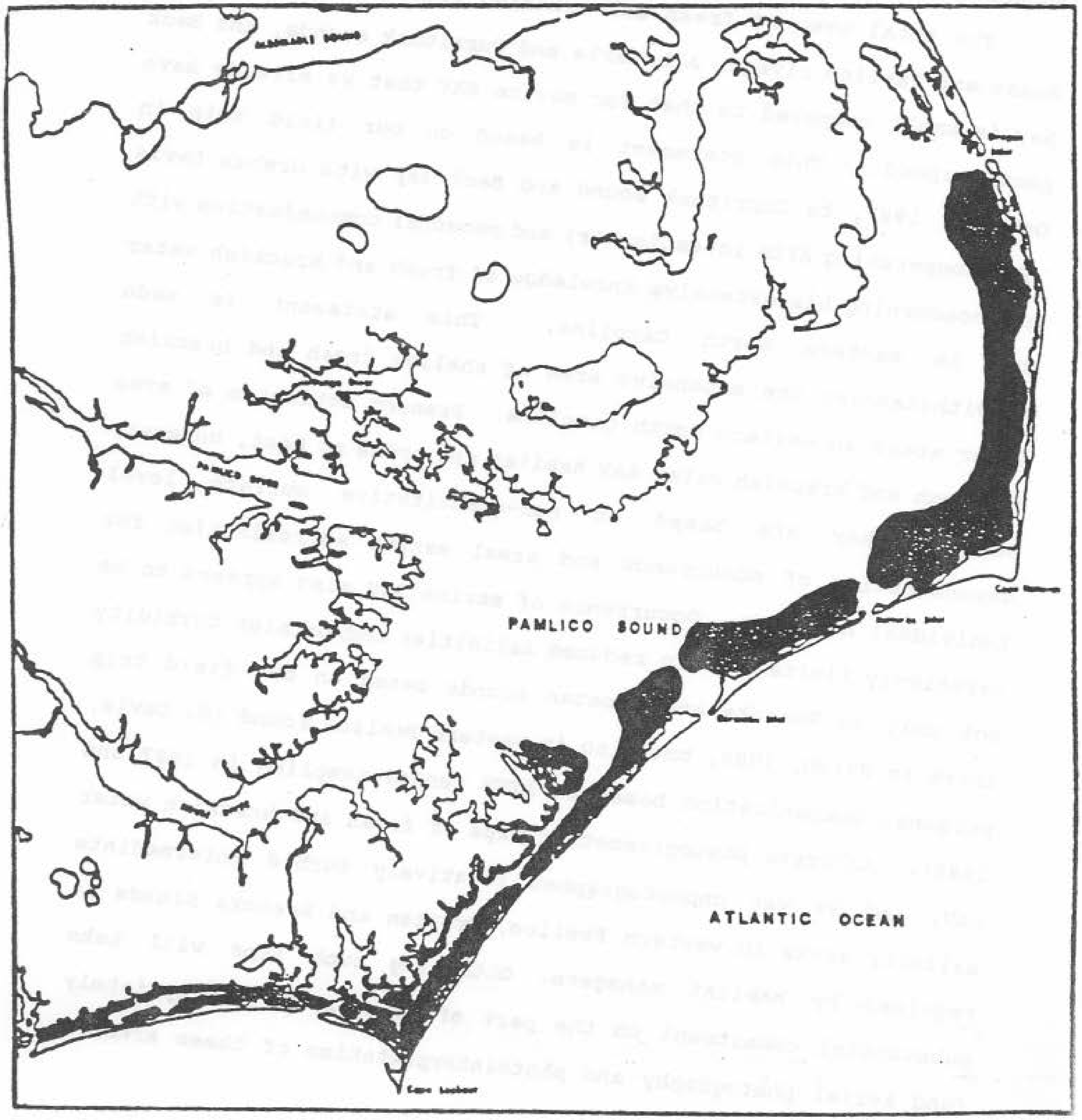


Figure 1. Approximate locations of seagrass habitat (SAV) photographed in 1985 or 1988 in eastern North Carolina.

particularly considering the large, highly reticulated area of occurrence for fresh and brackish water SAV (see Fig. 1).

The total area of fresh and brackish water SAV in the lower Neuse and Pamlico rivers, Albemarle and Currituck sounds, and Back Bay is small compared to that for marine SAV that we already have photographed. This statement is based on our field trip in October, 1987, to Currituck Sound and Back Bay with Graham Davis (ECU Cooperating APES investigator) and personal communication with him concerning his extensive knowledge of fresh and brackish water SAV in eastern North Carolina. This statement is made notwithstanding the extensive area of shallow fresh and brackish water areas in eastern North Carolina. Present estimates of area of fresh and brackish water SAV habitat are crude at best, however, because they are based on non-quantitative surface level demonstration of occurrence and areal extent approximation for individual habitats. Occurrence of marine SAV also appears to be relatively limited due to reduced salinities and/or high turbidity not only in Roanoke and Croatan Sounds based on our field trip there in March, 1988, but also in western Pamlico Sound (G. Davis, personal communication based on APES funded sampling in 1987 and 1988). Accurate photogrammetric maps of fresh and brackish water SAV, and as yet unphotographed relatively turbid intermediate salinity areas in western Pamlico, Croatan and Roanoke Sounds is required by habitat managers. Obtaining such maps will take substantial commitment on the part of managers to appropriately fund aerial photography and photointerpretation of these areas.

The general distribution of marine species of SAV in the Albemarle/Pamlico study area can be approximately sketched at the present time. Seagrasses inhabit broad expanses of low intertidal and subtidal (to 6 ft mean low water) bottoms in the high salinity relatively clear waters of eastern Core and Pamlico Sounds. The dominant species in these areas are Z. marina and H. wrightii with R. maritima generally present but relatively less abundant. This type of SAV habitat represents by far the majority of SAV habitat in the study area. Narrow shoreline beds, occur in shallow (less than 3 ft MLW) more turbid water along the western margin of Core Sound. Z. marina and H. wrightii also dominate species composition here but R. maritima is relatively more abundant on the western than the eastern side of Core Sound.

The reported northern limit for H. wrightii in the United States was extended in this study from southern Core Sound to Oregon Inlet. Z. marina (North Carolina is the southern limit of its distribution) was sampled in Core, Pamlico, Croatan and Roanoke Sounds but not in Currituck Sound due to low salinity. R. maritima was sampled throughout the study area including Core, Pamlico, Croatan, Roanoke and Currituck Sounds. Some Z. marina but much more R. maritima was observed in intermediate salinity waters, about 17 o/oo in western Pamlico Sound (G. Davis, personal communication). SAV habitat in western Pamlico, Croatan, and Roanoke Sounds tends to be restricted and dispersed in these intermediate salinity and higher turbidity waters.

Documentation of the location, nature and extent of SAV in the Sounds of eastern North Carolina, the ultimate goal of this work, development and enforcement of high standards for water quality, and conservation of extant SAV habitat will assure persistence of SAV. Persistence of SAV will help to assure the future of the commercial and the recreational water resources that we associate with eastern North Carolina.

RECOMMENDATIONS

Documentation of the location and species composition of marine SAV needs to be continued and expanded. Subsequently, mechanisms for monitoring marine SAV need to be identified and put in place. More cost effective methods than aerial photography but with greater resolution than satellite imagery and greater accuracy than ground level visual surveys need to be researched and implemented. One such approach is airborne image spectrometry that employs relatively inexpensive remote sensing systems such as the Xybion solid state imaging camera or the NASA Ocean Data Acquisition System (ODAS).

At the present time the only proven approach to mapping SAV at the scale, resolution and accuracy required for most management decisions, however, is via interpretation of conventional aerial photography. This is the method of choice, for example, for monitoring SAV in Chesapeake Bay. It certainly would be cost effective to complete interpretation of the photography on hand. We possess photography suitable for delineating SAV in Core Sound and southern and eastern Pamlico Sound (April, 1988) and for Bogue and Back Sounds (March, 1985). Given no suitably quantitative alternatives at the present time, continued photography of other sounds in eastern North Carolina also would be appropriate for completing maps of marine SAV, e.g. western Pamlico, Croatan and Roanoke Sounds.

species in eastern North Carolina also would be appropriate. One completing much of section 3?, e.g. western Halifax, Franklin, and Granville Counties.

INTRODUCTION

Seagrasses, marine species of submerged aquatic vascular plants (SAV), are critical components of shallow marine ecosystems worldwide (Ferguson et al., 1980). Beds of SAV provide food and cover for a great variety of commercially and recreationally important fauna and their prey. The leaf canopy calms the water, filters suspended matter and, together with an extensive root and rhizome mat, stabilizes sediment (Thayer et al., 1984).

Beds of SAV support many species of fish and shellfish and are major fishery habitats of the shallow sounds behind the barrier islands of eastern North Carolina, including Core and Pamlico Sounds (Epperly and Ross, 1986; Orth et al. 1984; and Thayer and Fonseca, 1984). Here, larval and juvenile fish and shellfish including gray trout, red drum, spotted seatrout, mullet, spot, pinfish, pigfish, gag grouper, white grunt, silver perch, summer and southern flounder,pink and brown shrimp, blue crabs, hard shell clams and bay scallops utilize beds of SAV as nurseries. Beds of SAV also are frequented by adult spot, spotted seatrout, summer and southern flounder, pink and brown shrimp, hard shell clams and blue crab, and are the primary habitat of the bay scallop. Birds feeding in SAV beds include egrets, herons, sandpipers, terns, gulls, swan, geese, ducks, and osprey.

Three seagrasses occur in eastern North Carolina (Table 1). These include the temperate species _Zostera marina_ (eelgrass), the tropical species _Halodule wrightii_ (shoalgrass), and the pan latitudinal _Ruppia maritima_ (widgeon grass) which also is found in freshwater. The overlapping distributions of these species is

Table 1. Characteristics of the three species of seagrasses in eastern North Carolina (see Beal, 1977 and Thayer et al., 1984).

Name		Leaf Morphology		Occurrence in North Carolina				
Common	Taxomomic	Width	Tip	Geographic Range	Seasonal Maximum	Flowering	Minimum Water Depth	Salinity Range (o/oo)
eelgrass	_Zostera marina_	1.5-3.0mm	convex with median point	southern limit	winter to early spring	Dec-March	high subtidal	8-34
shoal-grass	_Halodule wrightii_	0.3-1.0mm	concave with median point	northern limit	late summer and early fall	Un-known	low inter-tidal	8-34
widgeon grass	_Ruppia maritima_	0.3-1.0mm	lanceo-late	middle of range	summer	April-July	high subtidal to low intertidal	0-34

unique to North Carolina. The temperate species _Zostera_ flourishes in cooler months while the tropical species _Halodule_ thrives in warmer months. The halotolerant and panlatitudinal species, _Ruppia_, augments species composition in higher salinity regions and plays an increasingly important role as salinity grades into lower salinity waters not tolerated by the truely marine species _Zostera_ and _Halodule_. This overlap maximizes the degree of coverage of shallow bottoms in the sounds and provides food and bottom cover throughout much of the year.

PURPOSE AND OBJECTIVES

This study began determination of the location and extent of marine SAV in the Albemarle Pamlico Estuarine system based on conventional aerial photography. Sufficient sampling in the field was performed to justify interpretation of the photographs and provide regional information on species composition of the seagrasses. The objectives of the completed funding year were to:

1) Obtain a preliminary estimate of total marine SAV in the Albemarle/Pamlico system.

2) Acquire aerial photography at scales of 1:24,000 and 1:50,000 for Core Sound and southeastern Pamlico Sound from Cape Lookout to Oregon Inlet for interpretation and charting of marine SAV in subsequent funding years.

3) Construct stable base SAV charts for SAV distribution in southern Core Sound based on 1985 photography and analyze these charts for area of SAV habitat.

4) Submit SAV overlays of southern Core Sound to Land Resources Information Services for digitization.

5) Conduct SAV sampling from Cape Lookout to Oregon Inlet to be used to ground truth 1985 and 1988 photography and provide regional information on species composition of SAV in southern Core Sound (and northern Core and eastern Pamlico Sounds next year).

6) Complete analysis of current historical samples of SAV from southern Core Sound to verify photographic interpretation and determine regional species composition.

7) Conduct preliminary SAV sampling in Currituck Sound, Back Bay, Croatan Sound and Roanoke Sound and collect herbarium species in

preparation for aerial photographic and ground truth missions in subsequent years.

8) Collect surficial sediment samples throughout the sampling area for analysis by us or cooperating APES investigators in subsequent funding years.

9) Be immediately responsive to state and federal habitat managers requesting information and data pertinent to decision on water use management and conservation of living resources including marine SAV.

All of these objectives have been met. Analysis of SAV samples exceeded this year's stated objectives and was completed as far north as Ocracoke Inlet. A chart "Seagrasses in Southern Core Sound" is in press (NOAA-National Ocean Services). A paper, "Seagrasses in the Albemarle/Pamlico Estuarine System" will be presented at the 25th Annual Conference of the American Water Resources Association and published in their Symposium "Wetlands, Concerns and Successes". A report, "Current status and ecological importance of seagrass beds in Core, Back and western Bogue Sounds, North Carolina" was drafted in support of nomination of these waters for classification by the state of North Carolina as outstanding resource waters (Appendix B).

PROCEDURES

Preliminary aerial reconnaissance to determine appropriate location and extent of seagrass habitat was conducted by chartered small plane in December, 1987. Three investigators flew over the study area from Cape Lookout through Core, southeastern Pamlico, Roanoke, eastern Albemarle and Croatan Sounds. Approximate location and extent of SAV was sketched on NOAA nautical charts and recorded by oblique 35mm color slide photography using a polarizing filter. The estimate of total acreage for Bogue, Back, Core and eastern Pamlico sounds, approximately 200,000 acres, was obtained by planimetry of the charts and includes data for Bogue and Back Sounds from Carraway and Priddy (1983).

Aerial photography to determine precise location and extent of seagrass habitat at scales of 1:24,000 and 1:50,000 was completed in April, 1988. Parallel flight lines at the 1:24,000 scale were required to span the width of SAV habitat in Core and Pamlico sounds (up to 3 miles) and generated photographs with 20% sidelap and 80% endlap. These were overlain by 1:50,000 scale photography to provide horizontal control for those frames which would be devoid of cultural (e.g. road intersections, buildings) or geographic (e.g. shoreline) features recorded on the topographic maps. Color film (Aerochrome 2448) and color infrared film (Aerochrome 2443) were exposed by NOAA's Photogrammetry Unit using a NOAA jet aircraft with tandem cameras. Photography was conducted at low tide with a sun angle of less than 20 degrees, relatively low water turbidity and waves, low atmospheric haze and absence of clouds.

Aerial photography of Bogue, Back and southern Core Sounds had been previously commissioned by our laboratory and conducted by NOAA Photogrammetry in March 1985. Photointerpretation of that, photography (1:20,000) for southern Core Sound consisted of examination of the photography under low magnification (2-4x) and tracing polygons representing SAV habitat and 3 or 4 horizontal control points on mylar sheets. Polygons of SAV habitat circumscribed areas of continuous SAV or areas of discontinuous SAV where numerous beds or patches were dispersed in a relatively uniform pattern over the bottom. Thus, all locations designated SAV habitat contained beds of SAV that were identifiable in the photography. Thin or dense, continuous or patchy distributions of SAV habitat were not distinguished from each other in the charts. Horizontal control points for transferring SAV polygons to shoreline maps were cultural or geographic features visible on photographs and present on USGS 7.5 minute quadrangles. These were used to scale and compile the polygons of SAV habitat.

Cartography consisted of scaling and tracing projections of SAV polygons onto clear stable base overlays for stable base USGS 7.5 minute quadrangles. The most recently available USGS base maps were employed. No attempt was made to correct shorelines that had moved since the USGS maps were constructed or revised. As a result, SAV overlapped the charted shoreline or marshes in a few cases. Photographs were carefully reevaluated to verify the accuracy of location of SAV in these instances.

Video image analysis of the 1:24,000 scale SAV polygons was conducted with a personal computer-based image analysis system (SMI

Microcomp). Individual areas of SAV were measured in acres with a pixel size of approximately 0.1 acre. Subsequently, the stable base overlays of SAV were digitized by Land Resources Information Service in Raleigh. They added the SAV polygons to their GIS data base and verified our computations for area of SAV.

Seagrass sampling was conducted in several phases for a variety of purposes. The major sampling effort (113 samples) was conducted in March, 1988, by small boats dispatched from the NOAA ship Ferrel in northern Core, Pamlico, Croatan, Roanoke and eastern Pamlico Sounds (see Appendix A). Support of our sampling by the Ferrel, its officers and crew, and its two launches was provided at no cost to the contract. Support included officer participation in collection of samples, use of one of the ships computers, and the provision of ship's and NMFS's launches with portable Loran C units. The same sampling procedures were extended into southern Core Sound (20 samples) by small boats based at our laboratory in Beaufort during March, 1988. The primary purpose of these efforts was to provide surface information for interpretation of aerial photography of seagrasses in these areas either in hand (March 1985, from Bogue Inlet to Drum Inlet), or contracted for this funding year (April 1988, from Cape Lookout to Oregon Inlet) or anticipated in subsequent funding years (Oregon Inlet to Currituck Sound and Back Bay).

A preliminary survey of Currituck Sound and southern Back Bay (12 samples) was conducted in cooperation with Graham Davis, a cooperating Albemarle/Pamlico Estuarine Study investigator from East Carolina University. This area was predominantly brackish water and vegetated by fresh and brackish water species of SAV with which we were less familiar than marine species of SAV. We traversed the area in a small boat, recorded approximate locations of SAV and collected, by hand rake, 6 species of fresh and brackish water SAV for an herbarium collection. This trip was intended to familiarize us with the region and species present in anticipation of field sampling, aerial photography and photointerpretation proposed by subsequent years. Results of the sampling in Currituck Sound also was combined into a regional assessment of species composition of the study area from Cape Lookout to Back Bay.

Stations were selected in Core, Pamlico, Croatan, Roanoke and eastern Pamlico Sounds (Fig. 2 a,b,c) by placement of a rectangular dot matrix grid with dots approximately 1.3 scaled nm apart on a nautical chart (chart nos. 11544, 11548, 11555, 12204). The latitude and longitude of stations where bathymetry data indicated bottom depths of less than 10 ft were extracted from the chart and recorded to the hundredth of a minute. Deeper bottoms in this area would not receive light sufficient for SAV. Stations were located in the field by Loran C in small boats. Stations of about 5-10 ft water depth were sampled by SCUBA divers while shallower depth stations were sampled by divers with snorkles or by wading. SAV was collected with a hand operated 5 inch OD coring device or a shovel to provide samples for determination of relative species abundance. Heterogeneous or thinly vegetated beds were subsampled more than once to obtain a large sample of representative shoots and subsamples were combined. SAV was rinsed free of sediment in cloth mesh bags and stored in plastic bags. Sediment samples were

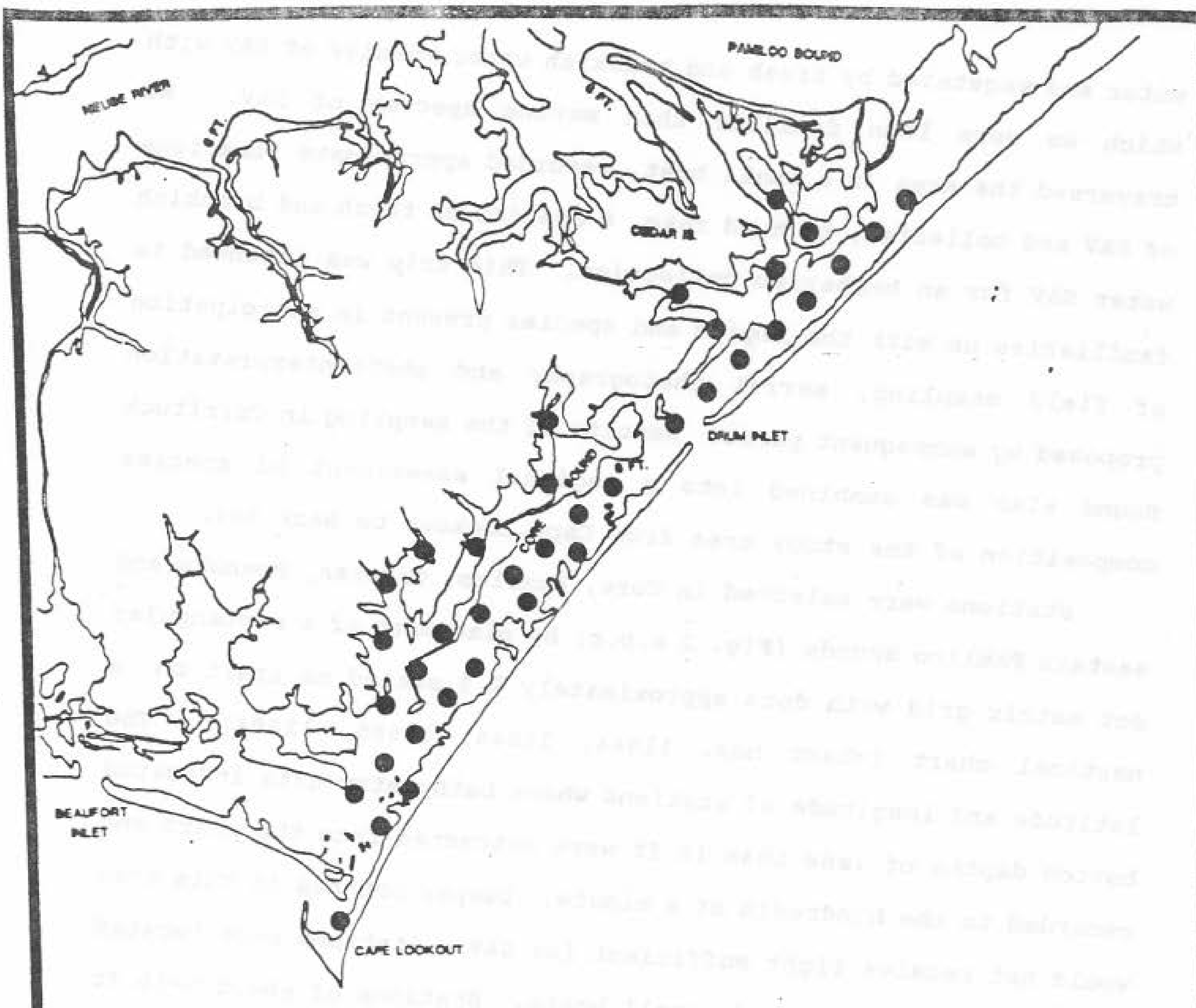


Figure 2a. Station locations at which SAV samples were attempted or collected in March 1988 in Core Sound.

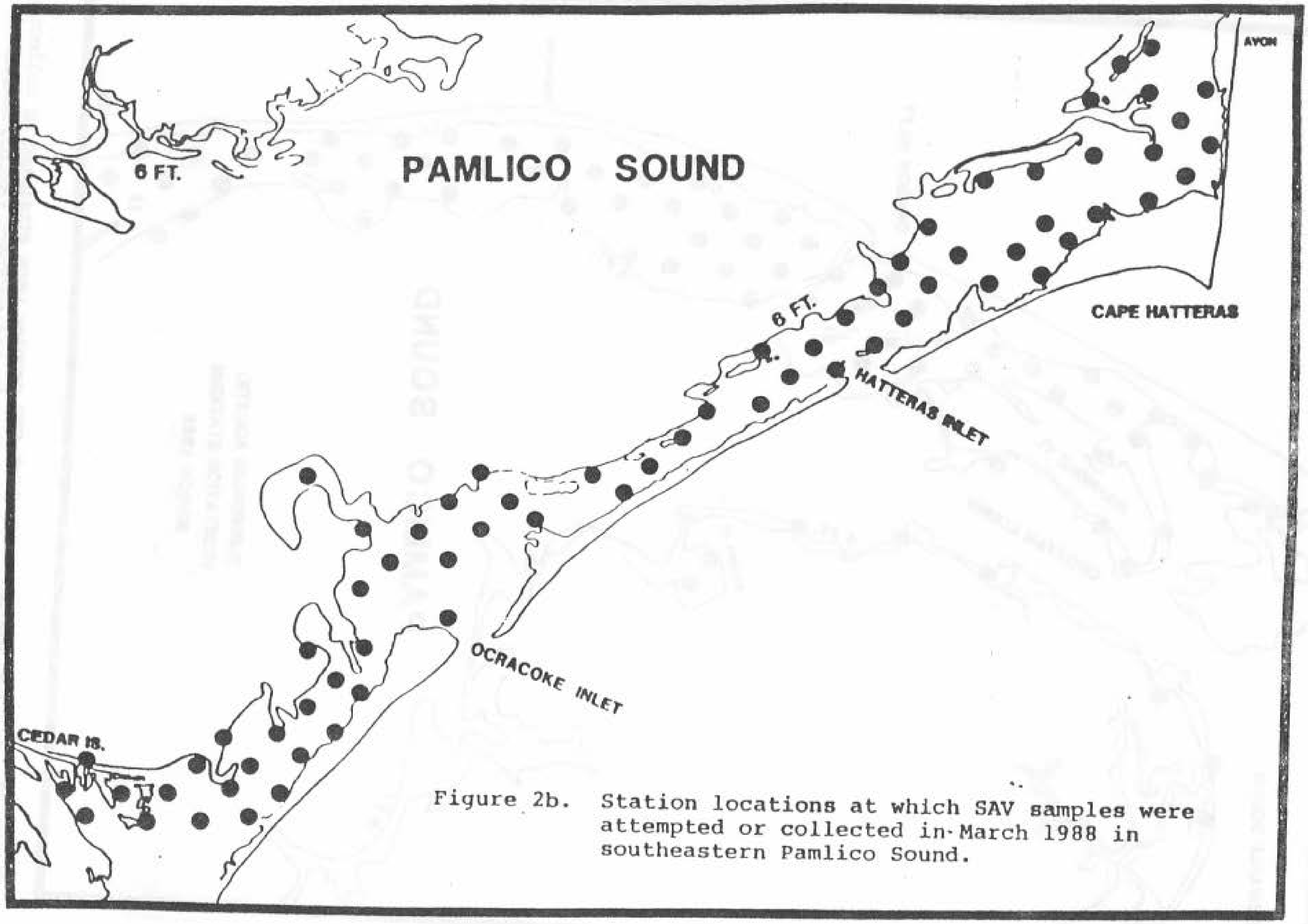


Figure 2b. Station locations at which SAV samples were attempted or collected in March 1988 in southeastern Pamlico Sound.

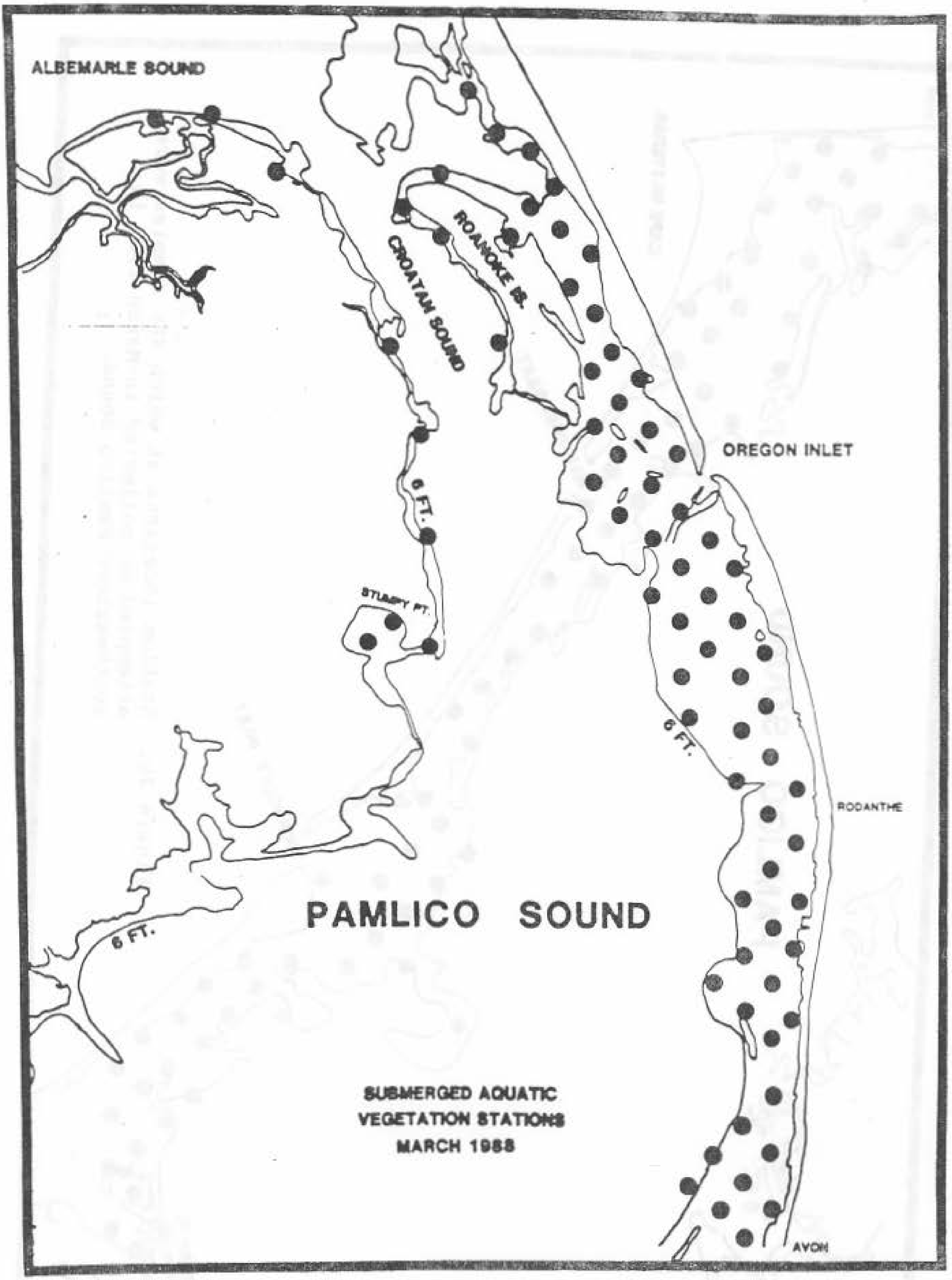


Figure 2c. Station locations at which SAV samples were attempted or collected in March 1988 in Croatan, Roanoke and northern Pamlico Sounds.

collected by scraping surficial sediment into small plastic cups. SAV and sediment samples were returned to the mother ship or laboratory on ice and frozen. Temperature, station depth, salinity (refractometer) and Secchi depth were recorded at each station. Compass bearings to identifiable cultural or geographic features or navigational aids were taken, if possible. In the absence of SAV at the nominal station location, a circle with a radius of 1/4 nautical mile was searched for SAV prior to departure from the station.

Fourteen samples collected with the same coring device at arbitrary stations in Core Sound in 1985 and 1986 were analyzed and incorporated into the data set. Likewise, 28 samples collected in February, 1988, in southern Core Sound, were incorporated. These stations were in SAV beds randomly selected according to area of the bed and then arbitrarily located within that selected bed. Beds to be sampled were selected with replacement.

Samples of SAV were thawed and separated into shoots and roots/rhizomes. Species composition data are based on shoot number and on ash free dry weight of shoots that had been acidified in 5% phosphoric acid to remove calcareous epiphytes.

RESULTS AND DISCUSSION

SAV IN SOUTHERN CORE SOUND

Aerial extent and species composition of SAV in southern Core Sound were quantified. Data are based on March, 1985 aerial photography and ground level visits to the study area in February (28 samples) and March, 1988 (20 samples) and spring and winter of 1985 and 1986 (14 samples).

Southern Core Sound is defined for this report as the open waters from Cape Lookout to Drum Inlet, bordered by a barrier island, Core Banks (not labeled), to the east and including all adjacent bays and creeks to the west between Marshallberg and Atlantic (Fig. 3). The southwestern border is a line along Barden's Inlet channel (not labeled) leading into the sound from Cape Lookout, extending along the eastern shores of Harkers and Browns (not labeled) Islands and crossing The Straits east of Sleepy Creek (not labeled). This excludes Back Sound, Eastmouth Bay (both unlabeled here) and The Straits.

Core Sound is relatively shallow with few areas deeper than 6 feet at mean low water with the exception of natural "holes" and artificially maintained channels. Turbidity is characteristically high in embayments along the western shore due to soft bottoms and watersheds with waters enriched with dissolved and particulate organic matter from marshes and low-lying forests. Figure 3 delineates the 109 habitats of SAV visible in the March, 1985 photography, and the locations of SAV sample stations, Spring, 1985-March 1988. Habitat sizes ranged from less than 1 to greater than 6,300 acres (Table 2). Largest habitats occurred on the

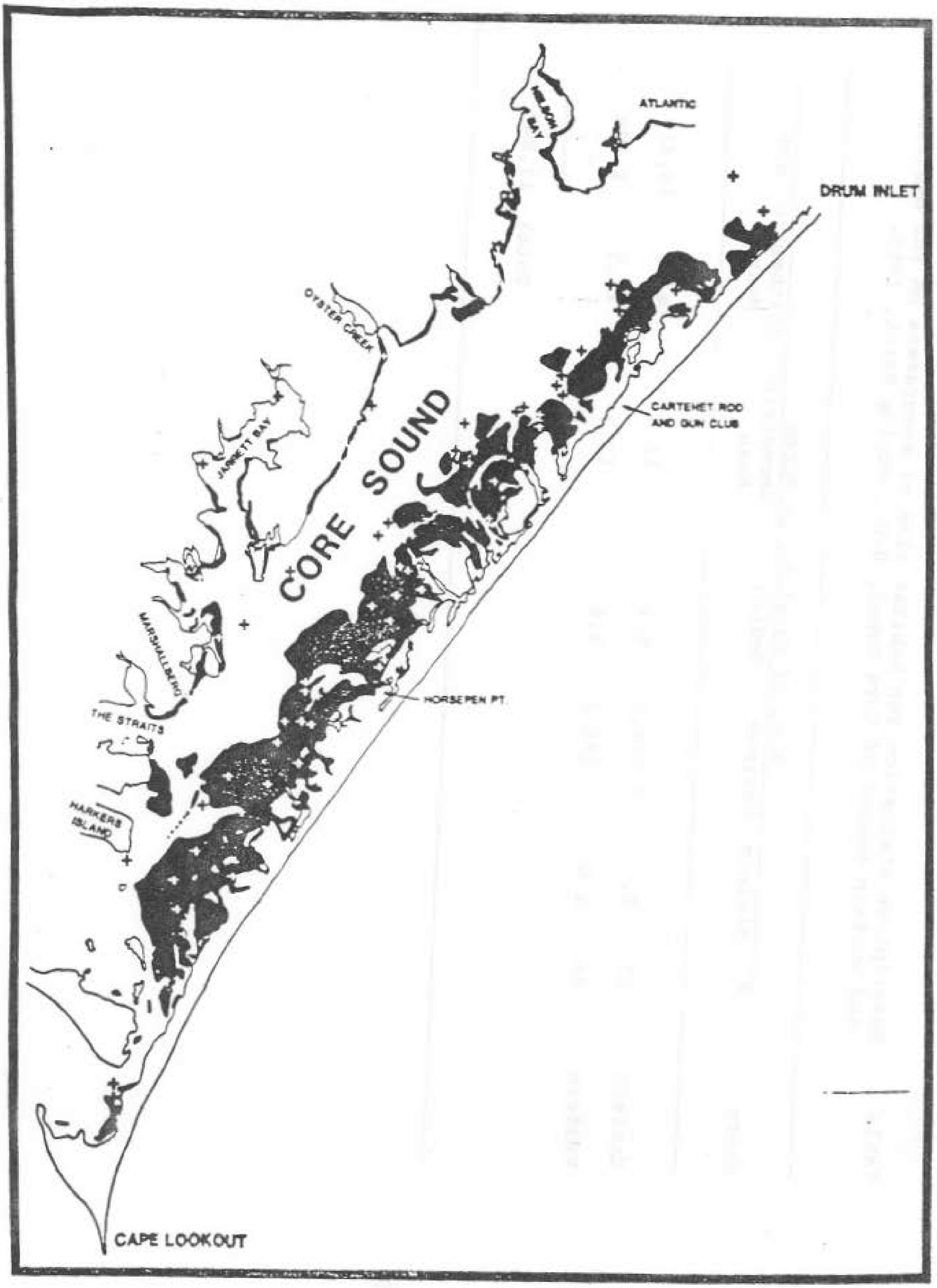


Figure 3. Southern Core Sound with locations of submerged aquatic vegetation (based on March 1985 photography) and sampling stations.

Table 2. Descriptive statistics for habitat size of seagrasses on the eastern and western shores of Core Sound, N.C., during March, 1985.

Shore	Area of Habitats in Acres						
	N	Minimum	Maximum	Median	Geometric Mean	Arithmetic Mean	Sum
Eastern	53	0.7	6,335.0	8.7	12.3	194.0	10,418
Western	56	1.0	194.2	9.5	12.3	25.5	1,426
						Total	11,844

eastern side, but the two sides had similar median and geometric mean sizes. Total area approached 12,000 acres, more than double that area reported previously (see Appendix B and below). Relatively few habitats exceeded 50 acres (Table 3). SAV habitats on the western side tended to be narrow, aligned along the shore at depths less than about 3 feet mean low water (MLW) and were less than 135 acres in total area. A notable exception was the large broad habitat southeast of The Straits. Broad SAV habitats occurred at water depths up to about 6 feet MLW on the eastern side. Total area of SAV habitat was 11,844 acres of which 12% was along the western shore and 88% along the eastern shore.

All three seagrasses found in eastern North Carolina occurred in our samples from southern Core Sound. Statistically significant differences were found between SAV on the eastern and western sides of the channel (Table 4). Widgeon grass was relatively more abundant on the western than eastern side. Shoalgrass was relatively more numerically abundant on the eastern than western side. Combining all 62 SAV samples confirmed this trend (Table 5). On average, eelgrass and shoalgrass contributed the most to species composition based on number of shoots, but the larger size of eelgrass leaves resulted in its dominant contribution to average species composition on a dry weight basis. Of the 62 total samples, 11 were from pure stands of either eelgrass (7) or shoalgrass (4), 44 samples were a mixture of two of the three species, and 7 samples contained all three species.

SAV in southern Core Sound was mapped on 7 USGS 7.5 minute quadrangles (Fig. 4). The location of 109 beds of SAV (Fig. 5 a-

Table 3. Distribution of habitat size of seagrasses on the eastern and western shores of Core Sound, N.C., during March, 1985.

Shore	Area of Habitat in Acres						
	Less than 2.5	2.6-20	21-50	51-135	136-350	351-1000	greater than 1000
	Number of habitats						
Eastern	12	24	6	3	2	4	2
Western	8	25	16	6	1	0	0

Table 4. Analysis of variance (ANOVA), means (x), and standard deviations (SD) of percent number and percent dry weight of shoots for seagrasses in Core Sound, N.C. in March, 1988. Sample sites were selected with the dot matrix grid approach and data transformed with the arc sine function for ANOVA. The null hypothesis (H_o) is: species contribution to total SAV is the same for habitats on the eastern and western shores of the sound. Degrees of freedom are: model = 1 and error = 18; F test, $1 - \alpha = 90\%$. Analysis is based on 14 samples (eastern shore) and 6 samples (western shore).

Species	ANOVA				Shore	Number		Weight	
	Number		Weight						
	F	H_o	F	H_o		x	SD	x	SD
Zostera marina	0.46	accept	0.33	accept	east	39.3	32.0	75.6	23.0
					west	48.8	41.3	80.6	16.3
Halodule wrightii	3.21	reject	1.67	accept	east	60.3	31.7	24.2	22.6
					west	31.9	37.9	13.3	16.0
Ruppia maritima	7.22	reject	6.22	reject	east	0.5	1.3	0.2	0.6
					west	19.2	29.9	6.0	9.6

Table 5. Species occurrence and percent composition of seagrasses in Core Sound, N.C. Samples were collected in May and December 1985 or June and December 1986 (14 samples), February 1988 (28 samples) and March 1988 (20 samples)

	Eastern Shore (N=54)			Western Shore (N=8)		
Species	Frequency (in samples)	Species composition (based on shoots)		Frequency (in samples)	Species composition (based on shoots)	
		number	weight		number	weight
		--------%---------			--------%---------	
Zostera marina	49	36.1	57.4	8	47.9	72.7
Halodule wrightii	47	59.6	40.7	5	37.6	22.8
Ruppia maritima	8	4.3	1.9	3	14.4	4.5

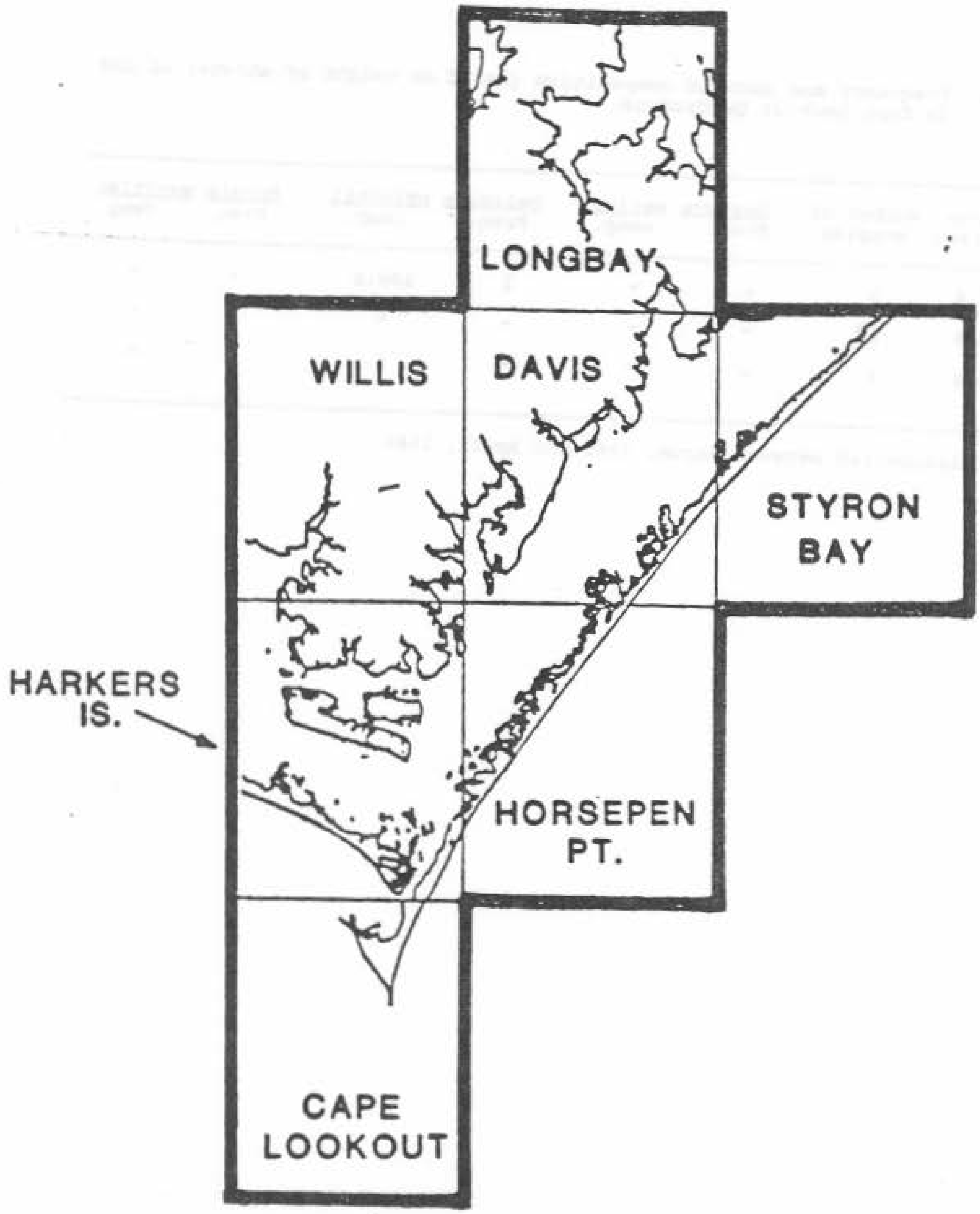


Figure 4. Orientation of U.S.G.S. 7.5 minute quadrangles covering study area in southern Core Sound.

Table 6a. Frequency and percent composition (based on weight of shoots) of SAV in Cape Lookout Quadrangle.

Bed No.	Area (acres)	Number of samples	*Zostera marina* Freq.	*Zostera marina* comp.	*Halodule wrightii* Freq.	*Halodule wrightii* Comp.	*Ruppia maritima* Freq.	*Ruppia maritima* Comp.
138	8.8	1	-	-	1	100.0	-	-
139	66.5	1[a]	-	-	-	-	-	-
140	4.8	0	-	-	-	-	-	-

[a] Bed 130 disappeared between March, 1985 and April, 1988.

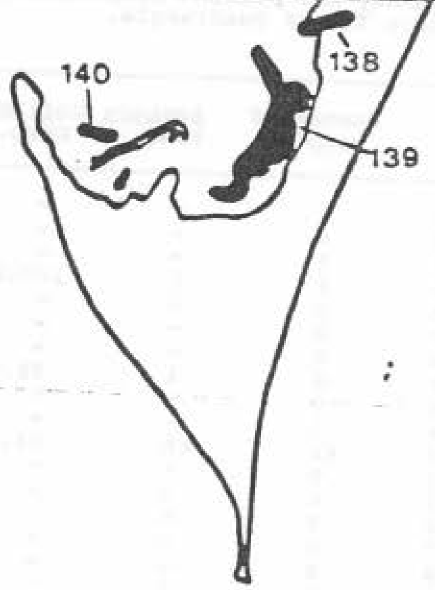


Figure 5. SAV in Cape Lookout Quadrangle.

Table 6b. Frequency and percent composition (based on weight of shoots) of SAV in Harkers Island Quadrangle.

Bed No.	Area (acres)	Number of samples	*Zostera marina* Freq.	*Zostera marina* Comp.	*Halodule wrightii* Freq.	*Halodule wrightii* Comp.	*Ruppia maritima* Freq.	*Ruppia maritima* Comp.
1	194.2	0	-	-	-	-	-	-
2	60.6	0	-	-	-	-	-	-
3	17.1	0	-	-	-	-	-	-
4	47.3	1	1	100.0	-	-	-	-
5	50.5	0	-	-	-	-	-	-
6	2.9	0	-	-	-	-	-	-
7	13.0	0	-	-	-	-	-	-
8	130.3	2	2	55.2	1	4.9	1	39.9
9	13.8	0	-	-	-	-	-	-
10	16.6	0	-	-	-	-	-	-
98	6335.0	45	45	32.3	34	58.3	7	9.4
122	14.6	0	-	-	-	-	-	-
123	1.3	0	-	-	-	-	-	-
124	.8	0	-	-	-	-	-	-
125	.7	0	-	-	-	-	-	-
126	.9	0	-	-	-	-	-	-
127	1.0	0	-	-	-	-	-	-
128	.9	0	-	-	-	-	-	-
130	8.7	0	-	-	-	-	-	-
136	45.3	0	-	-	-	-	-	-
137	11.5	0	-	-	-	-	-	-

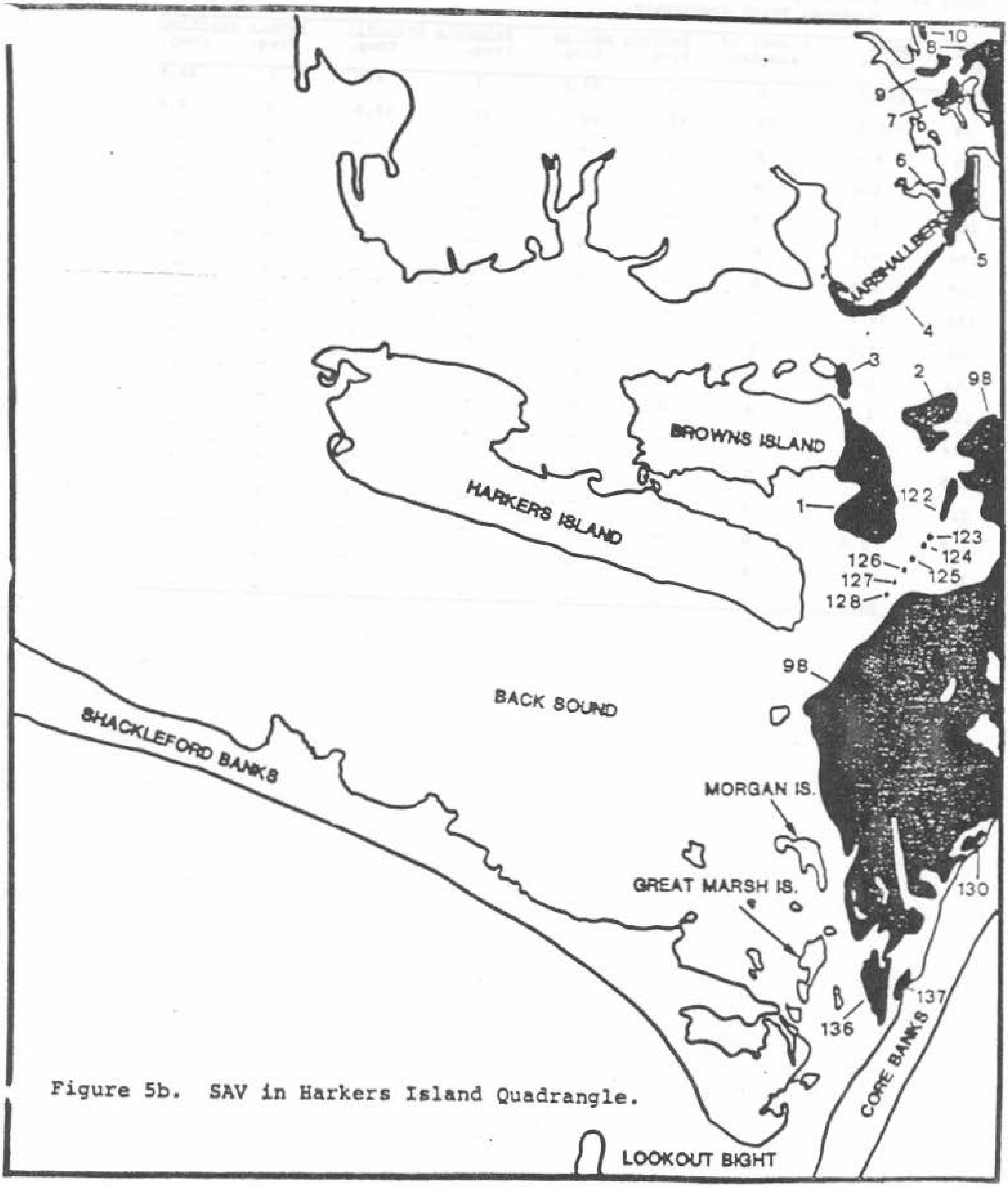


Figure 5b. SAV in Harkers Island Quadrangle.

Table 6c. Frequency and percent composition (based on weight of shoots) of SAV in Horsepen Point Quadrangle.

Bed No.	Area (acres)	Number of samples	*Zostera marina* Freq.	*Zostera marina* Comp.	*Halodule wrightii* Freq.	*Halodule wrightii* Comp.	*Ruppia maritima* Freq.	*Ruppia maritima* Comp.
8	130.3	2	2	55.2	1	4.9	1	39.9
98	6335.0	45	45	32.3	34	58.3	7	9.4
103	8.9	0	-	-	-	-	-	-
104	1.4	0	-	-	-	-	-	-
105	3.1	0	-	-	-	-	-	-
106	6.2	0	-	-	-	-	-	-
107	9.0	0	-	-	-	-	-	-
110	25.3	0	-	-	-	-	-	-
111	7.0	0	-	-	-	-	-	-
112	1.9	0	-	-	-	-	-	-
113	1.3	0	-	-	-	-	-	-
114	15.5	0	-	-	-	-	-	-
115	2.4	0	-	-	-	-	-	-
116	6.3	0	-	-	-	-	-	-
117	5.4	0	-	-	-	-	-	-
119	20.7	0	-	-	-	-	-	-
120	36.2	0	-	-	-	-	-	-

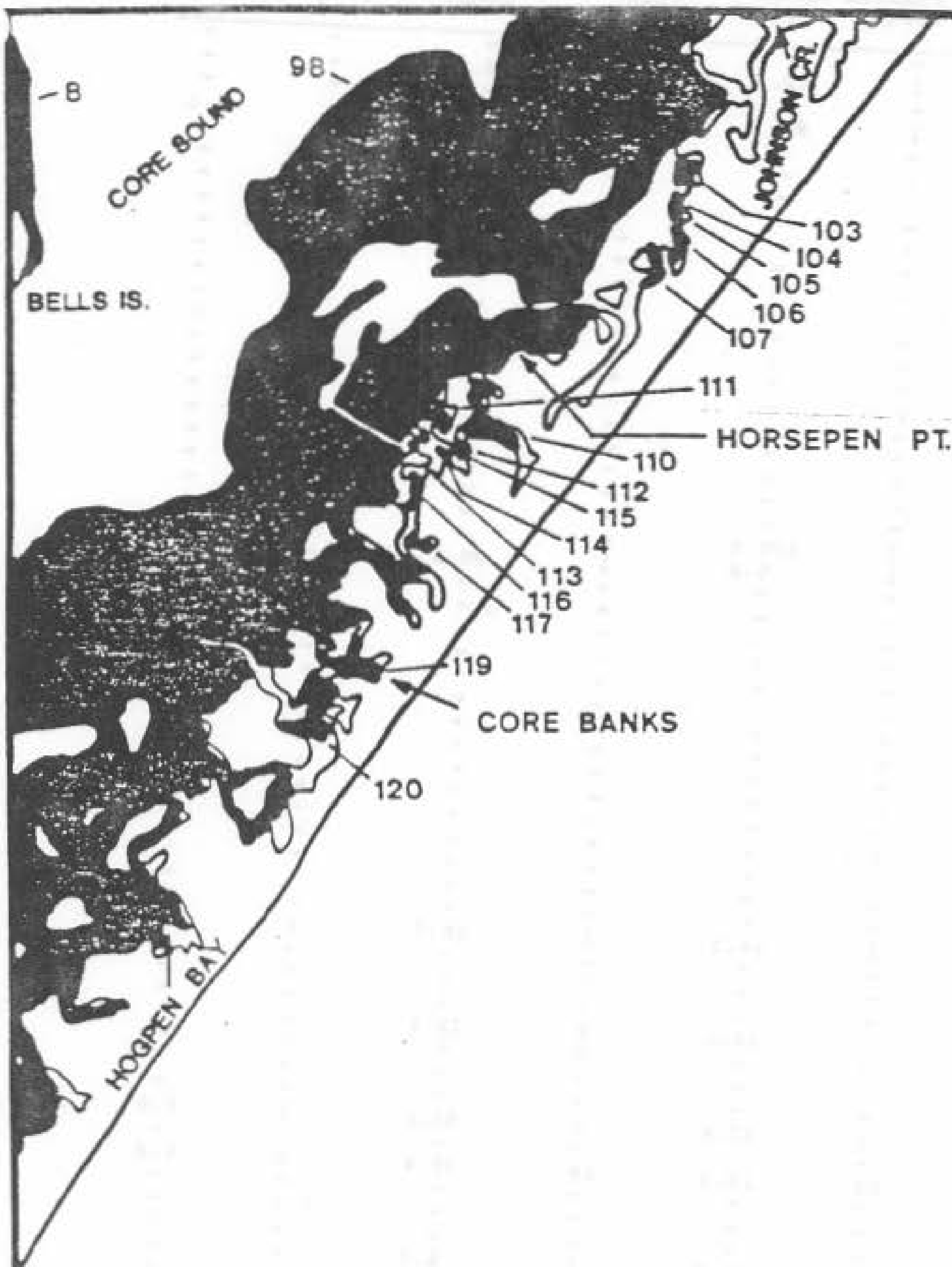


Figure 5c. SAV in Horsepen Point Quadrangle.

Table 6d. Frequency and percent composition (based on weight of shoots) of SAV in Davis Quadrangle.

Bed No.	Area (acres)	Number of samples	*Zostera marina* Freq.	*Zostera marina* Comp.	*Halodule wrightii* Freq.	*Halodule wrightii* Comp.	*Ruppia maritima* Freq.	*Ruppia maritima* Comp.
12	84.2	0	-	-	-	-	-	-
13	30.2	1	1	15.4	1	84.6	-	-
14	6.7	0	-	-	-	-	-	-
15	7.6	1	1	80.3	1	15.6	1	4.1
16	8.7	0	-	-	-	-	-	-
17	36.5	0	-	-	-	-	-	-
18	1.0	0	-	-	-	-	-	-
19	43.6	0	-	-	-	-	-	-
20	7.9	0	-	-	-	-	-	-
21	1.2	0	-	-	-	-	-	-
22	1.5	0	-	-	-	-	-	-
23	20.5	0	-	-	-	-	-	-
24	32.0	0	-	-	-	-	-	-
25	1.3	0	-	-	-	-	-	-
26	39.2	0	-	-	-	-	-	-
27	12.8	0	-	-	-	-	-	-
28	3.4	0	-	-	-	-	-	-
29	15.6	0	-	-	-	-	-	-
30	4.5	0	-	-	-	-	-	-
31	4.0	0	-	-	-	-	-	-
32	1.3	0	-	-	-	-	-	-
33	17.3	1	1	100.0	-	-	-	-
34	42.9	1	1	0.2	1	99.8	-	-
35	34.9	0	-	-	-	-	-	-
36	43.0	0	-	-	-	-	-	-
37	23.6	0	-	-	-	-	-	-
38	62.6	0	-	-	-	-	-	-
39	22.2	0	-	-	-	-	-	-
40	3.3	0	-	-	-	-	-	-
41	1.1	0	-	-	-	-	-	-
42	4.6	0	-	-	-	-	-	-
43	2.1	0	-	-	-	-	-	-
44	35.1	0	-	-	-	-	-	-
46	9.5	0	-	-	-	-	-	-
47	1.5	0	-	-	-	-	-	-
48	5.6	0	-	-	-	-	-	-
49	30.6	0	-	-	-	-	-	-
50	6.1	0	-	-	-	-	-	-
51	9.6	1	1	64.2	1	28.5	1	7.3
52	56.4	0	-	-	-	-	-	-
53	44.6	0	-	-	-	-	-	-
56	5.2	0	-	-	-	-	-	-
61	1177.0	8	7	26.1	8	73.9	-	-
67	97.2	0	-	-	-	-	-	-
70	23.0	0	-	-	-	-	-	-
71	13.1	0	-	-	-	-	-	-
72	501.9	4	4	32.4	4	66.8	1	0.8
77	563.4	0	-	-	-	-	-	-
79	377.9	19	10	17.8	19	75.6	5	6.6
80	3.9	0	-	-	-	-	-	-
81	3.9	0	-	-	-	-	-	-
83	50.7	0	-	-	-	-	-	-
84	5.7	1	1	94.0	1	6.0	-	-
86	2.3	0	-	-	-	-	-	-
87	11.2	0	-	-	-	-	-	-
88	8.5	0	-	-	-	-	-	-
89	6.7	0	-	-	-	-	-	-
90	10.2	0	-	-	-	-	-	-
91	465.7	4	3	14.5	4	85.5	-	-
92	1.4	0	-	-	-	-	-	-
93	136.4	1	1	91.5	1	8.5	-	-
94	3.0	0	-	-	-	-	-	-
95	4.7	0	-	-	-	-	-	-
96	4.8	0	-	-	-	-	-	-
98	6335.0	45	45	32.3	34	58.3	7	9.4

Figure 5d. SAV in Davis Quadrangle.

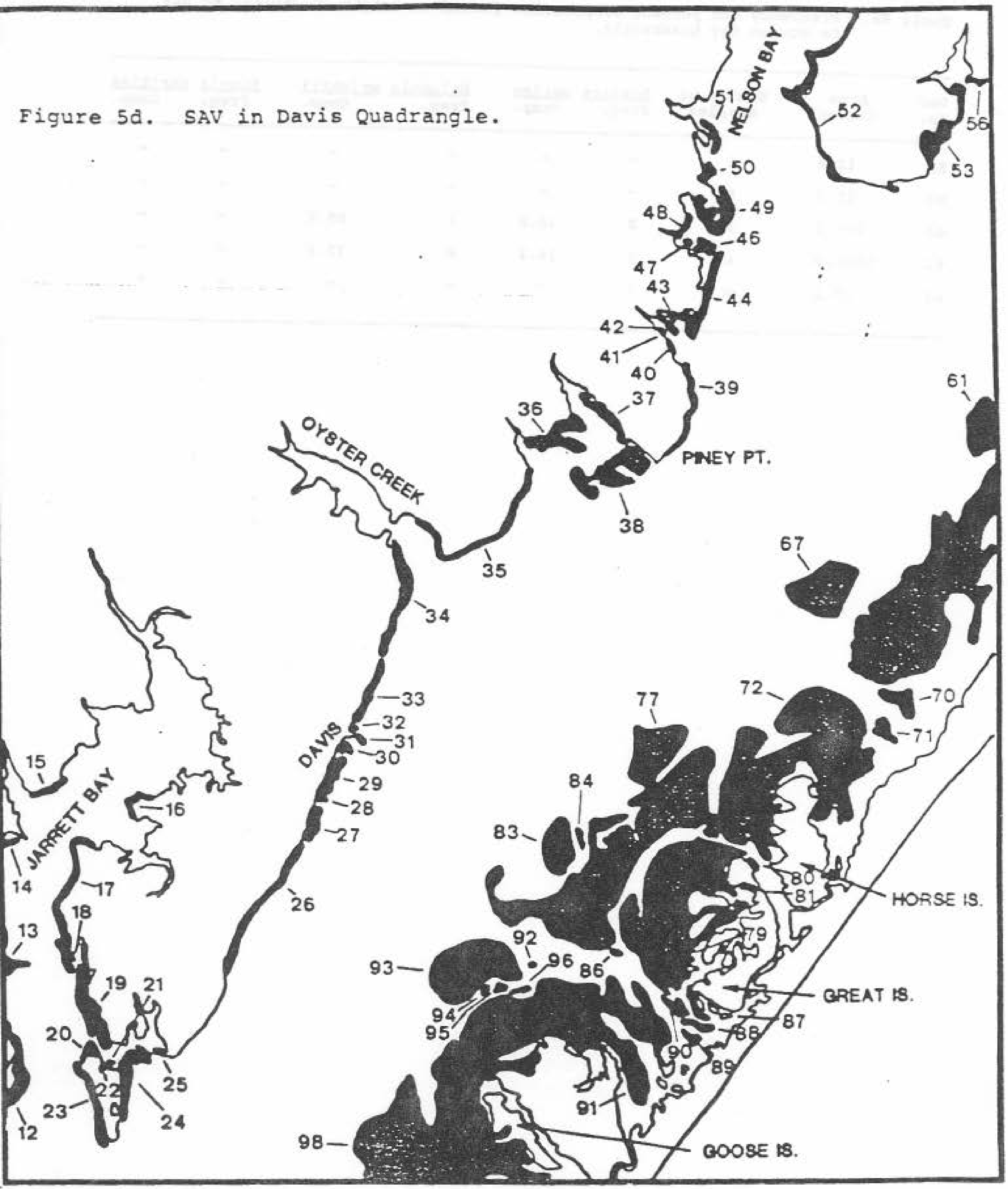


Table 6a. Frequency and percent composition (based on weight of shoots) of SAV in Styron Bay Quadrangle.

Bed No.	Area (acres)	Number of samples	*Zostera marina* Freq.	*Zostera marina* Comp.	*Halodule wrightii* Freq.	*Halodule wrightii* Comp.	*Ruppia maritima* Freq.	*Ruppia maritima* Comp.
58	12.8	0	-	-	-	-	-	-
59	11.3	0	-	-	-	-	-	-
60	279.1	2	2	40.8	1	59.2	-	-
61	1177.0	8	7	26.1	8	73.9	-	-
63	27.2	0	-	-	-	-	-	-

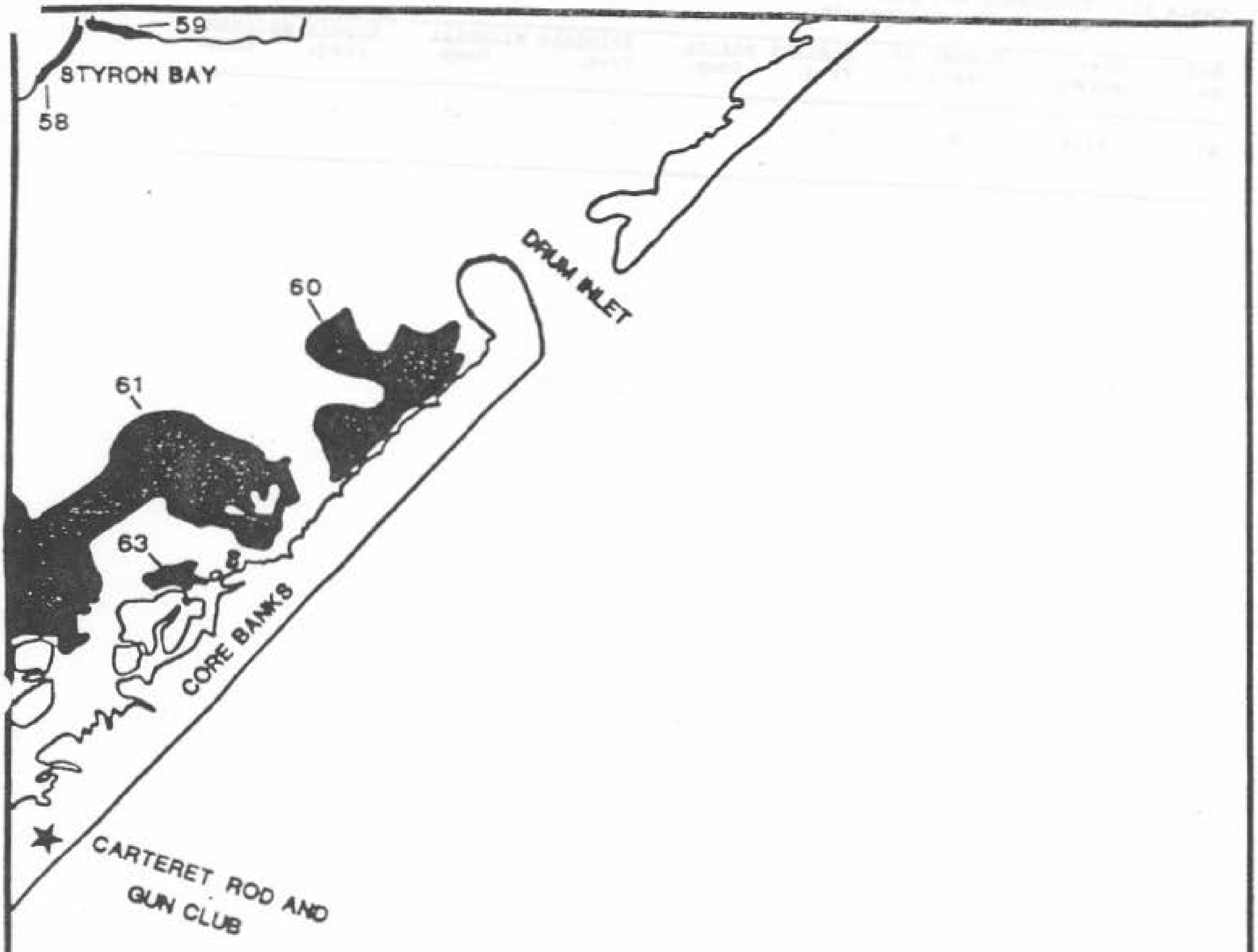


Figure 5e. SAV in Styron Bay Quadrangle.

Table 6f. Frequency and percent composition (based on weight of shoots) of SAV in Long Bay Quadrangle.

Bed No.	Area (acres)	Number of samples	*Zostera marina* Freq.	*Zostera marina* Comp.	*Halodule wrightii* Freq.	*Halodule wrightii* Comp.	*Ruppia maritima* Freq.	*Ruppia maritima* Comp.
57	24.0	0	-	-	-	-	-	-

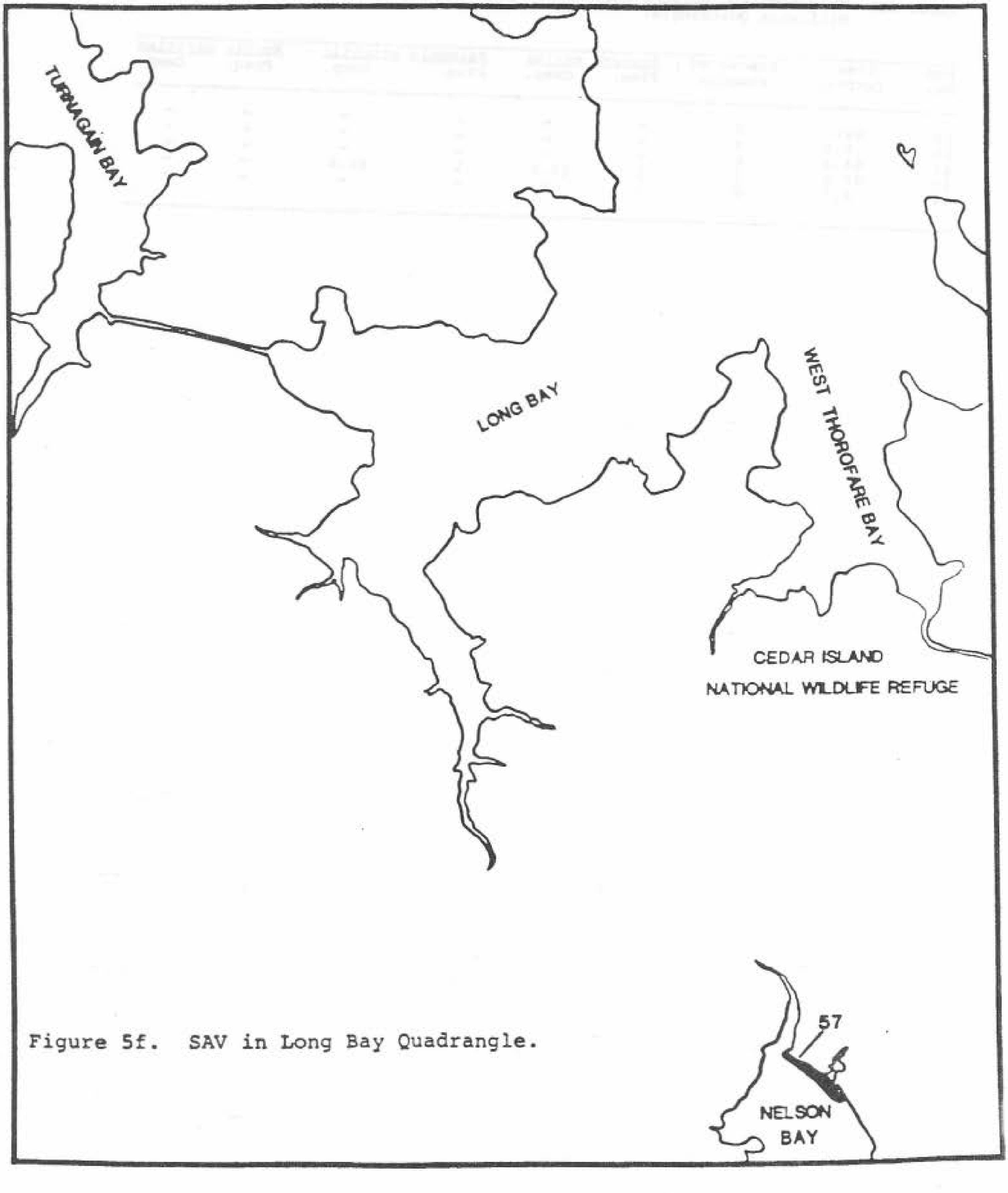
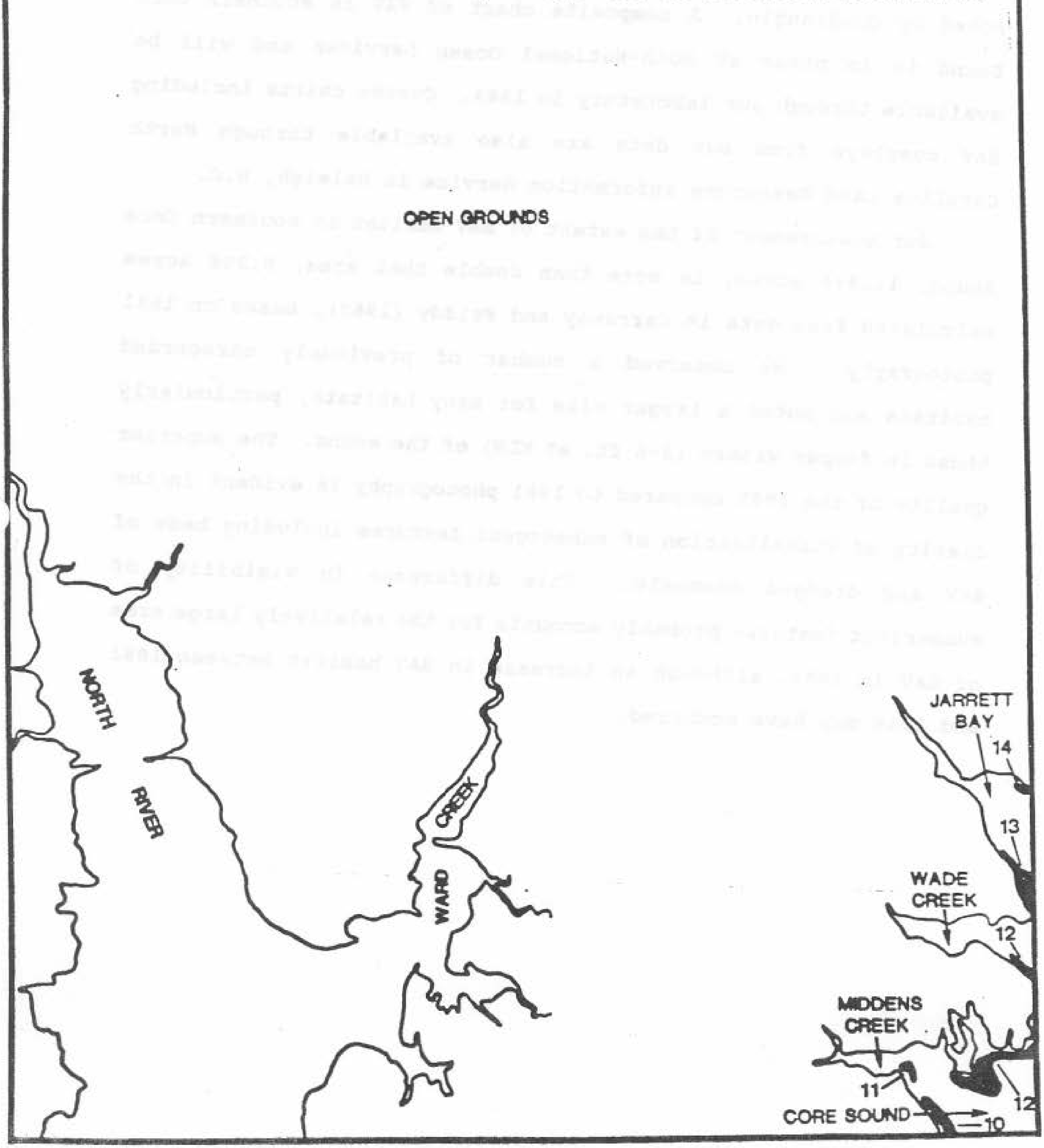


Figure 5f. SAV in Long Bay Quadrangle.

Table 6g. Frequency and percent composition (based on weight of shoots) of SAV in Williston Quadrangle.

Bed No.	Area (acres)	Number of samples	*Zostera marina* Freq.	*Zostera marina* Comp.	*Halodule wrightii* Freq.	*Halodule wrightii* Comp.	*Ruppia maritima* Freq.	*Ruppia maritima* Comp.
10	16.6	0	-	-	-	-	-	-
11	5.6	0	-	-	-	-	-	-
12	84.2	0	-	-	-	-	-	-
13	30.2	1	1	15.4	1	84.6	-	-
14	6.7	0	-	-	-	-	-	-

Figure 5g. SAV in Williston Quadrangle.



g) and the species composition of sampled beds (Table 6 a-g) are noted by quadrangle. A composite chart of SAV in southern Core Sound is in press at NOAA-National Ocean Services and will be available through our laboratory in 1989. Custom charts including SAV overlays from our data are also available through North Carolina Land Resources Information Service in Raleigh, N.C.

Our measurement of the extent of SAV habitat in southern Core Sound, 11,844 acres, is more than double that area, 5,206 acres calculated from data in Carraway and Priddy (1983), based on 1981 photography. We observed a number of previously unrecorded habitats and noted a larger size for many habitats, particularly those in deeper waters (3-6 ft. at MLW) of the sound. The superior quality of the 1985 compared to 1981 photography is evident in the clarity of visualization of submergent features including beds of SAV and dredged channels. This difference in visibility of submergent features probably accounts for the relatively large area of SAV in 1985, although an increase in SAV habitat between 1981 and 1985 may have occurred.

CORRESPONDENCE OF BEAUFORT AND LRIS ESTIMATES OF HABITAT SIZE

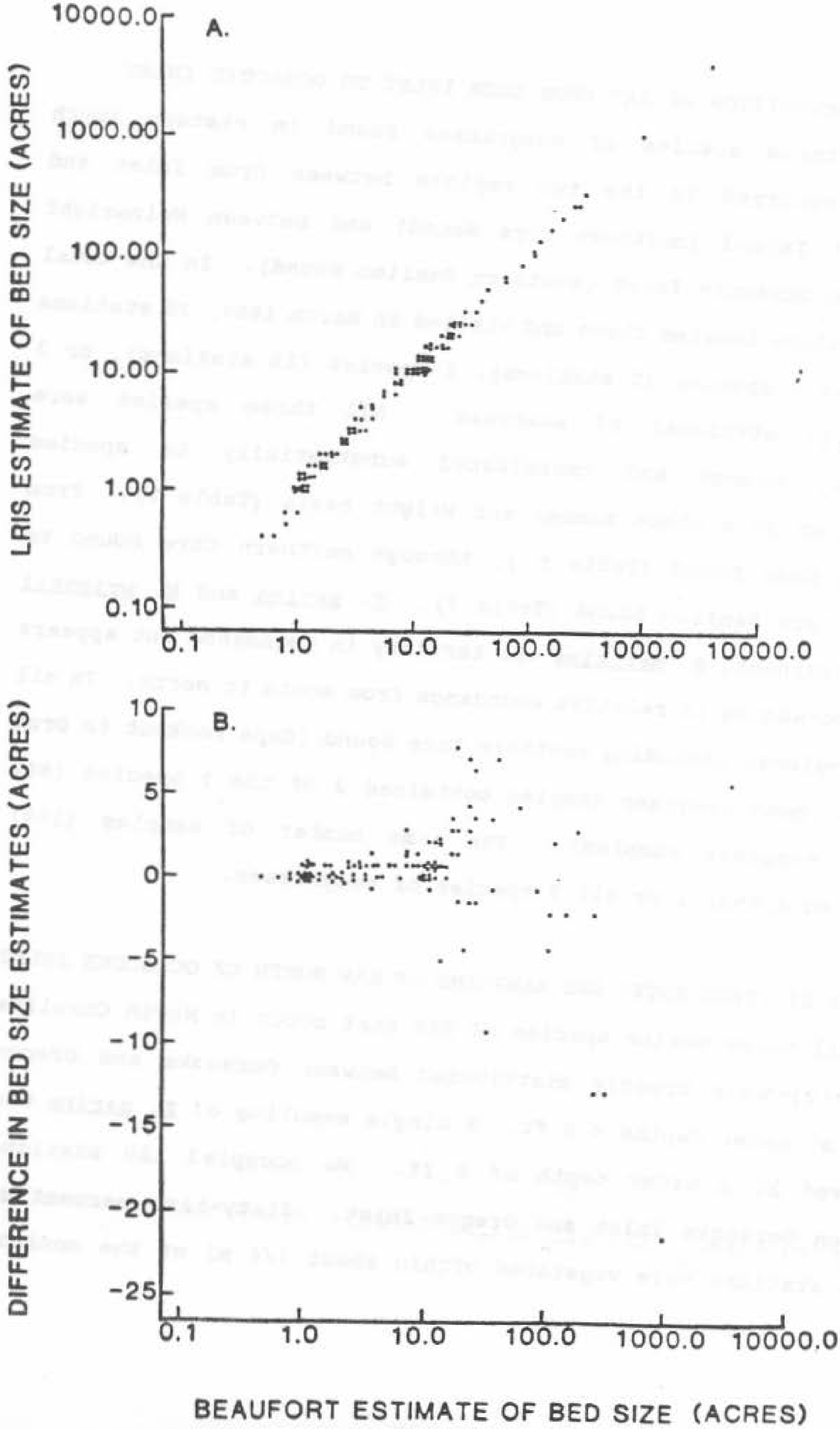
We compared regression analysis estimates (N=109) of bed sizes obtained with our video-based image analysis system to those obtained from manual tracings by LRIS of our SAV polygons. We regressed the LRIS estimates on the Beaufort estimates (Fig. 6a) and found the slope ($p<0.0001$) but not the intercept term ($p>0.42$) of the regression model was statistically significant. We therefore fit a second model, containing no intercept:

LRIS Estimate = 0.953533 (Beaufort Estimate)

More than 99.99% of the total variation in the LRIS estimates was explained by the variation in the corresponding Beaufort estimates. The estimated slope parameter of the fitted model indicates that the LRIS estimates exhibited a strong tendency to be about 4.6% lower than the corresponding Beaufort estimates. This proportionality of differences in the estimates, in turn, suggests that the source of the difference was due to intercalibration error. By increasing each of the LRIS estimates by 4.87% to compensate for the apparent intercalibration error, the maximum difference between any pair of estimates was 21 acres, only 4 of the 109 comparisons differed by more than 8 acres, and the average difference was 0.26 acres (Fig. 6b).

The intercalibration problem between the two approaches to measuring area of SAV polygons clearly deserves further study, but the relatively small size of the error (<5%) and the general consistency in the pairs of estimates reinforced our confidence in our results and in both area-measuring methodologies.

Figure 6. Comparison of estimates of area of SAV habitats by Beaufort and Land Resources Information Service (LRIS). SAV polygons were generated by analysis of March, 1985, 1:20,000 scale photography by Beaufort. A - Bivariate plot of Beaufort and LRIS estimates of the 109 SAV habitats. B - Bivariate plot of difference = (Beaufort estimate - LRIS estimate) after correction for intercalibration error (LRIS estimate was multiplied by 1,0487) and Beaufort estimate of area of SAV habitats.


A.
B.
LRIS ESTIMATE OF BED SIZE (ACRES)
DIFFERENCE IN BED SIZE ESTIMATES (ACRES)
BEAUFORT ESTIMATE OF BED SIZE (ACRES)
10000.0
1000.00
100.00
10.00
1.00
0.10
0.1
1.0
10.0
100.0
1000.0
10000.0
10
5
0
-5
-10
-15
-20
-25

SPECIES COMPOSITION OF SAV FROM DRUM INLET TO OCRACOKE INLET

All three species of seagrasses found in eastern North Carolina occurred in the two regions between Drum Inlet and Wainwright Island (northern Core Sound) and between Wainwright Island and Ocracoke Inlet (southern Pamlico Sound). In the total of 39 stations located there and visited in March 1988, 25 stations had either 1 species (3 stations), 2 species (15 stations), or 3 species (7 stations) of seagrass. All three species were relatively common and contributed substantially to species composition on a shoot number and weight basis (Table 7). From southern Core Sound (Table 5), through northern Core Sound to southeastern Pamlico Sound (Table 7), Z. marina and H. wrightii are co-dominant, R. maritima was tertiary in abundance but appears to be increasing in relative abundance from south to north. In all three regions, including southern Core Sound (Cape Lookout to Drum Inlet), most seagrass samples contained 2 of the 3 species (68% of the seagrass samples). The same number of samples (16%) contained either 1 or all 3 species of seagrasses.

SUMMARY OF FIELD NOTES AND SAMPLING OF SAV NORTH OF OCRACOKE INLET

All three marine species of SAV that occur in North Carolina (Table 1) were broadly distributed between Ocracoke and Oregon Inlet at water depths < 6 ft. A single seedling of Z. marina was observed at a water depth of 8 ft. We occupied 120 stations between Ocracoke Inlet and Oregon Inlet. Sixty-nine percent of these stations were vegetated within about 1/4 mi of the nominal

Table 7. Species occurrence and percent composition of seagrasses in northern Core Sound (Drum Inlet to Wainwright Island) and southeastern Pamlico Sound (Wainwright Island to Ocracoke Inlet) in April 1988. Total stations = 39.

Species	Northern Core Sound (N=19)			Southeastern Pamlico Sound (N=20)		
	Frequency (in samples)	Species Composition (based on shoots)		Frequency (in samples)	Species Composition (based on shoots)	
		number	weight		number	weight
		--------%----------			--------%----------	
Zostera marina	7	16.2	43.7	10	31.6	54.5
Halodule wrightii	8	55.6	45.7	11	44.9	29.2
Ruppia maritima	9	28.1	10.6	9	23.5	16.3

station location and were sampled for SAV. Sediments at all stations of less than 10 ft water depth were sampled.

Samples of SAV were collected in Currituck Sound and southern Back Bay in October, 1987, and in Core, eastern Pamlico, Croatan and Roanoke Sounds in March, 1988. During the trip to Currituck Sound and Back Bay (October, 1987), we collected six species of fresh water/brackish SAV (Table 8) and prepared an herbarium collection for subsequent SAV identifications. Nine sites were sampled with a rake in northern Currituck Sound, Knotts Island Bay (and Channel) and southern Back Bay, and three sites were sampled similarly in southern Currituck Sound. Many of these locations possessed the macroscopic alga _Chara sp_. The three most abundant species of SAV were Eurasian milfoil, wild celery and widgeon grass. SAV was most abundant in protected, shallow ($\leq$ 1.5m) waters but not widely distributed except in the Knotts Island Bay (and channel) area in the north and Kitty Hawk Bay and Point Harbor in the south. Water was brackish, salinity from 1.9-4.6 o/oo, and turbid, secci depth from 0.2-0.9 m. In comparison, for the 194 stations sampled in March and April, 1988, from Cape Lookout to Oregon Inlet, salinities ranged from 1.0-34 o/oo (n=183, mean = 18.2 o/oo). Secci depth ranged from 0.2-3.6 m (n=96, mean = 1.0 m). We concluded that high turbidity, occurrence of macroalgae and the relatively restricted and small SAV habitat sizes would make acquisition of aerial photography, suitable for delineation of SAV, problematic.

Table 8. Species of submerged aquatic vegetation collected in Currituck Sound October 1987.

Genus	Species	Common Name
Myriophyllum	*spicata*	Eurasian water milfoil
Najas	*guadalupensis*	Bushy pondweed
Potamogeton	*pectinatus*	Sago pondweed
Potamogeton	*perfoliatus*	Redhead grass
Ruppia	*maritima*	Widgeon grass
Vallisneria	*americana*	Wild celery

INTERACTIONS WITH STATE PERSONNEL, ENVIRONMENTAL MANAGERS AND THE PUBLIC

This project has been particularly responsive to information needs expressed by state personnel, state and federal environmental managers and the public (Table 9). Information requests ranged from general information on SAV measurement methodology and distributions and importance as fisheries habitat (16 requests) to site specific data on SAV occurrence and species composition (9 requests). We provided interviews to two newspapers and one TV news station, discussed our photography and our results with representatives of three universities, six state or national environmental conservation groups, and eight state or national governmental agencies. At the request of representatives of N.C. Coastal Federation, N.C. Wildlife Federation, N.C. Fisheries Association and Carteret County Crossroads, we prepared a document in support of the nomination of North Carolina marine waters as outstanding resource waters (see Appendix B).

TABLE 9. APPLICATION OF APES/SAV PROJECT PHOTOGRAPHY, DATA AND EXPERTISE TO USER GROUPS DURING 1987/1988.

PURPOSE	USER	LOCATION
PROPOSAL EVALUATION FOR BASIN AND CHANNEL DREDGING IMPACT ON SAV	N.C. COASTAL FEDERATION U.S. CORPS OF ENGINEERS	SANDERS CREEK BOGUE SOUND, NC
	N.C. DIV. OF MAR. FISH.	SANDY BAY, HATTERAS, NC
	NMFS ENVIRONMENTAL ASSESSMENT BRANCH	PAMLICO SOUND, WAVES, NC
	"	OCRACOKE, IS., NC
	"	MCLEAN MARINA PROJECT, DEER CREEK, BOGUE SOUND, NC
	"	MANTEO (SHALLOW-BAG) BAY NAVIGATION PROJECT, PAMLICO SOUND
	"	SUGARLOAF IS. MOREHEAD CITY, NC
	"	BLUE HERON BAY PROJECT, BOGUE SOUND, NC
	"	GOOSE CREEK, NC
QUANTIFY SAV FOR:		
WADING BIRD HABITAT	NAT'L AUDOBON SOC.	FLORIDA KEYS
EELGRASS WASTING DISEASE	JACKSON ESTUARINE LAB. DURHAM, NH	BACK SOUND, NC
HOBE SOUND SEAGRASS-MANATEE PROJECT	NMFS-FLA. DEPT. OF NATURAL RESOURCES U.S. FISH AND WILDLIFE	HOBE SOUND, FL

CONTINUED

Table 9 (Continued)

PURPOSE	USER	LOCATION
INFORMATION/EDUCATION:		
SAV IMPORTANCE AND DISTRIBUTION	RALEIGH NEWS AND AND OBSERVER	BEAUFORT, NC
	THE VIRGINIAN-PILOT 7 THE LEDGER-STAR	NOAA SHIP FERREL, CROATAN SOUND, NC
	WCTI TV NEWS	MOREHEAD CITY,NC
	NATIONAL WILDLIFE FEDERATION	"
	PAMLICO CITIZENS ADVISORY COMMITTEE	NEW BERN, NC
CLAM KICKING REGULATIONS	N.C. DIV. MAR. FISH	CORE SOUND, NC
SCALLOP RESEARCH	U.N.C.INSTITUTE OF MARINE SCIENCE	CORE SOUND, NC
PETITIONING FOR OUT-STANDING RESOURCE WATERS	N.C. COASTAL FEDERATION, N.C. WILDLIFE FEDERATION, N.C. FISHERIES ASSOCIATION, CARTERET COUNTY CROSSROADS	BOGUE SOUND & CORE SOUND
EVALUATION OF NOMINATIONS FOR OUT-STANDING RESOURCE WATERS	N.C. DIV. ENV. MANAGEMENT	MOREHEAD CITY,NC
NATIONAL COASTAL WETLAND INVENTORY	STRATEGIC ASSESSMENT BRANCH, NATIONAL OCEAN SERVICE	ROCKVILLE, MD
APPLY PHOTOGRAPHY TO OUTER BANKS LAND USE MAPPING	ECU GEOGRAPHY DEPARTMENT	GREENVILLE, NC
SHELLFISH MAPPING	N.C. DIV. MAR. FISH.	WASHINGTON, NC
SAV OVERLAYS FOR GIS RESOURCE MAPPING	LAND RESOURCES IN-FORMATION SERVICE-NRCD	RALEIGH, NC
PHOTOGRAPHY TO INTER-PRET AIRBORNE ELECTRO-MAGNETIC PROFILLING SYSTEM	NASA, JOHN C. STENNIS SPACE CENTER, MS	BACK SOUND, NC

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APPENDICES

A. Cruise Report, NOAA Ship Ferrel S492

B. Current Status and Ecological Importance of Seagrass Beds in Core, Back and Western Bogue Sounds, North Carolina. (A report drafted in support of their nominations by the State of North Carolina as outstanding resource waters)

Appendix A Cruise Report, NOAA Ship *Ferrel* S492

CRUISE REPORT
NOAA SHIP FERREL S492

NATIONAL MARINE FISHERIES SERVICE
ALBEMARLE-PAMLICO SOUND
SUBMERGED AQUATIC VEGETATION MAPPING PROJECT
FE-88-03-PSMP

CDR BURL L. WESCOTT
COMMANDING OFFICER, NOAA SHIP FERREL

MARCH 13-25, 1988

This cruise was sponsored by National Marine Fisheries Service (NMFS) lab in Beaufort, North Carolina. The cruise report is divided into two sections: the first section consists of the Ship's Summary which is submitted by the vessels Commanding Officer. The second section consists of the Cruise results which are submitted by the Chief Scientist. The Ship's Summary addresses the operational considerations that are the responsibility of the ship; while the scientific aspects of the cruise are covered by the Chief Scientist in the Cruise Results. The Cruise Results also include statistics on the numbers of samples taken during the cruise, a list of the scientific personnel and visitors, a chartlet of the working grounds, and the Evaluation of the Ship's Effectiveness.

SCHEDULE

The FERREL departed Atlantic Marine Center on the morning of 13 March 1988, and transited to the working grounds via the Intracoastal Waterway (ICW) during the daylight hours. The actual staging of the project took place on 14 March 1988 while the ship was at anchor west of Roanoke Island, North Carolina. The scientific gear and scientific personnel were loaded onto the ship by use of the vessel's two launches and the two launches that the scientific party provided. The cruise itinerary consisted of two five day legs, with a port call made on the weekend at Wanchese, NC.

The work area was located in the area of Pamlico Sound from Croatan Sound in the north to Core Sound in the south. The order of the stations was chosen with weather conditions in mind. Samples and equipment were off-loaded upon arrival at Wanchese, NC on 23 March 1988.

Mar 13 - The ship departed AMC at 0700 L via the ICW and transited to the operating area due west of Roanoke Island, NC. The FERREL was anchored at 1645 L.

Mar 14 - The ship's launches rendezvoused with the scientific party in the morning and shuttled equipment and personnel back to the FERREL. The afternoon was spent planning operations, testing LORAN-C accuracy in the area and testing radar reflectors.

Mar 15 - Actual station work began. Both of the scientific launches and the Sea Ox were utilized to conduct station work in and around the Roanoke Island area. The FERREL weighed anchor in the morning and transited to Wanchese, NC where she remained for the night. A total of 15 stations were completed.

Mar 16 - Both of the ship's launches and one scientific launch got underway and completed station work in the area of Pea Island and Oregon Inlet, NC. The FERREL got underway at 1400L from Wanchese and transited through the late evening hours to an anchorage just north of Cedar Island, NC. A total of 19 stations were completed.

Mar 17 - All four launches got underway and completed station work in northern Core Sound while the ship moved to a new anchorage located in West Bay, NC. A total of 19 stations were completed.

Mar 18 - All four launches worked stations from Cedar Island to Ocracoke, NC. Due to unfavorable weather conditions in the Sound and the lack of unprotected water for anchoring the FERREL in the new operating waters; the FERREL weighed anchor in West Bay and steamed to Ocracoke Coast Guard Base where she was safely moored by 1700 L. A total of 22 stations were completed.

Mar 19 - Both of the FERREL's launches and one scientific launch were used in operations. Due to bad conditions in the Sound the Sea Ox was unable to complete all of her stations in the deep water, though the remaining two launches continued station work in the shallow water. The FERREL stayed alongside Ocracoke Coast Guard Base. A total of 14 stations were completed.

Mar 20 - Launch work continues on a northerly trek, towards Cape Hatteras using both scientific launches and the MonArk. The FERREL remained alongside Ocracoke Coast Guard Base. A total of 19 stations were completed.

Mar 21 - Three launches were utilized for station work. Stations were completed between Hatteras Inlet and Salvo, NC. The FERREL departed Ocracoke and transited to Wanchese during the day. A total of 16 stations were completed.

Mar 22 - The small boats continued station work between Avon and Rodanthe, NC, while the FERREL remained inport at Wanchese. A total of 24 stations were completed.

Mar 23 - The small boats occupied the remaining stations around the Roanoke Island environs while the FERREL remained alongside. A total of 19 stations were completed on this last day of station work.

Mar 24 - The ship departed Wanchese, NC at 1100 L and began her transit back to AMC via the ICW. The ship arrived at Coinjock Coast Guard Base at 1730 L where she was moored for the night.

Mar 25 - The FERREL departed Coinjock at 0600 L and arrived at AMC at 1300 L.

OPERATIONS

The broad objective of the Albemarle-Pamlico Estuarine Study (APES) was to assess the current status and trends in the environmental characteristics and habitats within the APES complex. The objective of the APES Submerged Aquatic Vegetation (SAV) project is the develop a cartographic product detailing the distribution, shape, and species composition of SAV in the area from Currituck Sound to Cape Lookout, NC, and to estimate the acreage of SAV within the study area based on aerial photography, photographic interpretation, and ground truth analyses.

The NMFS cruise consisted of conducting specific tasks at a predetermined number of stations which were selected by the Chief Scientist prior to the beginning of the cruise. All stations were located between Croatan Sound in the northern part of Pamlico Sound and Core Sound in the southern section of Pamlico Sound, in water than was no deeper than ten feet. The tasks carried out at each station were inclusive of a thorough bottom survey for possible seagrass; if seagrass was seen a sample was taken in addition to a bottom sample. Various parameters were also recorded at each station, i.e. seawater temperature, air temperature, and salinity. A total of 219 stations were originally planned, of these 57 were dropped due to inaccessibility by the launches. The ship's activities are summarized below in Table I:

TABLE I
Ship's Accomplishments

Days at Sea	13
Days of Production	13
Seagrass Samples	111
Bottom Samples	164
Meteorological Observations	36
Public Relations Days	2

All station work was accomplished using launches. The maximum depth that these operations took place in was ten feet. Each launch transited to the station whereupon the anchor was let-go. Once it was determined that the anchor was not dragging, operations began. One of the scientists went over-the-side and began looking for seagrass beds. If any were found at that site a core was taken. This sample was then placed in a mesh bag and was washed thoroughly with water. What remained in the bag was the seagrass sample. Once the seagrass sample was obtained a sediment sample was taken. While one scientist was doing this the other scientist was obtaining the other required parameters, sea water temperature, air temperature, salinity, etc..

This method worked well in water that was four feet or less. In deeper water obtaining these samples required both scientists in SCUBA gear.

All samples obtained were taken back to the FERREL where they were frozen and stored for further analysis that was to take place at the lab.

NAVIGATION

LORAN-C was the primary method of navigation for the project. LORAN coverage in the project area is complete and was strong throughout the cruise.

WEATHER

For the most part the weather was very cooperative during this project. On the days when the deeper stations were too rough to sample at, the launches with the shallow drafts worked stations in the shallow water. No days were lost to weather.

SCIENTIFIC CREW

Most members of the scientific party had sailed on other NOAA vessels or had been at sea on another type or research vessel. The scientific party came well prepared and ready to work. They worked quickly, efficiently, and adapted well to the ship's routine, becoming an integral part of the work force.

Members of the scientific complement were always conscious of and contributed to the overall safety of the ship's operations.

A complete list of all scientific personnel and their affiliation will be included in the Chief Scientist's Cruise Results.

PUBLIC AFFAIRS

On our transit to the working grounds, Mr. Ford Reid, a reporter from the "Virginian-Pilot and the Ledger-Star" accompanied the ship and observed onboard operations for two days. From that experience he wrote the enclosed article, "Vital sea grasses lure scientists to North Carolina Sounds" which was published on Sunday, March 20, 1988 in the paper.

There were no official Open House planned for this cruise, though ship's personnel did give some tours to the public while the vessel was tied alongside Ocracoke Coast Guard Base.

Attachments:

1. Cruise Results
2. List of ship's personnel
3. Copy of newspaper article

Susan D. McKay
Susan D McKay, LT
LT, NOAA
Operations Officer

Burl L. Wescott
Burl L Wescott
CDR, NOAA
Commanding Officer

ATTACHMENT I

FINAL CRUISE REPORT

Jise Title: NMFS Albemarle-Pamlico Sound Submerged Aquatic Vegetation Mapping Project (Beaufort Laboratory, SEFC)

Period of Cruise: March 14-24, 1988

Area of Operation: Northern extremes of Roanoke and Croatan Sound to Core Sound (Drum Inlet) including the eastern shore of Pamlico Sound

Scientific Objectives:

The broad objective of the Albemarle-Pamlico Estuarine Study (APES) is to assess the current status and trends in the environmental characteristics and habitats within the APES complex. The objective of the APES Submerged Aquatic Vegetation (SAV) project is to develop a cartographic product detailing the distribution, shape, and species composition of SAV in the area from Currituck Sound to Cape Lookout, N.C., and to estimate the acreage of SAV within the study area based on aerial photography, photographic interpretation, and ground truth analyses. The specific objectives of the cruise were as follows:

a) Collect SAV core samples at selected locations on the eastern and western shores of Croatan Sound, throughout Roanoke Sound and in the shallow water habitat (less than 2.5 m) of eastern Pamlico Sound from Roanoke Island to Drum Inlet (Core Sound).

b) To examine samples for species composition and store under refrigerated or frozen conditions aboard NOAA Ship FERREL for transport to Beaufort Laboratory.

c) Collect ancillary environmental data at each station pertinent to SAV growth and distribution, e.g., light penetration, water depth, temperature, salinity, etc.

d) Accurately georeference location of each sampling station by use of Loran C units.

e) Collect sediment samples at SAV sampling sites for analysis by Beaufort SAV mapping project or cooperating APES investigators.

Methods

Stations were initially located by overlay of a dot matrix upon a nautical chart and designating stations as points where a dot occurred at a water depth of less than 10 feet. Stations were separated by approximately 1.3 nautical miles. Stations were located by latitude and longitude from the navigational chart and located by Loran C in the field. Station locations were recorded in terms of both latitude and longtitude and time dalays. All stations were visited by launch and samples were collected by personnel in the water, either wading or diving dependent on water depth. Launches included the FERREL's Sea Ox and Monarch and the Beaufort Laboratory's Mako and Alumacraft. Samples of SAV were collected by coring tube if possible or with shovels or "hand grabs" if necessary. We measured water depth and obtained ancillary water temperature, secci depth, and salinity data and collected surface sediment samples for all these stations. The general biological and physical nature of the station was observed and recorded.

Results

We occupied 170 stations between Drum Inlet (Core Sound) and the northern extremes of Roanoke and Croatan Sound. Six of these stations were not sampled because water depth exceeded 10 ft. Of the remaining 164 stations, 113 were vegetated and sampled for SAV. During the cruise we documented the previously unreported northern extreme of *Halodule wrightii* near Oregon Inlet and collected SAV at a maximum water depth of 2.5 m. Generally, SAV was restricted to water depths of 2m or less. The marine species of SAV we observed were *Zostera marina*, *Halodule wrightii* and *Ruppia maritima*.

Scientific Personnel List:

Chief Scientist	Randolph L. Ferguson	Fishery Biologist (Res)
	Beth Ann France	Biological Technician
	Michael W. LaCroix	Biological Technician
	Patti J. Marraro	Fishery Biologist
	Jose Rivera	NOAA Corp. Officer (Lt).
	Lisa Wood	Biological Technician
Alternates	Don McIvor	Biological Technician
	Allyn Powell	Fishery Biologist

Disposition of Samples

The 113 SAV samples and 164 sediment samples were frozen and transferred to the Beaufort Laboratory for storage and analysis.

Stations and Sites

See above

Types of Samples

See above

SHIP OPERATION'S EVALUATION REPORT

NOAA SHIP FERREL CRUISE/LEG Albemarle-Pamlico Sound

INCLUSIVE DATES March 14-24, 1988 CHIEF SCIENTIST Randolph L. Ferguson

ORGANIZATION National Marine Fisheries Service NUMBER IN PROJECT First

SEA DAYS 9

PRIMARY PROJECT (x) ANCILLARY PROJECT ( ) COOPERATIVE PROJECT ( ) PIGGYBACK PROJECT ( ) REIMBURSABLE ( )

PROJECT OBJECTIVE: Accomplish ground truth sampling for aerial photographic mission. Project will chart distribution of submerged aquatic vegetation along the inside of the outer banks from Cape Lookout to northern Roanoke Island, North Carolina.

EVALUATION OF SHIP EFFECTIVENESS

FACTORS	EXCEEDED	MET	PARTIALLY MET	NOT MET
	OBJECTIVES (Check for each Factor)			
PERSONNEL PERFORMANCE		x		
EQUIPMENT PERFORMANCE		x		
DATA QUANTITY		x		
OVERALL RATING		x		

Days Weather Adversely Affected Productivity: (x) Partially ( ) Totally

If the performance exceeded, partially achieved, or did not at all meet anticipated objectives, please explain how objectives were exceeded or why you feel that performance did not fully meet your expectations and/or what improvements would be required to meet your objectives. Also briefly describe the effects of weather on the cruise. (Continue on reverse if necessary.)

All objectives both primary and secondary were met in the face of consistently adverse weather conditions. The ship and crew were extremely helpful and did what was necessary for us to complete our mission 1 day ahead of schedule. I particularly (over)

PRODUCTIVITY GAINS DUE TO EARLY COMPLETION OF PLANNED ACTIVITIES

If planned activities are completed ahead of schedule, indicate number of days at sea gained and the use of these days for each category. (Specify additional tasks or activities.)

DAYS GAINED

___ ADDITIONAL TASKS

___ ADDITIONAL ANCILLARY TASKS

___ ADDITIONAL FIELD QUALITY CONTROL ACTIVITIES

1 SAVED DUE TO EARLY RETURN TO PORT

60

ATTACHMENT II

Attachment 2

NOAA Ship FERREL

List of Ship's Personnel

Commissioned Officers:	CDR Burl L. Wescott	Commanding Officer
	LCDR Ted I. Lillestolen	Executive Officer
	LT Susan D. McKay	Operations Officer
	LT Svetlana Andreeva	Augmentation Officer
	LTJG Steven A. Thompson	Fourth Officer
Licensed Officers:	CME George A. Chadwick	
	AE Charles E. Karlsson	
Chiefs:	SDC Teodoro D. Balbin	
	YNC Abraham B. Baltazar	
	BMC David L. Brannon	
	STC William C. Smith	
Crew:	FN Henry T. Gillikin	
	BGL Robert T. Linton	
	SS Gordan R. Pringle	
	SS Carlyle D. Lewis	
	2CK Dennis L. Moore	

ATTACHMENT III

B8 THE VIRGINIAN-PILOT AND THE LEDGER-STAR SUNDAY, MARCH 20 1988 SM

Vital sea grasses lure scientists to North Carolina sounds

By Ford Reid
Staff writer

ABOARD THE FERREL — Just after daybreak on a dank Sunday morning, the research ship cast off from the National Oceanic and Atmospheric Administration's Norfolk piers, pulled into the Elizabeth River and turned left.

It was a maneuver applauded by the crew, a group of 16 seasoned seamen who knew the course led to the Intracoastal Waterway, not to the Atlantic Ocean.

The Ferrel, one of 11 ships in NOAA's Atlantic fleet of research vessels, sees its share of open water, but this time it was heading for the protected North Carolina sounds to aid in a project aimed at securing a future for important beds of sea grass.

The 133-foot ship's most recent assignment took it as far as 60 miles offshore, where it dragged nets to capture specimens for a Virginia Institute of Marine Science study.

The winter seas roar and rush out there, unmercifully tumbling and tossing a shallow-draft hull such as the Ferrel's.

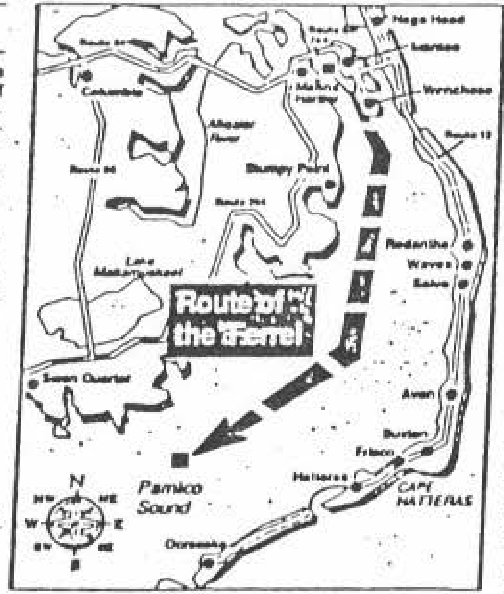
"We joke about asking them to issue us neck braces," said Cmdr. Burl Wescott, the Ferrel's skipper. "The ship really snaps in a sea."

Not that the ship and its crew are strangers to the fits of anger served up by the sea. The ship works the Atlantic and Gulf coasts from Maine to Texas, providing ample opportunity to see the water at its best and worst.

In 1986, the crew was looking forward to an uneventful cruise through the Straits of Florida and north along the coast when Hurricane Floyd began to kick up its heels south of Cuba.

"We pushed to the limit," Wescott said, "and got into Miami just in time."

The protected waters of the waterway, or ICW, promised a more relaxed, if less exciting, voyage. By Sunday evening, after a day of negotiating the narrow channels of the waterway's cuts and lowering the mast to slip under a 45-foot fixed bridge, the ship was anchored in Croatan Sound, nestled between Roanoke Island and the Dare County mainland.



Staff map

For the next two weeks, the Ferrel would be home and office to six scientists from NOAA's National Marine Fisheries laboratory as they studied sea grasses in Croatan and Pamlico sounds. As the work progresses, the ship moves south, its task scheduled for completion Friday from a mooring off Ocracoke.

The scientists, with the help of the Ferrel's crew, are visiting sea grass beds identified through aerial photography to "ground-truth" the pictures and collect samples.

The photographs show large patches. "We have to check that they are sea grass," said Randy Ferguson, one of the principal scientists on the project, "and not oyster beds."

The study, part of the Environmental Protection Agency's National Estuaries Program, is being paid for through a federal grant to the state of North Carolina.

"Sea grasses provide a valuable nursery area," said Don Hoss, chief of the Beaufort lab's ecology division. "The object of the project is to determine the condition of the beds now and to find any pollution problems."

Sea grasses, such as eel grass, provide protective cover for the young of many sea creatures. Tiny fish hide from predators there and scallops settle in to spend their lives. Blue crabs seek the beds when they are ready to shed, looking for a safe place to spend the hours of vulnerability when their shells are as soft as warm chocolate.

But these vital nurseries have been disappearing from estuaries at an alarming rate. In the Chesapeake Bay, Long Island Sound and Tampa Bay, the situation is critical. The Pamlico Sound, with far less shore-side development than those waters, apparently has suffered much less.

Marine scientists have estimated that the "crop" of shellfish and finfish produced and nurtured on an acre of sea grass is worth $10,000 a year. The scientists would like nothing better than to prevent major problems in North Carolina.

"One thing the study aims to find is the best way to manage the area," Hoss said.

That takes data. Reams of numbers and thousands of observations. One problem with collecting information from a large body of water is knowing exactly where you are, or have been, at a particular time.

Enter the Ferrel.

The ship, built in the 1960s as an offshore oil rig supply boat and later refitted for adaptation to NOAA work, was used until early in this decade in studie tides and currents. Then, with the addition of on bo laboratories for the scientists, it was assigned to " tus and trends" work, gathering information from sea and the things that live in it.

The ship has lab space and equipment that all investigators to do some of their initial studies board. But it is perhaps the navigational equipm that most aids the researchers.

On the ship's bridge are all the marvels of mod navigation, including two radars and two state-of-t art Loran units. By measuring the difference in ti between radio signals from two or more stations, l rans can tell the receiver precisely where he is, how he is from another location and what course he sho steer to get there. The radar can also be used to p point locations of objects.

But even though the Ferrel draws only about 6 f of water, a very shallow draft for such a large vess the ship and its sophisticated equipment cannot proach the shoal water where much of the resear measurements and observations must be taken.

Enter the Ferrel's small boats.

Lashed to the ship's deck are two open outboa boats, craft that can go almost any place where the is enough water to support marine life. But boats su as those — a 19-footer and a 23-footer — are not signed for fancy electronic equipment.

Technicians at NOAA's Atlantic Marine Center Norfolk took care of that by designing and building small, waterproof box that holds a Loran C, a VH radio and speaker and a digital depth finder. Take t top off the box, screw on an antenna for the radio a one for the Loran, attach a power cord with alligat clips to the boat's electrical system and the small bo is ready to advance science.

"Terrific!" Ferguson said as he watched a demo stration of the portable Loran.

"As part of an ongoing National Marine Fisheri study this will help us understand what is happening the estuaries," Hoss said. "That is important."

Appendix B Current status and ecological importance of seagrass beds in Core, Back and Western Bogue Sounds, North Carolina. (A report drafted in support of their nominations by the State of North Carolina as outstanding resource waters.

CURRENT STATUS AND ECOLOGICAL IMPORTANCE OF SEAGRASS BEDS IN CORE, BACK AND WESTERN BOGUE SOUNDS, NORTH CAROLINA

Dr. Randolph L. Ferguson
National Marine Fisheries Service, NOAA
Beaufort Laboratory
Beaufort, N.C. 28516

I. DISTRIBUTION AND ABUNDANCE

Seagrasses, marine species of submerged aquatic vascular plants (SAV), form underwater meadows that are prominent features of Core, Back and Bogue Sounds. Three seagrasses occur in these sounds: the temperate species Zostera marina (eelgrass), the subtropical species Halodule wrightii (shoalgrass), and Ruppia maritima (widgeon grass) which also is found in freshwater. The co-occurrence of these three species, unique to North Carolina, provides fishery habitat throughout most of the year and maximizes the degree of coverage of shallow bottoms of the sounds. We estimate that the total area of beds of SAV in Core, Back and Bogue Sounds is 30,000 to 40,000 acres. NMFS Beaufort laboratory commissioned aerial photography of Bogue Sound and Core Sound from Cape Lookout to Drum Inlet in March, 1985 and under APES funding for the entire Core sound in April 1988. Both the 1985 and 1988 photography are far superior to the previously available photography. We have completed quantification of the 1985 photography from Cape Lookout to Drum Inlet under contract to APES (see attached manuscript "Seagrasses in southern Core Sound, North Carolina" by Ferguson, Rivera and Wood). Our measurement of the extent of SAV beds in that section of Core Sound was 11,709 acres compared to 5,206 for that area based on 1981 photography. We observed a number of previously unrecorded beds and noted a larger size for many beds, particular in deeper waters (3-6 ft MLW) of the Sound. Preliminary examination of the 1985 photography for Bogue and Back Sounds suggests that this photography will produce increased estimates for SAV in these sounds as well. The 1988 photography confirms this trend throughout Core Sound.

Seagrasses are particularly abundant throughout Core Sound, Back Sound and in Western Bogue Sound. The most comprehensive previous study of the location and extent of SAV in Core, Back and Bogue Sounds is that of Carraway and Priddy, 1983, (CEIP REPORT NO. 20). Their total area of SAV beds in these sounds and based on N.C. Dept of Transportation photographs in 1981 was 16,901 acres. Calculated from their data the percent distribution of SAV beds is: 12% for western Bogue Sound (from Bogue Inlet to a line running from east of Gales Creek to Rock Point), 13% for Back Sound (east and south of a line from Shackleford Jetty to the north end of Middle Marsh to the southeastern corner of Harkers Island and running along the south shore of that island to Lighthouse Channel), and 70% for Core Sound (from Lighthouse Channel to a line between Camp Point and Core Banks.

II. FUNCTIONAL VALUE

About 90% of the North Carolina commercial landings are composed of estuarine dependent species. Beds of SAV in Core and Bogue Sounds provide prime habitat in terms of food and cover and outstanding water quality for a great variety of estuarine-dependent commercially and recreationally important fauna and their prey. The most productive shallow water habitats for marine species are those with salinity greater than 8 ppt such as Bogue and Core Sounds. Larval and juvenile fish and shellfish including spotted seatrout, mullet, spot, pinfish, pigfish, gag grouper, white grunt, silver perch, summer and southern flounder, pink and brown shrimp, bluecrabs, hard shell clams and bay scallops utilize beds of SAV as nurseries. Beds of SAV are also frequented by adult spot, spotted seatrout, summer and southern flounder, pink and brown shrimp, hard shell clams, and blue crab, and are the primary habitat of the bay scallop. Birds feeding in SAV beds include egrets, herons, sandpipers, terns, gulls, swan, geese, ducks, and osprey.

Beds of SAV actually enhance water quality by reducing turbidity and at the same time reduce sediment movement into natural and artifically maintained waterways. The leaf canopy calms the water, filters suspended matter and, together with an extensive root and rhizome mat, stabilizes sediment.

III. RELATIVE VALUE

North Carolina may be second only to Florida in abundance of SAV. Precise measurement of total SAV area in coastal marine waters of North Carolina has not been completed. Based on aerial reconnaissance in a small plane conducted in December, 1987, we estimate a total area of marine SAV of approximately 200,000 acres. About 20% of this total occurs within Bogue, Back and Core Sounds.

Bogue, Back and Core Sounds are unique, being relatively narrow, polyhaline (18-30 ppt), coastal lagoons. Bay scallops occur only in seagrass beds south of Ocracoke Inlet, and thus, virtually are restricted to beds of SAV in Bogue, Back and Core Sounds. Economically valuable shellfish generally are restricted to medium and higher salinity areas such as occur in Bogue, Back and Core Sounds. The unusual morphological and salinity regimes of Bogue and Core Sounds brings together seagrass meadows and shallow (less than 3 ft), saline (greater than 8 ppt) muddy creeks. The close proximity of these prime nursery areas for inshore warm weather spawners and offshore cold weather spawners benefits both resident marine life and local fishermen.

The value of fish and shellfish harvested from these areas is enhanced by the exceptional water quality which results, for example, in the harvest of notably unpolluted shellfish. Middle Marsh and Back Sound, for example, are among the highest water quality areas in the state in terms of the fecal contamination index. For ten years our laboratory has used oysters and blue crabs from Middle Marsh and Back Sound as baseline controls in the study of metal pollution (copper, zinc and cadmium) in coastal waters of the United States. We also have supplied animals from the same area to other laboratories concerned with obtaining baseline controls for other pollutants such as petroleum hydrocarbons.

IV. KNOWN THREATS

Seagrasses in Bogue, Back and Core Sounds are thriving but are in jeopardy at the present time. Factors that stress seagrass reduce its productivity and restrict the depth range over which it can survive. Dredge and fill operations can remove or bury SAV and raise or lower bottoms out of the depth range suitable for SAV. Such operations also can result in current patterns or salinity distributions detrimental to SAV. SAV can be uprooted during commercial harvest of fish and shellfish or scarred by the propellers of boats. Such scarring can be visible for years.

Disruption of natural watersheds by development of coastal lands can displace the enrichment of estuaries by water runoff from low-lying coastal forests and wetlands with the contamination of estuaries by polluted, uncontrolled storm water runoff from urban developments. Organic and inorganic pollutants from point and nonpoint sources can inhibit the survival of SAV and stimulate the growth of less desirable species.

All of the above activities which resuspend bottom sediments or introduce particulate matter from terrestrial sources will inhibit SAV by reducing light necessary for survival of SAV. SAV can not inhabit bottoms receiving insufficient light. In turbid waters SAV will occur only in very shallow water where it is vulnerable to stress resulting from exposure during low tides. Even boat wakes, given sufficient size, speed, and number of passing boats, can significantly inhibit SAV due to increases in the degree and persistence of turbidity. At the present time, our laboratory is working cooperatively with the U.S. Fish and Wildlife Service and the State of Florida to determine the impact on SAV of turbidity caused by heavy boat traffic in the ICWW in Hobe Sound, Florida.

In summary, North Carolina possesses a rich resource in its seagrass beds of Core, Back and Western Bogue Sounds, which undoubtedly contributes significantly to the high fisheries productivity in these sounds. The State of North Carolina now has an opportunity to learn from the lessons of the northeastern states. Inappropriate development and use of coastal lands and waters results in a degradation of water quality, loss of fisheries habitat (such as SAV in Chesapeake Bay) and a resultant reduction in the quality and abundance of our renewable marine resources, fish and shellfish. It is essential that we preserve the present high water quality, abundant SAV and diverse fishery resources of Core, Back and Western Bogue Sounds.