A Survey of the Benthic Macrofauna of Fripp Inlet and Hunting Island, South Carolina, Prior to Beach Nourishment

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A SURVEY OF THE BENTHIC MACROFAUNA OF FRIPP INLET AND HUNTING ISLAND, SOUTH CAROLINA, PRIOR TO BEACH NOURISHMENT[1]

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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INTRODUCTION

Hunting Island lies along the coast of South Carolina between Fripp Inlet and St. Helena Sound (Figure 1). This sea island is about 6.5 km long with an average width of 1400 m, and it has an extensive sand beach fronting on the Atlantic Ocean. An extensive network of tidal streams, mudflats, and large expanses of saltmarsh, composed predominantly of smooth cordgrass, *Spartina alterniflora*, borders the island on the west.

Shoreline erosion along Hunting Island Beach State Park has been a severe problem for many years. Prior to 1968, erosion at the northern end of this island averaged 7.5 m/year, and the average rate for the entire ocean front was 3.1 m/year. Beach property and wooded highlands were being lost rapidly.

In 1968 a joint State-Federal project to curb this erosion problem was implemented through periodic beach nourishment and establishment of a 700-foot (213-m) terminal groin at the northern end of the island. A borrow area (Figure 1) behind Hunting Island Beach was selected as a source of beach nourishment material. This area has been used twice since 1968 for pumping sand to the front beach.

During 1973 the Division of Marine Resources of the South Carolina Wildlife and Marine Resources Department was informed by the Charleston District, U. S. Army Corps of Engineers that several alternative plans for the nourishment of Hunting Island Beach were being considered. One of these plans would involve removal of sand from the mouth of Fripp Inlet (Thurman Morgan, personal communication); another would be to use an offshore borrow area as a source of nourishment material. Before implementing either plan, an environmental evaluation was needed to investigate the possible ecological effects of the proposed alternatives.

The present study was initiated on 29 June 1973 by the Division of

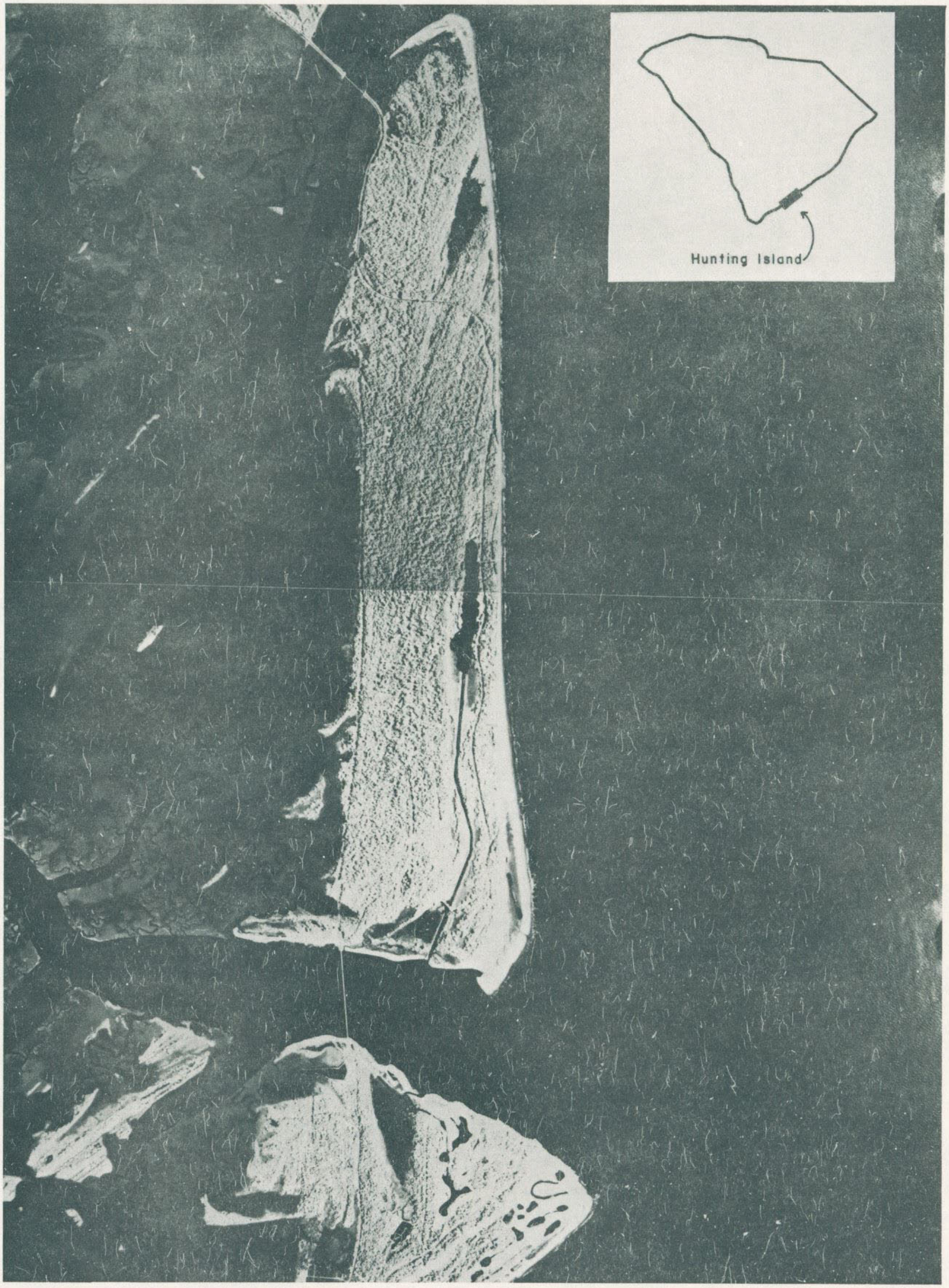

Figure 1. Aerial photograph (black and white IR) of Fripp Inlet and lower extent of Hunting Island, 1971. Inset locates Hunting Island in the southern region of the South Carolina coastal zone. This photograph was taken on high tide, and therefore, sandbars and other bottom features are not readily visible. (National Ocean Survey Photo).

Marine Resources, South Carolina Wildlife and Marine Resources Department, in cooperation with the U. S. Army Corps of Engineers. The primary objectives of this study were to:

(1) collect and evaluate benthic samples from selected stations at the mouth of Fripp Inlet, just offshore from Hunting Island, and in the intertidal area along Hunting Island Beach;

(2) conduct low-altitude aerial surveys of the Fripp Inlet estuary and adjacent areas with infrared photography to indicate sand dispersion patterns in the Inlet and along Hunting Island Beach; and

(3) estimate, using all available information, the potential environmental effects of obtaining borrow material from each of the following alternate areas not sampled in this study: (a) the inland borrow area on Hunting Island, (b) sandbars and shoals near the mouth and just inside of Johnson Creek, (c) Harbor River about 1200 m (4000 feet) from South Carolina Highway 21 bridge.

These objectives were considered to be most significant in evaluating the general environmental condition of the study area and in providing base line information which could be used in the future determination of ecological effects of the proposed beach nourishment project. The present project was a short-range study designed to meet the specific needs outlined, and was not intended to be a general or comprehensive environmental impact study of the Hunting Island-Fripp Inlet area.

METHODS AND MATERIALS

Benthic communities in and around possible sand acquisition sites and along the Hunting Island beach zone were sampled during July 1973.

Two replicate, quantitative bottom samples were collected at each of six stations located at 0.5-km (0.3-mile) intervals for a distance of 3.2 km in Fripp Inlet on a transect from latitude 32° 19.2' N, longitude 80° 25.9' W offshore to latitude 32° 20.3' N, longitude 80° 26.6' W inland near the bridge over Fripp Inlet (Figure 2).

Two bottom sample replicates were also collected at each of six stations for a distance of 2.6 km across the alternate sand acquisition site off Hunting Island. Stations were occupied by the R/V Two Angels at 0.5-km (0.3-mile) intervals from 3.0 km (1.8 miles) offshore, latitude 32° 21.5' N and longitude 80° 26.0' W, to latitude 32° 22.0' N and longitude 80° 26.0' W, immediately seaward of the Hunting Island Beach surf zone (Figure 2).

These transects were selected to provide reasonable coverage for both possible sand borrow areas, as well as covering adjacent areas, which may serve as control sites for future evaluations of borrow areas after beach nourishment has taken place.

In addition, two replicate, quantitative, bottom samples were collected at each of six stations on the shore along the intertidal beach zone of Hunting Island (Figure 2). Samples were collected near the low water mark at 1-km (3500-foot) intervals, along a transect from the upper extent of nourishment at the mouth of Johnson Creek, to the southernmost extent of the beach on Fripp Inlet.

All samples from the cruise transects were collected with a weighted Petersen dredge. This dredge had a volume of 10.5 liters, a bite covering 0.13 m^2 of bottom area, and, with 18 kg of added weight, a total weight in air of 52 kg. Substrate samples having volumes equivalent to those of the

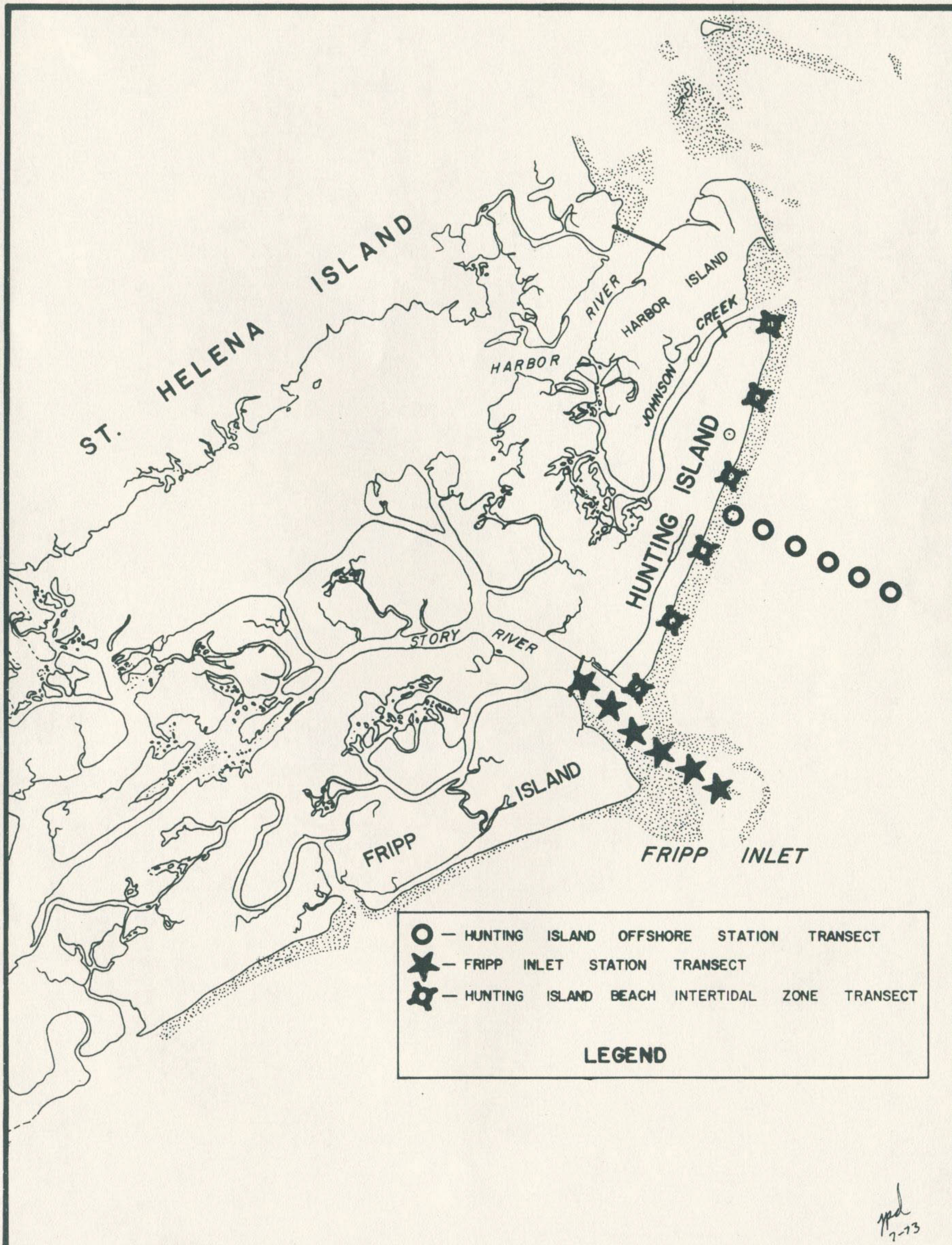

Figure 2. Map of Fripp Inlet-Hunting Island study area, showing benthic sampling stations, lengthy sand beach fronting on the Atlantic Ocean and an extensive estuarine complex to the west, made up of networks of tidal streams, mudflats, and large expanses of saltmarsh.

Petersen dredge were collected by hand along the beach at the Hunting Island intertidal zone stations.

Bottom samples were immediately washed through two standard benthic sieves in series with mesh aperture dimensions of 2.00 mm and 1.00 mm, and nominal wire diameters of 0.900 and 0.580 mm, respectively. These meshes correspond to U. S. Standard Series Sieve Numbers 10 and 18, respectively, and meet all specifications set forth by the National Bureau of Standards Organization (W. S. Tyler, Inc., 1972).[1] These mesh sizes were selected after considering the U. S. Army Corps of Engineers' request that the study be limited to an evaluation of macrobenthos.

After sieving, all species of benthic organisms were preserved in 10% formalin with Rose Bengal stain and returned to the laboratory for identification and enumeration.

Van Dorn bottles (six-liter capacity) were used to obtain water samples at the most seaward and landward stations during ebb tide on both the offshore and Fripp Inlet cruise transects. Samples were collected 1 m below the water surface and 0.3 m above the bottom at each station. All water samples were returned to the laboratory the same day as collected for analysis. Concentrations of dissolved oxygen, nitrates, phosphates, silicates, and suspended and settleable solids, as well as, salinity, pH, and turbidity were determined for all water samples. In addition, water temperatures were taken on station by stem thermometers internally mounted in the Van Dorn bottles. Dissolved oxygen and turbidity samples were fixed immediately upon collection. Dissolved oxygen was analyzed by modified Winkler titration, salinity by Beckman RS7B Induction Salinometer, pH by Corning Model 10 pH Meter, turbidity

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[1]Reference to trade names in this paper does not imply endorsement by the U. S. Army Corps of Engineers, the Coastal Plains Regional Commission, or the State of South Carolina.

by Hach Model 2100A Turbidimeter, total suspended solids by American Public Health Association (APHA) Standard Method 224C (APHA, 1971), settleable solids by Standard Method 224F (APHA, 1971), and remaining chemical characteristics by Technicon AutoAnalyzer II.

On 25 July 1973 low-altitude flights were made over the Fripp Inlet-Hunting Island area (Figure 3) for the purpose of taking vertical format false-color infrared photographs at scales of 1:3000 and 1:6000 to study submersed sand dispersion patterns. A Cessna 172 aircraft was employed, utilizing a pod-mounted Fairchild "K-17" camera converted to a "T-2" configuration through the addition of a 6-inch focal length Planagon lens. Kodak Aerochrome infrared (2443) film was utilized. Flights were made during lower tidal stages between 1000 and 1400 hrs., EDT. Complete coverage of Hunting Island, Fripp Inlet, Old House Creek, Story River, and their tributary streams and adjacent marshlands was accomplished.

Color diapositives from the flights were indexed and interpreted by the Environmental Evaluation Section, Office of Conservation and Management, Division of Marine Resources. These photographs were then compared with others of the area taken in 1971 by the U. S. Army Corps of Engineers to determine recent patterns of sand dispersion in the estuary. These methods are similar to those used previously by Reimold, Gallagher, and Thompson (1972) and Wobber and Anderson (1972).

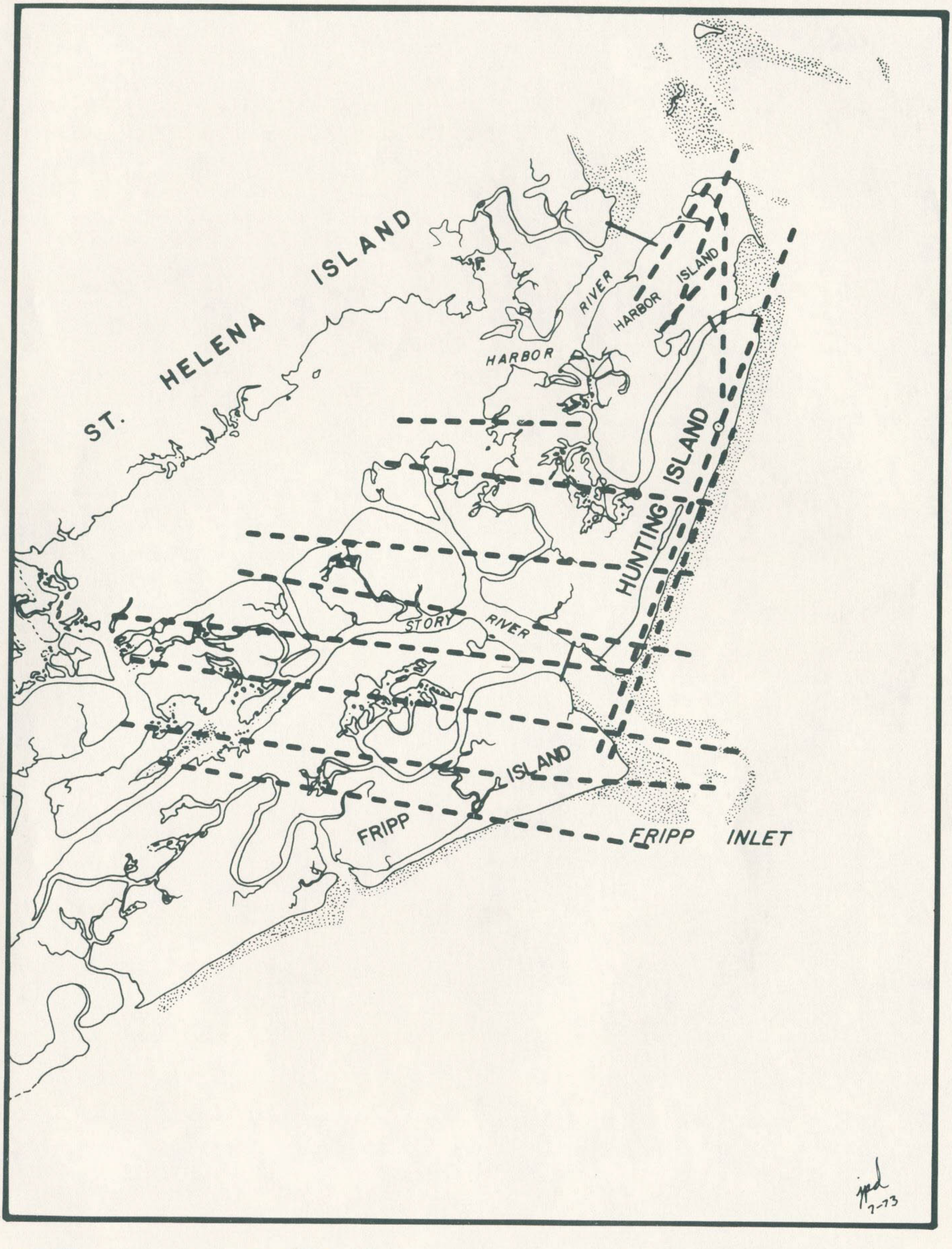

Figure 3. Low-altitude flight lines traversed at low tide for vertical format false-color infrared photography of Fripp Inlet-Hunting Island study area. This technique was utilized to record submersed sand dispersion patterns.

RESULTS AND CONCLUSIONS

Benthic Macrofauna

Each dredge sample was recorded along with water depth, volume of dredge bite, and general bottom type (Table 1).

Macrobenthic organisms and their densities at each of the three areas (Fripp Inlet, offshore, and intertidal beach zone) are summarized in Tables 2 through 4. Species composition, abundance, and diversity of benthic organisms in the three areas varied considerably, as did bottom type.

Samples from the intertidal zone along the front beach of Hunting Island (Table 2) were composed primarily of sand and shell and were dominated by three groups of organisms -- pelecypods, polychaetes, and amphipods. Coquina (*Donax variabilis*) was the most abundant benthic organism encountered at all intertidal beach stations, followed by amphipods and the polychaete *Glycera* sp. *D. variabilis* accounted for 80% of the total fauna collected in the intertidal area. Densities for this species ranged from a low of 39 organisms/m^2 of bottom sediment to a high of 474/m^2 of substrate. The polychaete *Glycera* sp. made up 2% of the intertidal fauna, with densities ranging from 0 to 23/m^2 of substrate. Other forms found along the beach zone in less abundance included tube worms, hermit crabs, isopods, and moon snails. These combined groups represented only 3% of the total intertidal fauna. The mole crab (*Emerita talpoida*), a common inhabitant of many Carolina beaches (Pearse, Humm, and Wharton, 1942) was conspicuously absent in our samples.

Samples from the offshore cruise transect were composed primarily of sand and mixed sand and shell (Table 1). Offshore benthic samples contained 50 identified species (Table 3), a much greater diversity than found in either of the other transects. Of these 50 species, four groups were most abundant. Amphipods comprised 39%, unidentified worms 17%, *Tellina* sp. 13%, and the isopod *Apanthura magnifica* 8% of the total number of animals collected.

Table 1. Station depths, Petersen dredge volumes, and bottom types found at each of the three sampling transects during the study.

Station	Station Depth (meters)	Grab Volume (liters)*	Bottom Type
Beach Nourishment Transect:			
1	Low tide mark	21	Large shell
2	Low tide mark	21	Large shell
3	Low tide mark	21	
4	Low tide mark	21	
5	Low tide mark	21	Fine Sand
6	Low tide mark	21	Large shell & sand
Offshore Cruise Transect:			
1	4.0	13.0	Sand
2	4.0	14.0	Sand
3	3.0	5.0	Sand
4	4.0	8.0	Sand
5	4.0	7.0	Sand
6	4.6	14.0	Coarse Shell & Sand
Fripp Inlet Cruise Transect:			
1	8.5	9.5	Broken shell & sand
2	6.8	14.0	Broken shell & sand
3	7.0	17.0	Sand & med. sized shell
4	8.1	9.0	Fine sand & shell
5	6.1	8.0	Sand
6	4.0	13.0	Very fine sand

* Volume equals total of two sample replicates combined.

Table 2. Macrobenthic species and their densities (numbers/m^2 of substrate) at six sampling stations along the intertidal beach transect. Values expressed are mean population densities based on two replicate samples at each station.

Identification	Population Densities (Number of organisms/m^2) By Station					
	1	2	3	4	5	6
FORAMINIFERA						
PORIFERA						
CNIDARIA						
Renilla reniformis						
PLATYHELMINTHES						
NEMERTINA	4				8	
NEMATODA						
BRYOZOA						
MOLLUSCA						
Gastropoda						
Bulla sp.						
Nassarius trivittatus						
Natica pusilla						
Olivella mutica						
Polinices duplicatus	4					
Terebra dislocata						
Terebra protexta						
Pryamidella crenulata						
Pelecypoda						
Brachidontes sp.						
Cardium sp.						
Donax variabilis	154	39	458	474	424	470
Ensis directus						
Mercenaria sp.						
Mulinia lateralis						
Nucula sp.						
Tellina sp.						
Unidentified						
SIPUNCULIDA						
OLIGOCHAETA						
POLYCHAETA						
Glycera sp.	12		23	8	4	8
Nereis sp.						
Sabellaria vulgaris						
Unidentified		4	8	54		
Diopatra cuprea						

Table 2. (Continued).

Identification	Population Densities (Number of organisms/m^2) By Station					
	1	2	3	4	5	6
CRUSTACEA						
Ostracoda						4
Copepoda						
Cirripedia						
Balanus sp.						
Balanus amphitrite						
Unidentified						
Mysidacea						
Bowmaniella dissimilis						
Neomysis americana						
Cumacea					4	
Amphipoda						
Acanthohaustorius millsi	35	120	38	8	8	8
Parahaustorius longimeris		150	8			8
Protohaustorius deichmannae	8					
Isopoda						
Ancinus depressus						
Apanthura magnifica						
Chiridotea caeca		4				
Chiridotea stenops						
Unidentified						
Decapoda						
Crab						
Portunus gibbesii						
Portunus sayi					4	
Pagurus longicarpus						
Emerita talpoida						
Pinnixa sayana						
P. chaetopterana						
Ogyrides alphaerostris						
Dissodactylus mellitae						
Unidentified						
Shrimp						
Unidentified						
Squilla neglecta						
Palaemonetes sp.	4*					
Pycnogonida						
ECHINODERMATA						
Mellita quinquesperforata						
Ophiophragmus sp.						

* - Denotes Larval Stage
t - Denotes Young Adults

Table 3. Macrobenthic species and their densities (numbers/m^2 of substrate) found at six sampling stations along the offshore cruise transect. Values expressed are mean population densities based on two replicate samples at each station.

Identification	Population Densities (Number of organisms/m^2) By Station					
	1	2	3	4	5	6
FORAMINIFERA						
PORIFERA	8					
CNIDARIA						
Renilla reniformis	8		31	50	93	8
PLATYHELMINTHES						
NEMERTINA	12	8				
NEMATODA						104
BRYOZOA						
MOLLUSCA						
Gastropoda						
Bulla sp.	8	31			23	
Nassarius trivittatus			16			
Natica pusilla						
Olivella mutica						43
Polinices duplicatus						
Terebra dislocata					35	
Terebra protexta					12	
Pyramidella crenulata				12		
Pelecypoda						
Brachidontes sp.						
Cardium sp.						77
Donax variabilis						
Ensis directus						
Mercenaria sp.						12
Mulinia lateralis		8				8
Nucula sp.					35	12
Tellina sp.	12	50	143	100	324	31
Unidentified	23					
SIPUNCULIDA						
OLIGOCHAETA						
POLYCHAETA						
Glycera sp.	38				12	
Nereis sp.		12				
Sabellaria vulgaris		58			12	
Unidentified	104	35	16	58	185	493
Diopatra cuprea		8				

Table 3. (Continued)

Identification	Population Densities (Number of organisms/m^2) By Station					
	1	2	3	4	5	6
CRUSTACEA						
Ostracoda						
Copepoda						
Cirripedia						
Balanus sp.	8					
Balanus amphitrite				12		
Unidentifed		8				
Mysidacea						
Bowmaniella dissimilis					23	
Neomysis sp.				12		31
Cumacea						
Amphipoda						
Acanthohaustorius intermedius	12	8				
Acanthohaustorius millsi				38	585	
Bathyporeia sp.	12	23				
Gammarus mucronatus					12	
Parahaustorius longimerus		8		17	12	
Protohaustorius deichmannae		1061		64		
Protohaustorius wigleyi		8	64	12	23	45
Pseudoplatyischnopus floridanus				12	23	8
Trichophoxus epistomus	8				12	
Isopoda						
Ancinus depressus						
Apanthura magnifica				81	324	8
Chiridotea caeca						
Chiridotea stenops	8		16			8
Unidentified						12
Decapoda						
Crab						
Portunus gibbesii						
Portunus sayi						
Pagurus longicarpus						
Emerita talpoida	8*					8^t
Pinnixa sayana					35^t	
P. chaetopterana					23^t	
Ogyrides alphaerostris						
Dissodactylus mellitae						
Unidentified						
Shrimp						
Unidentified		8*				
Squilla neglecta	8^t					
Palaemonetes sp.						
Pycnogonida						
ECHINODERMATA						
Mellita quinquesperforata			16	12	46	8
Ophiophragmus sp.	23	8		19	12	

* - Denotes Larval Stage
t - Denotes Young Adults

Table 4. Macrobenthic species and their densities (numbers/m^2 of substrate) found at six sampling stations along the Fripp Inlet cruise transect. Values expressed are mean population densities based on two replicate samples at each station.

Identification	Population Densities (Number of organisms/m^2) By Station					
	1	2	3	4	5	6
FORAMINIFERA						
PORIFERA						
CNIDARIA						
Renilla reniformis			4		19	12
PLATYHELMINTHES						
NEMERTINA			4		12	12
NEMATODA						
BRYOZOA						
MOLLUSCA						
Gastropoda						
Bulla sp.						
Nassarius trivittatus						
Natica pusilla					12	
Olivella mutica						
Polinices duplicatus					12	
Terebra dislocata						
Terebra protexta						
Pyramidella crenulata						
Pelecypoda						
Brachidontes sp.			4			
Cardium sp.		8				
Donax variabilis						
Ensis directus						23
Mercenaria sp.		8	81			
Mulinia lateralis					12	
Nucula sp.			4			
Tellina sp.	43	38	62	8	12	58
Unidentified			8			
SIPUNCULIDA						
OLIGOCHAETA						
POLYCHAETA						
Glycera sp.	8					
Nereis sp.						
Sabellaria vulgaris			4	73		
Unidentified	62	46	62		50	8
Diopatra cuprea						

Table 4. (Continued).

Identification	Population Densities (Number of organisms/m^2) By Station					
	1	2	3	4	5	6
CRUSTACEA						
Ostracoda						
Copepodaa						
Cirripedia						
Balanus sp.				88		
Balanus amphitrite						
Unidentified						
Mysidacea						
Bowmaniella dissimilis			4			
Neomysis sp.	16					
Cumacea						
Amphipoda						
Acanthohaustorius intermedius	30	176				
Acanthohaustorius millsi						158
Bathyporeia sp.						8
Gammarus mucronatus						8
Parahaustorius longimerus	3119	23	42	285	60	
Protohaustorius deichmannae			4		642	664
Haustoriidae						
Isopoda						
Ancinus depressus			4			
Apanthura magnifica						
Chiridotea caeca				8		
Chiridotea stenops			4			
Unidentified						
Decapoda						
Crab						
Portunus gibbesii			4^t			
Portunus sayi			4t			
Pagurus longicarpus		8	19	8		12
Emerita talpoida						
Pinnixa sayana						12^t
P. chaetopterana						
Ogyrides alphaerostris	8^t					
Dissodactylus mellitae		8			12	12
Unidentified						
Shrimp						
Unidentified						
Squilla neglecta						
Palaemonetes sp.						
Pycnogonida						
ECHINODERMATA						
Mellita quinquesperforata						
Ophiophragmus sp.						

* - Denotes Larval Stage

t - Denotes Young Adults

Protohaustorius deichmannae densities ranged from 0 to 1061 organisms/m^2 of substrate. Densities ranged from 8 to 493/m^2 for unidentified worms, 8 to 324/m^2 for Tellina sp., and 0 to 324/m^2 for Apanthura magnifica. At these stations, sea pansies (Renilla reniformis), echinoderms, various molluscs, polychaete worms, and a wide variety of small crustaceans, were also common. R. reniformis and the echinoderms Mellita quinquesperforata and Ophiophragmus sp. were found at at least four of the six offshore stations. These species tend to inhabit clean, sandy bottoms (Pearse, Humm, and Wharton, 1942). This substrate preference may at least partially explain their relatively greater abundances at offshore sampling sites than along the Fripp Inlet cruise transect (Table 4). Offshore molluscs were represented primarily by Bulla sp., Cardium sp., and Nucula sp.; polychaetes by Glycera sp. and Sabellaria vulgaris; and crustacea by young commensal crabs Pinnixa chaetopterana and P. sayana, Dissodactylus mellitae, and the mysid, Bowmaniella dissimilis.

Although there were some differences in species composition, diversity, and abundance of organisms from station to station, the macrobenthic communities along the transect were similar and generally typical of those found at other localities having the same depth range and bottom type (sand or mixed sand and shell) along the South Carolina coast. Also, this area supports a wide variety of fishes and other commercially valuable species, including penaeid shrimp, portunid crabs and sciaenid fishes, and it represents the type of near-shore bottom habitat trawled by shrimp fishermen in South Carolina.

Sediment samples collected from Fripp Inlet ranged from sand and shell near the Fripp Inlet bridge to fine-grained sand at the stations further offshore (Table 1). Fripp Inlet sediments contained comparatively greater abundance of shell and larger sand grain sizes at some stations than found along the offshore cruise transect. The dominant organisms in these samples were various crustacea, molluscs, and polychaete worms (Table 4). Crustacea comprised 89%, polychaete worms 4%, and molluscs 2% of the total number of Fripp Inlet benthic animals collected. Crustacea were represented by Amphipods, several crab species (primarily *Pagurus longicarpus*), isopods, mysids, and barnacles. Amphipods comprised 78%, adult *P. longicarpus* 0.6%, and larval crabs 1% of the total fauna. Densities of *Parahaustorius longimerus* ranged from 0 to 3119 organisms/m^2 of substrate. *P. deichmannae* densities ranged from 0 to 664/m^2. Larval crab densities ranged from 0 to 14/m^2 of substrate. Polychaete worms were represented primarily by unidentified species and *Sabellaria vulgaris*. Unidentified species and *S. vulgaris* each comprised about 1% of the total organisms sampled in Fripp Inlet. Polychaete densities ranged from 0 to 62 organisms/m^2 of Fripp Inlet bottom area. Molluscs were represented by *Tellina* sp. and by small hard clams *Mercenaria* sp. *Tellina* sp. made up 3% and *Mercenaria* sp. 1% of the Fripp Inlet benthic macrofauna.

Hydrographic Measurements

At various stations during the study dissolved oxygen ranged between 3.9 and 6.9 mg/liter, water temperature between 28.9 and 30.0 C, salinity between 30.40 and 31.65 o/oo, pH between 8.0 and 8.1, turbidity between 4.0 and 24.0 Formazin Turbidity Units, settleable solids between 0.8 and 37.4 mg/liter, suspended solids between 12.0 and 29.2 mg/liter, nitrates between 0.4 and 16.8 mg/liter, phosphates between 0.0 and 6.0 mg/liter, and silicates between 295.0 and 498.8 mg/liter (Table 5).

Aerial Infrared Photography

Infrared photographs taken on 25 July, 1973 present a general picture of major sand dispersion patterns in Fripp Inlet (Figure 4). The Fripp

Table 5. Surface and bottom physical and chemical water conditions occurring during benthic macrofauna sampling on offshore and Fripp Inlet cruise transects during July, 1973.

Location	Dissolved Oxygen (mg/liter)	Temp. (C)	Salinity (o/oo)	pH	Turbidity (FTU*)	SOLIDS (mg/liter)		Nutrients (µg/liter)		
						Settleable	Suspended	Nitrates	Phosphates	Silicates
OFFSHORE TRANSECT										
Inland Station (Number One)										
Surface	5.7	28.9	30.40	8.0	24.0	37.4	15.6	6.0	6.0	498.8
Bottom	6.9	28.9	30.45	8.1	18.0	2.0	21.4	3.4	4.0	456.6
Seaward Station (Number Six)										
Surface	5.7	29.2	31.32	8.1	6.7	2.8	17.2	2.4	3.6	379.4
Bottom	5.6	29.4	30.88	8.1	5.3	0.8	12.0	6.0	0.0	365.3
FRIPP INLET TRANSECT										
Inland Station (Number One)										
Surface	3.9	29.2	31.65	8.1	14.5	2.2	29.2	16.8	0.6	456.6
Bottom	6.2	29.4	31.45	8.1	6.4	1.4	12.4	0.4	0.6	295.2
Seaward Station (Number Six)										
Bottom only	4.9	30.0	31.62	8.1	4.0	4.0	23.0	1.4	0.0	295.0

*Formazin Turbidity Units.

Figure 4. Infrared aerial photography taken during flyover of Fripp Inlet, 25 July, 1973. This photograph, taken at low tide, shows extensive formations of shoals and sandbars which have developed at the Fripp Inlet mouth.

Inlet estuary is characterized by deep tributaries and strong tidal currents. Sand dispersion into the estuary from the inlet mouth and offshore has not resulted in the formation of extensive inside bars or in the filling of tidal creeks in this area such as may be found in estuaries such as Murrells Inlet and Pawleys Inlet. Although extensive formations of shoals and sandbars have developed at the Fripp Inlet mouth (Figure 4), major bars are evident within the estuary only at a few locations such as at the mouth of Old House Creek and at the entrance of the borrow area canal on Hunting Island.

DISCUSSION

This study has provided baseline information on the macrobenthic communities and existing sand dispersion patterns in the Hunting Island Beach-Fripp Inlet area. Bottom sediment, hydrographic, and benthic biota analyses indicate that the area generally is similar to other near-shore habitats along the South Carolina coast having sand and sand-shell bottoms.

No evidence of juvenile or adult species of shellfish having commercial significance were found in the benthic samples except inside the mouth of Fripp Inlet. Inside the mouth of Fripp Inlet, possible effects of increased turbidity on shellfish should be considered. It appears unlikely that dredging for beach nourishment material offshore from Hunting Island or off Fripp Inlet would have significant direct or long-lasting impact on such resources. However, the area seaward of Hunting Island Beach from 0.5 km (0.3 miles) offshore out to about 13 km (4 miles) offshore is utilized heavily by commercial shrimp fishermen, and extensive dredging in this area could have at least temporarily disruptive effects on this fishery.

Utilization of the shifting sand bars and shoals near the mouth of Fripp Inlet for nourishment material would appear to have definite advantages. The physical effects of dredging in this area should be of a short-term nature due to the constant shifting and filling by migrating sand. Faunal communities in such areas are generally more transitory (Swedmark, 1964) and are, therefore, of less commercial significance than would be the case, for example, in areas having more stable bottom. More physical stability of substrate would occur within the estuary, where some protection from wind and wave action is afforded (Hutchinson, 1957), or even further offshore, where influences of wind and surface wave energy on ocean substrate tend to decrease with increasing depth (Dietrich, 1957).

The intertidal zone of Hunting Island Beach is characterized by benthic species typical of high-energy beach environments. Sand nourishment in this area would probably have a temporary effect through mechanical disturbance and smothering. However, most of the animals in this zone are mobile and accustomed to changing and shifting conditions. In addition, rapid repopulation of the nourished area through migration from unaffected areas of the beach would be likely. Also, impact of the nourishment on intertidal benthic species would probably be minimized both in degree and intensity if the sand used is similar to the existing beach material in grain size and texture.

This project was limited to benthic macrofauna. However, some information on ichthyofauna in the study area is available. Beach seining in the surf zone of Hunting Island during 1971 showed that a variety of juvenile fishes occurred in this area (Cupka, 1972). Predominant species collected included bay anchovy (Anchoa mitchilli), Atlantic silverside (Menidia menidia), southern kingfish (Menticirrhus americanus), striped (Mugil cephalus) and white (Mugil curema) mullet, and Florida pompano (Trachinotus carolinus).

Beach seining during 1967-70 near the Fripp Inlet bridge revealed that this area is important as habitat for a variety of fish species, including juvenile Florida pompano, permit (Trachinotus falcatus), striped and white mullet, southern kingfish, and various forage species such as bay anchovy, Atlantic silverside, and striped killifish (Fundulus majalis) (Bearden and Dias, unpublished data). Blue crab (Callinectes sapidus and C. ornatus), white shrimp (Penaeus setiferus), and brown shrimp (Penaeus aztecus) were also found in abundance in the seine collections.

The infrared photographs taken during this project include complete coverage of Hunting Island Beach, Fripp Inlet, and the adjacent estuarine areas. Information now available from these photographs include: sand dispersion patterns at the mouth of Fripp Inlet (Figure 4), beach erosion conditions on Hunting Island, marshlands of the Fripp Inlet estuarine system, highland features of Hunting and Fripp Islands, and intertidal estuarine areas such as mud and sand flats and oyster reefs.

The infrared photographs present details of the Hunting Island Beach Erosion Control Project area as of July 1973 and should prove quite useful in future comparisons of "before" and "after" effects of dredging and beach nourishment operations.

The infrared photographs should provide base line information prior to the removal of beach nourishment material from the inlet mouth if this alternative is to be utilized. Changes which take place in sand dispersion patterns in the vicinity, including physical recovery rates of borrow areas, should become evident in future photographs of the area. These photographs can also be used to classify type and acreage of marshland vegetation and to chart intertidal oyster reefs in the area. Such information will be useful in assessing general characteristics of the estuary. However, no meaningful comparison of these photographs, taken on lower stages of the tide, could be made with National Ocean Survey photographs of the area provided by the Charleston District, U. S. Army Corps of Engineers (Figure 1). The latter aerial photographs were taken on high tide, and therefore sandbars and other bottom features were not visible.

In addition to the two possible borrow areas discussed previously (Fripp Inlet and offshore from Hunting Island Beach), three other alternate areas have been considered for future nourishment operations. The following is a brief discussion of each of these areas, accompanied by recommendations concerning their use for further beach nourishment purposes.

(1) <u>The inland borrow area used for two previous beach nourishment operations</u>. This area, located immediately behind Hunting Island, is a

long saline lagoon system, connected to Fripp Inlet by a narrow canal at the southern end of Hunting Island (Figure 1). Although this area is an accessible source of borrow material for nourishing Hunting Island Beach, there are a number of potential disadvantages to its future utilization. This area is typified by finer-grained sandy material than that which occurs offshore from the beach front or at the mouth of Fripp Inlet (Thurman Morgan, personal communication). Therefore, sand from this area would probably provide much shorter-term benefits to the project since this finer material would be more vulnerable to transport off the beach once more after the nourishment operation.

Another possible disadvantage would be in the further deepening of the lagoon itself, which could result in steep-sided holes and channels, where anaerobic conditions might develop. The lagoon system is presently used extensively by sport fishermen and probably should not be modified.

For these reasons, it is recommended that the inland borrow area receive low priority consideration for future use as a source of borrow material for beach nourishment purposes.

(2) Sand bars and shoals near the mouth of and just inside Johnson Creek. This is a small, but highly productive, creek which enters the ocean at the northern end of Hunting Island. Johnson Creek has considerable shellfish resources, including both clams and oysters, and the entire creek bottom is currently under lease to the Ocean, Lake and River Fish Company of Ladies Island near Beaufort (Lease No. 119) (Figure 5). It is also heavily utilized by sport fishermen, and the South Carolina Parks, Recreation and Tourism Department plans to construct a public crabbing dock in this creek. Dredging within this small creek could have significant deleterious effects upon fish and wildlife resources and should not be considered.

Even dredging of sand at the mouth of Johnson Creek inlet might prove

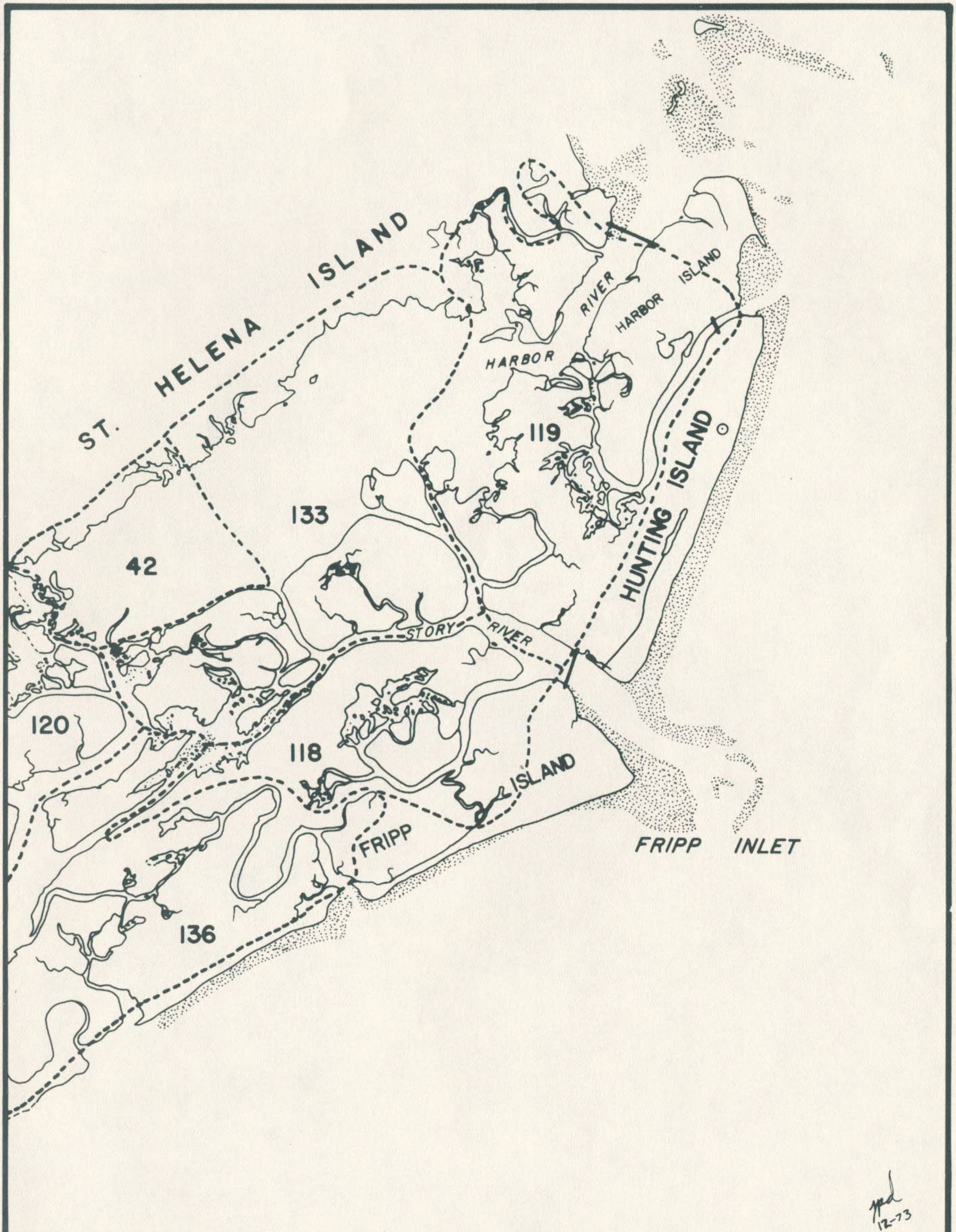

Figure 5. Map of study area showing current shellfish leases.

detrimental if suspended sand from such operations were transported into the creek and its tributaries by tidal currents (thus making the creek shallower). In addition, removal of material from the mouth of Johnson Creek might not prove beneficial to beach nourishment over a long time since net sand transport in the area is downcoast (Shepard and Wanless, 1971).

(3) Harbor River, about 1200 m (4000 feet) south of South Carolina Highway 21 crossing. This area is well within the estuary and is also included in oyster lease Number 119. Excess turbidity and siltation caused by dredging operations in this area could adversely affect intertidal oyster beds. In addition, sizeable subtidal clam beds exist in this vicinity. This area also provides significant habitat for bottom-dwelling crustaceans such as shrimp and blue crab, as well as many benthic fishes, both sport and commercial (Tom Martin, Bears Bluff Laboratory, unpublished data, 1966).

RECOMMENDATIONS

In summary, the following general recommendations are proposed relative to future Hunting Island beach nourishment projects:

(1) The sand shoal area off the mouth of Fripp Inlet should be considered one of the most suitable sources of borrow material. The effects of dredging, such as increased turbidity and disruption of benthic populations, should be of less consequence here than in more stable bottom areas, and the materials should be of suitable grain size and quality for nourishment purposes. Use of the area offshore from Hunting Island as a source of borrow material should be considered as an alternative to the above location.

(2) Inner estuarine areas, such as locations in Harbor River, Johnson Creek, and the inland borrow lagoon, should not be utilized as borrow areas. These areas are generally more stable and contain richer, more diverse fauna than do unstable areas such as the sandbars and shoals off the mouth of Fripp Inlet.

(3) Studies should be conducted after nourishment projects to investiate the changes in benthic populations and the physical effects of dredging (e.g., sand dispersion and fill-in rates of borrow areas).

(4) If the area off Fripp Inlet is utilized for borrow material, improvement of the access channel off the Inlet to the open ocean should be considered. This could benefit sport fishermen in the area who enter and exit from Fripp Inlet.

(5) Dredging activities should be conducted during periods of low biological activity. In particular, seasons of peak reproduction and recruitment should be avoided. Major periods of larval and postlarval recruitment in South Carolina are during February through mid-April for important species such as spot (*Leiostomus xanthurus*) and Atlantic menhaden (*Brevoortia tyrannus*), as well as brown shrimp and several species of flounder and mullet; and during

May-August for the blue crab, white shrimp, and a wide variety of estuarine-dependent fishes (Bearden, 1961). Thus, the ideal time for dredging would be during colder weather in late fall and early winter (November through January). We also feel that dredging operations at the mouth of Fripp Inlet should be carried out on the ebb tide to the greatest degree possible to minimize movement of suspended sediments into the estuary.

(6) Dredging should not be carried out near the wreck of the "Savannah" off Fripp Inlet (32° 19.0'N, 80° 24.2'W). This is a prime sport fishing location (Bearden and McKenzie, 1973) which should be protected.

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